

**XXIV INTERNATIONAL
ECO-CONFERENCE® 2020
23–25th SEPTEMBER**

XI SAFE FOOD



PROCEEDINGS

NOVI SAD, SERBIA

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ECOLOGICAL MOVEMENT OF NOVI SAD
21000 Novi Sad, Vojvođanskih brigada 17
Phone: (+381 21) 6372 940
Mob: (+381 69) 304 73 38
E-mail: ekopokretns@gmail.com
www.ekopokret.org.rs

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SAFE FOOD

PROCEEDINGS
2020.

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- Ecological Movement of Novi Sad

Co-organizers:

- University of Novi Sad
- Russian State Agrarian University–MTAA, Moscow, Russian Federation
- International Independent Ecological–Politicalology University in Moscow, Russian Federation
- Institute for Field and Vegetable Crops Novi Sad, Novi Sad, Serbia
- Pasteur Institute of Novi Sad,
- Scientific Veterinary Institute "Novi Sad" Serbia
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Official host of the XX International Eco-Conference® 2018

- **Institute for Nature Conservation of Vojvodina Province in Novi Sad**

THE ECOLOGICAL MOVEMENT OF THE CITY OF NOVI SAD: AN IMPORTANT DECISION OF ITS PROGRAMME COUNCIL

Since 1995, the Ecological Movement of the City of Novi Sad organizes "Eco-Conference® on Environmental Protection of Urban and Suburban Areas", with international participation. Seven biennial conferences have been held so far (in 1995, 1997, 1999, 2001, 2003, 2005, 2007, 2009, 2011, 2013 and 2015.). Their programs included the following environmental topics:

- Session 1: Environmental spheres: a) air, b) water, c) soil, d) biosphere
- Session 2: Technical and technological aspects of environmental protection
- Session 3: Sociological, health, cultural, educational and recreational aspects of environmental protection
- Session 4: Economic aspects of environmental protection
- Session 5: Legal aspects of environmental protection
- Session 6: Ecological system projecting (informatics and computer applications in the field of integrated protection)
- Session 7: Sustainable development of urban and suburban settlements-ecological aspects.

Conference participants have commended the scientific and organizational levels of the conferences. Conference evaluations have indicated that some aspects are missing in the conference program. In addition, since a team of conference organizers was completed, each even year between the conferences started to be viewed as an unnecessary lag in activity.

Eco-Conference® on Safe Food

With the above deliberations in mind, a decision was made that the Ecological Movement of the City of Novi Sad should embark on another project – the organization of Eco-Conferences® on Safe Food. These Conferences were planned to take place in each even year. Preparations for the first Eco-Conferences® on safe food started after the successful completion of the Eco-Conference® '99.

So far four Eco-Conferences® have been held (in 2000, 2002, 2004, 2006, 2008, 2010, 2012 and 2014.) focusing this general theme.

Theme of the Eco-Conference®

By organizing the Eco-Conference® on Safe Food, the organizer wishes to cover all factors that affect the quality of human living. Exchange of opinions and practical experiences should help in identifying and resolving the various problems associated with the production of safe food.

Since 2007 Eco-Conference gained patronship from UNESCO and became purely scientific Conference.

Objectives of the Eco-Conference®

- To acquaint participants with current problems in the production of safe food.
- To make realistic assessments of the causes of ecological imbalance in the conventional agricultural production and the impact of various pollution sources on the current agricultural production.
- Based on an exchange of opinions and available research data, to make long-term strategic programs of developing an industrialized, controlled, integral, alternative and sustainable agriculture capable of supplying sufficient quantities of quality food, free of negative side effects on human health and the environment.

Basic Topics of the Eco-Conference®

Basic topics should cover all relevant aspects of the production of safe food.

When defining the basic topics, the intention was itemize the segments of the production of safe food as well as the related factors that may affect or that already have already been identified as detrimental for food safety and quality. The topics include ecological factors of safe food production, correct choice of seed (genetic) material, status and preparation of soil as the basic substrate for the production of food and feed, use of fertilizers and pesticides in integrated plant protection, use of biologicals, food processing technology, economic aspects, marketing and packaging of safe food.

To paraphrase, the envisaged topics cover the production of safe food on the whole, individual aspects of the production and their mutual relations, and impact on food quality and safety.

Sessions of the Eco-Conference®

1. Climate and production of safe food.
2. Soil and water as the basis of agricultural production.
3. Genetics, genetic resources, breeding and genetic engineering in the function of producing safe food.
4. Fertilizers and fertilization practice in the function of producing safe food.
5. Integrated pest management and use of biologicals.

6. Agricultural production in view of sustainable development
7. Production of field and vegetable crops.
8. Production of fruits and grapes.
9. Livestock husbandry from the aspect of safe food production.
10. Processing of agricultural products in the framework of safe food production.
11. Economic aspects and marketing as segments of the production of safe food.
12. Food storage, transportation and packaging.
13. Nutritional food value and quality nutrition.
14. Legal aspects of protecting brand names of safe food.
15. Ecological models and software in production of safe food.

Attempts will be made to make the above conference program permanent. In this way will the conference become recognizable in form, topics and quality, which should help it find its place among similar conferences organized elsewhere in the world.

By alternately organizing conferences on environmental protection of urban and suburban areas in odd years and conferences on safe food in even years, the Ecological Movement of the City of Novi Sad is completing its contribution to a higher quality of living of the population. Already in the 19th century, Novi Sad was a regional center of social progress and broad-mindedness. Today, owing first of all to its being a university center, Novi Sad is in the vanguard of ecological thought in this part of Europe.

It is our duty to work on the furtherance of the ecological programs of action and, by doing so, to make our contribution to the protection of the natural environment and spiritual heritage with the ultimate goal of helping the population attain a higher level of consciousness and a higher quality of living.

Director of the Ecological
Movement of Novi Sad
Nikola Aleksic

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ECOLOGICAL MODELS AND SOFTWARE IN SAFE FOOD PRODUCTION

B. Sc. Dusan Milincic, M. Sc. Bratimir Nestic, M. Sc. Nemanja Petrovic,

B. Sc. Nenad Nestic, M. Sc. Natalija Totic, B. Sc. student Luka Nestic,

B. Sc. Aleksandar Aleksic, M. Sc. Dusan Stevanovic

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FOREWORD

Ecological Movement of Novi Sad continuously for two decades is successfully organizing international scientific Eco-conference. Every odd year a conference devoted to the ecological problems of cities and suburbs is organized and even years a conference devoted to safe food is organized. Thus, this year the program of the conference represent various aspects of safe food production. Population nutrition and in this regard, correctness and biological value of food represents not only local but also a global problem, which is why this problem attaches great importance worldwide.

Population nutrition is a multilayered problem of population and includes both quantitative and qualitative indicators which have a great impact on the health and prosperity of the human population, but also represent the social, political, economic, and not at the end, an environmental problem. It is believed that in the world, every ninth inhabitant is starving or about 800 million, of which 98% in developing countries, 500 million in Asia and the Pacific region and 23 million in Africa. The reasons for insufficient amounts of food on a global scale are numerous: local and regional wars for which it is not possible to cultivate the land, the production of fuels from vegetable products, increasing production and thus consumption of meat, which requires a greater quantity of plant products, food price growth and reproduction materials for which farmers are not able to establish manufacturing. Then, there is lack of agro-technical knowledge, corruption, inefficient use of natural resources, environmental pollution, global climate change and others. It is believed to be due to climate change by 2030.

Yields of cultivated species reduced by approximately 30%, while, at the same time, there will be a reduction in arable land per capita, which in 1970, amounted to 3205 in 1990, to 2372, and in 2050, it will be reduced to 1500 m². At the same time it is estimated that the Earth's globe in 2050 to live more than nine billion people. An interesting fact is claiming that 30,000 edible plant species in the world, only four species: rice, wheat, maize and potatoes provide 60% of energy needs in nutrition.

Using large edible plant species on a large scale would contribute to partially solving the problem of hunger, and probably better quality food. There is also an opinion that in the world, enough food is produced and that will be in the future be able to provide increased needs. The problem is the global distribution of agricultural products, their price and the huge losses that arise in the course of their processing, storage and transport. This among other things is confirmed by the fact that especially in developed countries, but not only there, the problem of obesity seems a growing health problem.

It stems not only from the relatively low prices of food and in this regard the entry of excessive amounts of calories, but also from an inadequate diet, intake of foods rich in carbohydrates and fats.

Based on the above, one can reasonably ask how it fits the concept of safe food and organic agricultural production to overcome its lack of quantity, especially in economically underdeveloped countries, but also in other parts of the world. It would be wrong to reduce the problem of hunger only in economically undeveloped countries, it exists, and in countries in transition and prosperity, it is true to a lesser extent. Due to the lack of application of chemicals (fertilizers, pesticides, etc.) still yields compared to conventional production to organic production is the lower 15 to 25%, a price on that technology manufactured goods is also increased by about the same percentage.

Organic production is encouraged from the state budget funds, which means that the poorer classes of the population is co-funding the consumption of organic food to the upper classes of citizenship that such foods can buy. Additionally, organic food production deserves attention for several reasons. Consumption of organic food contributes to the health of the population, increasing environmental awareness not only among food producers but also among consumers, it provides effective management in smaller areas, as well as the export of such manufactured food for which there is a significant demand in the world market.

Problem of safe food is very complicated, so the program and this year's conference is designed so that it covers all aspects of this issue: climate, soil, genetics, fertilizers, integrated crop protection, sustainable development of agriculture, food safety, production of fruit and grapes, livestock production, food processing, storage, transport and packaging, nutritional value, legal aspects and environmental models and software in the production of safe food.

Ecological Movement of Novi Sad and the co-organizers hope that the conference will contribute to better understanding and addressing specific environmental issues regarding the production of healthy full-value food and thanks to everyone who contributed to the organization and holding together with the message what attitude we should have toward nature, since natural resources are borrowed from future generations.

R. Kastori

INTRODUCTORY PRESENTATION



Željko Mihaljev
Scientific Veterinary Institute "Novi Sad"
E-mail: zeljko@niv.ns.ac

RADIONUCLIDES IN THE ENVIRONMENT AND THEIR IMPACT ON FOOD SAFETY AND HUMAN HEALTH

Abstract

The paper shows results of gamma spectrometry testing, determination of specific activity of ^{90}Sr as measurements of activity concentration of torium and uranium isotopes by a technique of inductively coupled plasma with mass spectrometry. Soil samples were collected from locations in Vojvodina and central Serbia and sludge samples from the bottom of the Danube in the region of Novi Sad. Food samples of fish, dairy (powdered milk, powdered whey, powdered eggs), honey and meat were collected from various markets, and animal feedstuff samples (fish flour, premixes, mineral feedstuff) from regular production. Also, the results of determining the activity concentration of natural and artificial radionuclides in internal organ samples (kidneys) of different types of wild birds, as well as of game urine (samples of roe deer) are shown. Contamination sources of anthropogenic origin were discussed in more detail, as well as nuclear accidents and their influence on technological production chain of plant- and animal- source foods.

Key words: *radioactivity, food, feed, nuclear accidents*

INTRODUCTION

Ionizing radiation is a natural phenomenon that has been accompanying the development of organic matter and all living beings on Earth from the very beginning. However, people have no natural senses that would be able to detect ionizing radiation, and therefore they could be exposed to lethal doses of it without sensing anything at the moment of exposure to the radiation. Consequences of radiation are noticeable only after some time, a few hours, a few days or even a few years.

There is no surface on Earth without natural radioactivity. It is present everywhere in nature: the soil, rocks, building material, water, air, vegetation, even in human body. All living beings on Earth are exposed to this type of ionizing radiation. Natural

radionuclides can be primordial (original), i.e. the ones from before Earth was created, such as ^{40}K , ^{235}U , ^{238}U , ^{232}Th , ^{226}Ra and ^{222}Rn . Another significant source of natural radioactivity is cosmic radiation of galactic and solar origin, composed mostly of ^{14}C , ^7Be , ^3H and ^{22}Na . (Levant, 1996).

Besides the natural radioisotopes in the atmosphere, water and soil, radionuclides of anthropogenic origin that were created after human (technological) activities can also be found. That, above all, includes above-ground testing of nuclear weapons. There were more than 400 of those between 1945 and 1980. These nuclear tests expelled into atmosphere around 1300 PBq ^{90}Sr and 1500 PBq ^{137}Cs . Nuclear explosion tests mostly contributed to the radiation doses received by people (Mitrović, 2010). Development of nuclear weapons brings wider use of radioactive materials and nuclear energy for peaceful uses: industry, energy, medicine and agriculture. Technical and technological shortcomings of some nuclear plants, even with most modern security systems, paired with human factor (lack of knowledge, negligence, mistakes, disregard for prescribed procedures) are a constant danger of nuclear accidents that cause damage in nuclear plants with high degree of radioactive pollution of biosphere.

Nuclear accidents

Chalk River – 1952 (Canada) there was an accident on an experimental nuclear reactor of the Chalk River research center. Causes of the accident were operator mistake and a mechanical malfunction in the reactor shutdown system. Due to uncontrolled increase in the reactor power, there was a partial fuel meltdown and fuel elements were damaged, which resulted in release of radioactivity. During the accident cleanup, some workers were exposed to significant doses of radiation. The combination of mechanical malfunction on the reactor and human mistake during preparations for the experiment caused an uncontrolled increase of power – in one minute, reactor power increased to 90 MW, which is 3 times more than the nominal power that the reactor was designed for. A part of fuel rods lost cooling and were damaged. Radioactive products leaked into the cooling liquid and hydrogen explosion damaged the cooling system pipes. Besides the reactor damage, the problem was also a large quantity of contaminated water (around 4.5 thousand tons). In order to prevent pollution of the Ottawa River by the contaminated water, a 1600-meter pipeline was built, which moved that water into a sandy area. Activity of long-lived fission products, which were in the contaminated water, was around 10 000 curies. Median equivalent dose that the employees of the research center received was around 24 mSv, while military personnel received a median equivalent dose of around 19 mSv (Ninković, 2016; <http://www.nemis.hr/index.php/nesrece.html>).

Windscale – 1957 (Great Britain) there was a fire on a graphite moderated and air-cooled nuclear reactor Windscale 1, that was used to produce plutonium (^{239}Pu) for the first British atomic bomb. The cause of the accident was reheating of the graphite that happened too quickly, in order to relax the graphite crystal grid. Due to the uncontrolled fuel temperature increase, there was damage on the aluminum coating of the fuel element and oxidation of the metal uranium fuel, which sped up the overheating and

caused a fire. The released fission products, above all iodine ^{131}I and noble gases entered the atmosphere through a 120 m tall chimney and were dispersed by wind through Central and Southern England. The activity of the iodine ^{131}I and noble gases released into the environment was around 20 000 curies. The employees and the inhabitants of the area were exposed to increased doses of radiation. The reactor was significantly damaged in the accident and, as its further use was considered unsafe, it was permanently disabled. Very soon after that, the other reactor of the same type in that location was disabled as well, due to safety reasons (Ninković, 2016; <http://www.nemis.hr/index.php/nesrece.html>, Pantelić et al, 2016).

Lagoona Beach – 1966 (USA) there was an accident on a fast breeder reactor of the Fermi I nuclear plant, in Lagoona Beach, near Detroit, Michigan. The cause of the accident was a mechanical breakdown that caused a cooling blockage in two cooling channels. Due to decreased cooling, there was a partial fuel meltdown and 4 fuel elements were damaged. Partition breakoff resulted in the blockage of the cooling channel around fuel elements, which prevented the flow of liquid sodium. The partition has no function during regular operation, but in the case of core meltdown, it should secure such distribution of fuel material that there cannot be a repeated critical situation. Activity of the fission products that leaked into the cooling agent (liquid sodium) was 10 000 curies. During the analysis of possible consequences of a repeated critical situation of the melted core, it was noted that it would be possible for such melted mass to produce enough heat so that it can enter the soil through the foundations of the containment building. One of the engineers suggested that such melted mass could go through Earth "all the way to China". That is how the phrase "China syndrome" was created, in relation to this accident (<http://www.nemis.hr/index.php/nesrece.html>).

Three Mile Island – 1979 (USA). Accident in the Three Mile Island nuclear power plant started with a minor breakdown in the secondary cooling circle of the power plant, which made the steam generator lose its cooling. Even though those types of breakdowns are solved by activating automatic protection systems, this time a mistake in signaling and improper interpretation of physical processes by the operator caused the malfunction to also spread onto the primary circle. The core lost its cooling fluid, which evaporated, and there was a partial meltdown of the core. Such breakdown is a routine one, and is solved by activating an automated system for auxiliary water supply with automatic shutdown of the turbine, and after that the reactor itself. However, after the previous overhaul of the power plant, the valve of the auxiliary water supply system remained closed by mistake, without the operators even noticing. Potentially insignificant breakdown developed into a breakdown with heavy damage to the reactor. This breakdown showed that even small disruptions can lead to potentially serious accidents, if they are not interpreted on time and properly. A whole sequence of incorrect pieces of information by government agencies caused great fear, panic and general confusion among local people. During the accident, the media developed great interest in it, and the nuclear energy opponents finally had their opportunity for a big anti-nuclear media campaign. That campaign had an additional media effect due to the movie *The China Syndrome*, which premiered exactly 12 days before the TMI accident. In the movie, due to a string of security errors, the reactor core almost melted, so even today such

type of accident is called "China syndrome" (Ninković, 2016; <http://www.nemis.hr/index.php/nesrece.html>, Pantelić et al, 2016).

Chernobyl – 1986 (USSR) On that fatal day, the plant staff was conducting reactor testing at low power of about 200 MW, which is about three times lower than the prescribed safety level. The goal was to test how the power plant will behave after losing the external electric energy power supply. Specifically, they wanted to determine if the turbines in shutdown phase are able to produce enough energy to start the recirculation pumps for cooling systems. Such type of reactor is moderated by graphite and cooled by water, so it is known that it is unstable when operating at a power level lower than 20% of its nominal power. However, all those known facts did not prevent the operators from going ahead with the experiment that demands lowering the power to as low as 7% of the declared power. Safety procedures were neglected in that process, automated safety systems were turned off, and control rods completely removed from the core. Specific physical conditions brought the reactor to the state of prompt criticality, which caused steam explosion. The fuel dispersed into tiny fragments that created explosive steam in contact with water. High pressure expelled a lid that was 3 m thick and weighed 2 000 tones, which left the reactor core exposed. Red hot uranium ignited the graphite moderator when it came into contact with oxygen. An additional problem was the reaction of zirconium (coating of fuel rods) and hot water steam. Within a few days, a large quantity of highly radioactive material was released from the exposed and completely destroyed core (Ninković, 2016; <http://www.nemis.hr/index.php/nesrece.html>, Pantelić et al, 2016).

A total of 56 people lost their lives due to the consequences of the accident, mostly rescuers and firefighters. More than 130 000 people were evacuated, environment was significantly damaged, and vast area of Europe was contaminated. It is necessary to point out that the RBMK reactor was not constructed in accordance with internationally recognized safety principles, which especially refers to the lack of protective building (containment). This fatal accident was solely a result of human recklessness. Also, all prescribed safety procedures were violated. Members of special intervention services (so-called liquidators) stopped the fire and spread of radioactivity by depositing over 2 000 tons of led into the core, and they put out the graphite fire by pumping nitrogen through the bottom side of the reactor.

Tokaimura – 1999 (Japan) There was an accident, 113 km north-west of Tokyo, in the uranium conversion plant, solely as a result of unskillfull and unattentive plant staff. The plant used to produce about 3 tons of enriched uranium (20% ^{235}U) which was transported to various research and experimental reactors. Three workers received potentially lethal radiation doses, and two of them soon died, after they reached the critical values of uranium solution by mistake. Shortly after the accident, 119 workers who participated in the chain reaction extinguishing intervention were exposed to the radiation. Local inhabitants were temporarily evacuated due to release of radioactive gases into the atmosphere. The accident showed lack of safety protocols in Japanese nuclear plants, as well as lack of education of the plant staff. The uniqueness of this reaction, which lasted for 20 hours, was that the water in the solution had the role of neutron moderator, and the water surrounding the reactor vessel acted as neutron

reflector. The chain reaction was finally stopped after the water that surrounded the reactor vessel was pumped out. To ensure subcriticality of the mixture, phosphorous acid, which is a parasitic neutron absorber, was introduced at the end. During the accident, 160 TBq of noble gases and 2 TBq of iodine gas were released (Ninković, 2016; <http://www.nemis.hr/index.php/nesrece.html>)

Fukushima Daiichi – 2011 (Japan) Devastating Mercalli Scale magnitude IX earthquake struck the east coast of the Honshu island in 2011. In the region affected by the earthquake, there were 11 working reactors in four locations. Due to the earthquake intensity, all 11 reactors automatically shut down. Electric energy from the grid or backup generators enabled the cooling pumps to operate in 8 out of the 11 reactors. The remaining three reactors at Fukushima Daiichi location lost power, and with it the ability to properly cool down the reactor an hour after the earthquake, due to a flood caused by a 15 meter tsunami. There was a breakdown at 12 out of 13 backup generators, as well as at heat exchangers. That resulted in overheating and melting of all three reactor cores. Explosion of hydrogen that was created through a reaction between zirconium and water steam damaged reactor buildings and released a large amount of radioactivity (570 PBq ¹³¹I). Due to such great release of radioactivity in the environment, this accident was classified as the accident of highest category – 7 on the International Nuclear Event Scale (INES scale). A large amount of contaminated water flowed from the damaged reactors into the sea. This accident resulted in three deaths. Approximately 160 000 people were evacuated from the contaminated area. The area outside the power plant has been contaminated with caesium isotopes ¹³⁴Cs and ¹³⁷Cs, as well as ⁹¹Y and ⁹⁰Sr long term (Ninković, 2016; <http://www.nemis.hr/index.php/nesrece.html>, Pantelić et al, 2016).

Nuclear submarine accidents: The worst submarine accident in American history happened in 1963, when nuclear submarine USS Thresher (SSN-593) sank during diving testing, killing all 129 crew members. Soviet, i.e. Russian nuclear submarine history noted a high number of accidents caused by breakdowns of nuclear components or their unskilled use. In 1961, during regular training in the north Atlantic, close to south Greenland shores, there was a leak of cooling liquid from the stern reactor cooling system, which caused pressure drop in the reactor and turned off the pumps in the cooling system. Due to excessive radiation, 27 crew members died. Thanks to the movie adaptation ("The Widomaker"), the public was introduced to the K-19 submarine accident. Parts of the script that describe the technical side of the accident and the problems with the nuclear reactor are almost entirely true. During the fuel exchange, in 1985, there was an uncontrolled chain reaction and explosion on the K-314 submarine, which led to the death of 10 pier workers. (<http://www.nemis.hr/index.php/nesrece.html>).

"Vinca accident": Known in the world as the "Vinca accident", on October 15, 1958. At a zero-power experimental reactor RB, at the Vinca Institute, six young people were exposed to lethal dose of radiation, after a number of errors in the protection system. At that time, Yugoslavia was the fifth country in the world developing nuclear technology. The following technical fellows participated in the tragic experiment: Rosanda Dangubic, Drasko Grujic, Zivorad Bogojevic and Stjepo Hajdukovic, as well

as final year physics majors Zivota Vranic and Radojko Maksic (Hajduković, 1997). The irradiated young researchers were urgently transported to Paris, to the "Curie" hospital. Due to bone marrow transplant, which was done for the first time in the history of medicine by the famous Dr. Georges Mathe, five of them successfully recovered. The sixth one, Zivota Vranic (1934–1958) died even before the treatment, because his burns were fatal, which made him the first post-war victim of radioactive radiation (Milašinović, 2011).

Serbia, in its close proximity, in 500 km radius, has 15 nuclear power plants that represent great potential danger of possible catastrophe. Each possible malfunction at the surrounding power plants would be felt promptly, within an hour, in Serbia, bringing with it all the consequences that a nuclear accident can produce. Bulgaria had to shut down four out of its six blocks in Kozloduy, and they are planning to build a nuclear power plant by the town of Belene on the Danube. Hungary has two reactors in Paks, on the Danube, while Croatia and Slovenia have a shared border nuclear power plant in Krsko. Romania has a nuclear power plant by Cernavoda on the Danube, and they are planning to build another one in the central part of the country.

Worldwide, there are 442 working nuclear reactors, which produce 15% of the total electric energy in the world. Most of them are in the USA – 104, France – 59, Japan – 55, Russia – 31, South Korea – 20, Great Britain – 19, Canada – 18, Germany and India – 17 each, Ukraine – 15, Sweden – 10. Europe has a total of 205 nuclear reactors.

Technologically elevated level of natural radioactivity

Uranium levels in soil can increase due to application of artificial phosphorus fertilizers. Production of phosphorus fertilizers is based on dissolving natural phosphates in sulphuric acid. In that process, in the first phase phosphoric acid is created, which further dissolves natural phosphates, creating phosphorous fertilizers as the final product (Mitrović et al., 2011). By dissolving African natural phosphates (Morocco, Jordan), 90-95% of uranium turns into phosphoric acid, to be deposited in phosphorous fertilizers as a final product. Processing of phosphoric ore creates mono- and di- calcium phosphate, that are used in animal feedstuff as a source of calcium and phosphorous, and they can also contain high concentration of uranium (Vranješ et al., 2017).

Coal mining and its burning in thermal power plants is potentially the most important process of creation of technologically increased level of natural radioactivity. Coal burning releases huge amounts of radionuclides into the atmosphere, which then accumulate in large areas. During the burning process, almost all of radon in the coal moves into gas phase, and Th and U, as well as the products of their disintegration remain in the solid waste (Kisić et al., 2013).

Technologically elevated levels of natural radioactivity are created during all major ground works, such as construction of hydroenergy and hydromelioration structures. Also, heavy metal ore extraction (zinc, copper, lead) from deep layers of lithosphere and their processing speed up the release of radon from deeper layers of Earth's crust. Disintegration of uranium (^{238}U) gives radium (^{226}Ra) and disintegration of its nuclei

creates radon (^{222}Rn), which is the most important for contamination, especially of closed spaces. Disintegration of ^{222}Rn nucleus gives short-lived progeny ^{218}Po , ^{214}Pb and ^{214}Bi , which, as alpha and beta emitters of high energy, present a very important radiation and health risk, because they interact with negative ions from the atmosphere, adhering to natural aerosols that are deposited in human lungs. The results of the latest research show that in normal conditions, over 70% of total annual dose that the people receive comes from natural sources of ionizing radiation. There, 50% is conditioned by breathing in natural radioactive gas, radon (^{222}Rn), i.e. its progeny (Bikit et al., 1995).

Depleted uranium

In nature, uranium can be found as a compound of isotopes $^{238}\text{U}_{92}$, $^{235}\text{U}_{92}$ and $^{234}\text{U}_{92}$, created in the process of Earth's crust formation. The most important one for nuclear energy is ^{235}U . However, its concentration in natural uranium is not sufficient. In order for uranium to be used as fuel, it is necessary to increase its contents from 0.72% to 1.7% to 3.5%, depending on the reactor type (Rajković, 2001). As a result of separation method, gas diffusion or centrifuge, two phases are created: product with increased content of ^{235}U and byproduct with decreased content of ^{235}U , called depleted uranium. When it comes to chemistry, uranium and depleted uranium act in the same way (Orlić, 2000).

Table 1. Isotope contents of natural and depleted uranium (IRSN, 2010)

Types of uranium	^{234}U	^{235}U	^{238}U
	Mass percent [%]		
Natural uranium	0.0053	0.71	99.285
Depleted uranium	0.0008	0.202	99.797

Military industry showed great interest in depleted uranium, because it is a highly dense and pyrophoric material, but extremely inexpensive. It was available in large quantities. After a projectile hits a solid target, its temperature goes up to about 1230 °C and the temperature of the target (immediately around the impact area) goes up to 780 °C. The penetrator gradually melts, and a thin stream of liquid metal goes through the shell (Divković, 2016). After the shell is penetrated, projectile body falls apart, and due to prominent pyrolytic qualities of depleted uranium, there is oxidation of uranium (UO_2 , UO_3 and U_3O_8) and self-ignition of the created pieces. Apart from penetrating and pyrogenic effect, depleted uranium projectiles also have radioactive effect on people and very adverse effect on the environment. At the impact site, there are: large pieces of the penetrator ($m > 10\text{g}$), small pieces of the penetrator ($m < 10\text{g}$), large aerosols ($\text{Ø} > 10\mu\text{m}$) and aerosols created by combustion of penetrator parts ($\text{Ø} \sim 0.3\mu\text{m}$). Due to

their weight, the first two types of particles remain in the vicinity (~10m) of the impact site. These particles react intensely with liquids from the environment and as compounded solutions have damaging effect on living beings. The tiniest aerosols are transported to distances of up to several tens of kilometers. Inhaled or ingested, these aerosols become a health hazard, partly because they are radioactive, and partly because of their chemical toxicity in lungs. If it enters the bloodstream and spreads around a body, depleted uranium causes damage of the spinal cord, kidneys, cardiovascular and lymphatic systems (Bakrač et al., 2018).

So far, in war actions, it has been estimated that NATO forces have used around 300 t of depleted uranium on the territories of Irak, Kuwait and Saudi Arabia. During the intervention in Bosnia and Herzegovina in 1994/95, NATO used over 3 t of depleted uranium from A-10 planes (at 19 locations). In the war between NATO and Federal Republic of Yugoslavia (FRY) in 1999 at 112 locations a total of around 10 t of depleted uranium was used. Most are located in Kosovo and Metohija. Other locations are on the territory of Vranje, Bujanovac and Presevo municipalities. In the republic of Montenegro, Cape Arza on the peninsula of Lustica was targeted with depleted uranium projectiles. Intentional dispersion of depleted uranium into the environment contributes to the increase of the existing values of uranium content in nature (Stojanović et al., 2015; Divković, 2016).

MATERIAL AND METHODS

Sampling: soil samples were collected from locations in Vojvodina and Central Serbia. Sludge samples were taken from the Danube river bed in the area of Novi Sad. Samples were dried at 105 °C to constant mass. All mechanical contaminants, mainly small stone pieces and plant material were removed. The samples were then sieved and homogenized as fine powder. Food samples of fish, dairy (powdered milk, powdered whey, powdered eggs), honey and meat were collected from various markets, and animal feedstuff samples (fish flour, premixes, mineral feedstuff) from regular production. Samples of about 300 g were prepared and packed in cylindrical geometry-Marinelli beakers (V=250ml) and measured on the cap of detectors (IAEA, 1989).

Analysis: Activity concentrations of radionuclides gamma emitters were determined by the method of low-level gamma spectrometry on high resolution HPGe coaxial detector system produced by ORTEC with nominal efficiency of 28%, resolution (FWHM) at 1.33 MeV ⁶⁰Co of 1.67 keV and Peak-to-Compton ratio 67:1. The detector was shielded with cylindrical lead shield with 10 cm wall thickness. The gamma spectra were acquired and analyzed using the GammaVision[®] software. The precision and accuracy of the method was tested using a certified reference material LR 320 (Deutscher Kalibrierdienst, Germany). Typical measurement time was 100 ks. Activity concentrations of thorium and uranium in all the samples were analyzed by a technique of inductively coupled plasma with mass spectrometry, on the Agilent ICP-MS 7700 and the samples were prepared by wet digestion using Ethos, Labstation Microwave, Milestone (Pappas et al, 2002).

RESULTS AND DISCUSSION

The basic component of the biosphere is lithosphere (Earth's crust), which represents the first link in the ecology chain: soil-vegetation-animals-man. The soil plays a crucial role in the process of radionuclide distribution and transfer, thus, information about radioactive contamination of the soil is of great importance for radiation safety issues in biotechnology. Uncontrolled application of phosphate fertilizers gives broad possibilities for damaging ecological balance, because it represents by far the greatest anthropogenic source of ^{238}U and ^{232}Th contents increase in soil, and through that in plants and other food chain links (Mihaljev et al., 2015).

Based on the results presented in Table 2., it can be concluded that all analyzed soil specimens contained artificial radionuclide ^{137}Cs . Median value of activity concentration for the area of Vojvodina was 5.41 Bq/kg, and in Central Serbia it was 5.94 Bq/kg. The highest value of ^{137}Cs activity was measured in the Danube mud and it was 15.4 Bq/kg. Average ^{40}K activity in the analyzed soil samples was between 353 Bq/kg (central Serbia) and 548 Bq/kg (Danube mud) what is in accordance with the results of other authors (Bikit et al, 2010). Average ^{232}Th activities in all analyzed samples were very uniform and between 34.8 – 47.9 Bq/kg. Highest values for ^{238}U activity were measured in the Danube mud (33.4 Bq/kg), while median activity concentrations of ^{235}U in Vojvodina soil (36.4 Bq/kg) and central Serbia (41.0 Bq/kg) were significantly higher than ^{235}U activity in the Danube mud.

Table 2. Activity concentration of caesium-137, potassium-40, thorium-232, radium-226, uranium-235 and uranium-238 in soil and mud samples

Activity	Location		
	Vojvodina (n = 11)	Central Serbia (n = 18)	Novi Sad Danube - Sludge (n = 5)
^{137}Cs [Bq/kg, L]	$\bar{A} = 5.41$ VI = 4.10-9.10	$\bar{A} = 5.94$ VI = 0.91-16.7	$\bar{A} = 15.4$ VI = 13.8-17.0
^{40}K [Bq/kg, L]	$\bar{A} = 531$ VI = 344-741	$\bar{A} = 353$ VI = 70-629	$\bar{A} = 548$ VI = 494-640
^{232}Th [Bq/kg, L]	$\bar{A} = 47.9$ VI = 43-54	$\bar{A} = 38.3$ VI = 32.2-49.6	$\bar{A} = 34.8$ VI = 19.6-43.9
^{226}Ra [Bq/kg, L]	$\bar{A} = 42.3$ VI = 41-51	$\bar{A} = 39.8$ VI = 32.2-49.6	$\bar{A} = 5.46$ VI = 4.15-8.12
^{238}U [mBq/kg, L]	$\bar{A} = 1.87$ VI = 1.51-2.71	$\bar{A} = 2.10$ VI = 1.59-3.43	$\bar{A} = 33.4$ VI = 11.6-51.8
^{235}U [mBq/kg, L]	$\bar{A} = 36.4$ VI = 29.2-52.5	$\bar{A} = 41.0$ VI = 31.0-66.8	$\bar{A} = 1.72$ VI = 0.60-2.66

\bar{A} – Median value of activity concentration;

VI – variation interval (span) = min. value – max. value

Based on the results presented in Table 3., it can be concluded that in all tested samples of fish, dairy, honey and meat, ^{40}K is the dominant natural radionuclide compared to other radionuclides. The highest ^{40}K activity was measured in powdered milk (dairy) and it was, on average, 535 Bq/kg.

Table 3. Activity concentration of caesium-137, potassium-40, thorium-232, radium-226, uranium- 235 and uranium-238 in food samples

Activity	Sample type			
	Small blue fish (n = 15)	Dairy (n = 10)	Honey (n = 11)	Meat (n = 12)
^{137}Cs [Bq/kg, L]	$\bar{A} = 3.05$ VI = 2.55-4.13	$\bar{A} = 1.99$ VI = 0.80-4.12	< 0.5	< 0.5
^{40}K [Bq/kg, L]	$\bar{A} = 122$ VI = 101-162	$\bar{A} = 535$ VI = 113-894	$\bar{A} = 53$ VI = 32-84	$\bar{A} = 123$ VI = 87-132
^{232}Th [Bq/kg, L]	$\bar{A} = 1.94$ VI = 1.03-3.33	$\bar{A} = 2.08$ VI = 1.22-3.12	$\bar{A} = 1.33$ VI = 0.5-2.0	$\bar{A} = 0.98$ VI = 0.53-1.94
^{226}Ra [Bq/kg, L]	$\bar{A} = 2.91$ VI = 1.23-4.88	$\bar{A} = 4.52$ VI = 1.37-15.8	$\bar{A} = 4.86$ VI = 1.9-6.0	$\bar{A} = 22.6$ VI = 6.96-68.3
^{238}U [mBq/kg, L]	$\bar{A} = 8.78$ VI = 3.0-17.0	$\bar{A} = 17.23$ VI = 9.0-31.6	$\bar{A} = 13.8$ VI = 10-21	$\bar{A} = 5.51$ VI = 1.3-8.2
^{235}U [mBq/kg, L]	$\bar{A} = 0.45$ VI = 0.15-0.87	$\bar{A} = 0.88$ VI = 0.46-1.62	$\bar{A} = 0.71$ VI = 0.5-1.0	$\bar{A} = 0.28$ VI = 0.07-0.42

\bar{A} – Median value of activity concentration;

VI – variation interval (span) = min. value – max. value

As it can be seen from the presented results (Table 3), the presence of produced ^{137}Cs radionuclide was determined in the analyzed fish (3.05 Bq/kg) and powdered milk (1.99 Bq/kg) samples. Measured activity concentrations in all tested samples for ^{232}Th were lower than 2 Bq/kg, and activities of ^{235}U were lower than 1 Bq/kg (Mihaljev et al.,2019). However, it should be pointed out that the measured values for activity concentration of ^{137}Cs radionuclide in all tested samples were below maximum allowed values (*Official Gazette of the Republic of Serbia*, No. 36/2018).

Table 4. shows the results of activity concentration for ^{137}Cs , ^{40}K , ^{232}Th , ^{226}Ra , ^{235}U and ^{238}U radionuclides in the tested animal feedstuff samples. Based on the obtained values, it can be concluded that Potassium-40 is the predominant radionuclide in animal feedstuff. Median value of ^{40}K activity was between 52 Bq/kg in mineral feedstuff to 448 Bq/kg in fish flour. Thorium-232 is a metallic, naturally occurring element that is radioactive. Because of its insolubility and very low specific activity, thorium can be found in biosphere in very small amounts. That has been confirmed by our results as well, because in most samples the measured ^{232}Th activity was lower than 15 Bq/kg. Based on the results shown in Table 4., it can be concluded that ^{238}U activity in the

tested samples of fish flour (28.4 Bq/kg) and premix (14.5 Bq/kg) is significantly lower than ^{238}U activity in mineral feedstuff, where it was 486 Bq/kg. In mineral feedstuff, we also measured increased ^{235}U activity of 24.9 Bq/kg (Mihaljev et al., 2019).

Table 4. Activity concentration of caesium-137, potassium-40, thorium-232, radium-226, uranium-235 and uranium-238 in animal feedstuff samples

Activity	Sample type		
	Fish flour (n = 16)	Premixes (n = 14)	Mineral feedstuff (n = 5)
^{137}Cs [Bq/kg, L]	$\bar{A} = 4.08$ VI = 0.6-10.4	$\bar{A} = 1.03$ VI = 0.37-2.8	< 0.5
^{40}K [Bq/kg, L]	$\bar{A} = 448$ VI = 145-583	$\bar{A} = 321$ VI = 99-604	$\bar{A} = 52$ VI = 20.2-80.0
^{232}Th [Bq/kg, L]	$\bar{A} = 1.76$ VI = 0.56-2.61	$\bar{A} = 2.62$ VI = 1.58-3.84	$\bar{A} = 14.0$ VI = 2.43-46.6
^{226}Ra [Bq/kg, L]	$\bar{A} = 4.13$ VI = 1.02-11.0	$\bar{A} = 3.29$ VI = 1.09-9.69	$\bar{A} = 6.57$ VI = 1.36-9.59
^{238}U [mBq/kg, L]	$\bar{A} = 28.4$ VI = 22.3-37.7	$\bar{A} = 14.5$ VI = 5.0-26.0	$\bar{A} = 486$ VI = 32-1474
^{235}U [mBq/kg, L]	$\bar{A} = 1.46$ VI = 1.14-1.93	$\bar{A} = 0.74$ VI = 0.26-1.34	$\bar{A} = 24.9$ VI = 1.65-75.7

\bar{A} – Median value of activity concentration;

VI – variation interval (span) = min. value – max. value

A total of 5 samples of monocalcium phosphate of different geographic origin (Russia, Lithuania, Tunisia, Serbia, Brazil) were tested for presence of radioactive residue. Measured values for activity concentration [Bq/kg] of the tested radionuclides (^{137}Cs , ^{226}Ra , ^{232}Th , ^{40}K , ^{238}U , ^{235}U) in all tested samples were below maximum allowed values (*Official Gazette of the Republic of Serbia*, No. 36/2018). The natural radionuclide U-238, whose activity was between 32 to even 1474 Bq/kg, should especially be pointed out.

Samples of internal organs (kidneys) of different wild bird species, such as: white-tailed eagle (*Haliaeetus albicilla*), stork (*Ciconia*), common buzzard (*Buteo buteo*), Eurasian eagle-owl (*Bubo bubo*), saker falcon (*Falco cherrug*), black-headed gull (*Larus ridibundus*), mallard (*Anas platyrhynchos*), common pheasant (*Phasianus colchicus*), common quail (*Coturnix coturnix*) and common kingfisher (*Alcedo atthis*) were collected from various hunting grounds and forests in Vojvodina. The game that lives in certain geographical areas can be quite good bioindicator of radioactive residue pollution, since they eat unprocessed plant food and their area of movement is connected to a specific habitat. A total of 21 samples of roe deer (*Capreolus capreolus*) urine from different locations in Vojvodina were tested.

Table 5. Activity concentration of caesium-137, potassium-40, thorium-232, radium-226, uranium-235 and uranium-238 in biological material samples

Activity	Sample type	
	Wild bird kidneys (n = 10)	Game urine (n = 21)
¹³⁷ Cs [Bq/kg, L]	< 0.5	< 0.5
⁴⁰ K [Bq/kg, L]	$\bar{A} = 175$ VI = 108-341	$\bar{A} = 253$ VI = 128-381
²³² Th [Bq/kg, L]	$\bar{A} = 1.70$ VI = 0.58-4.93	$\bar{A} = 17.9$ VI = 0.77-106
²²⁶ Ra [Bq/kg, L]	$\bar{A} = 8.63$ VI = 3.56-16.6	$\bar{A} = 22.2$ VI = 4.18-29.3
²³⁸ U [mBq/kg, L]	$\bar{A} = 120.3$ VI = 38.6-463	$\bar{A} = 42.3$ VI = 17.4-232
²³⁵ U [mBq/kg, L]	$\bar{A} = 6.18$ VI = 1.98-24	$\bar{A} = 2.17$ VI = 0.89-11.9

\bar{A} – Median value of activity concentration;

VI – variation interval (span) = min. value – max. value

Table 5. shows average measurement results of activity concentration of natural radionuclides, as well as ¹³⁷Cs in the tested samples of internal organs (kidneys) of different kinds of wild birds, as well as roe deer urine. Based on the results shown in Table 5, it can be concluded that, out of all the elements tested, potassium is present in the largest quantities, both in kidney samples (175 Bq/kg), as well as urine samples (253 Bq/L). In some of the roe deer serum samples, the measured activities of ²³²Th were significantly higher and went up to 106 mBq/L. The highest activity of ²³⁸U was measured in wild birds' kidneys and it was 463 mBq/kg, while in the roe deer urine it was 232 mBq/L. The measured activity concentrations of ²³⁵U in all tested samples were quite low, < 10 mBq/kg,L (Mihaljev et al., 2018).

Determination of Strontium-90

Milk samples were collected from private dairy farms at two-month intervals during 2018/2019. A total of seven samples were collected, whereby each sample implies a composite milk sample for a two-month period. ⁹⁰Sr was determined using extraction method with tri-butyl phosphate as a specific reagent (AOAC, 2012) with addition of inactive Y-carrier. Count speed (imp/s) of annealed Y-oxalate was measured in an anti coincidence system for measuring low-level beta-activity OMNI GUARD, Tracerlab (USA). The strontium-90 activities measured in the tested milk samples were very low and ranged from 5.8 to 11.6 mBq / L.

CONCLUSION

Consistent monitoring of radioactivity levels in agricultural soil is extremely important, because if it is contaminated by wet or dry atmospheric residue, as well as substances with technologically increased level of natural radioactivity, the soil can be a permanent reservoir of radionuclides, that can largely contribute to the radioactive radiation for the inhabitants.

For Serbia, as an area with vast possibilities for production of safe food, the control of radioactive material contents in biosphere is the base parameter that provides maximum radiation safety of the people. Research in this area contribute to better overview of translocation of radioactive residue from soil to plants and certain tissues in humans and animals. From the environment protection standpoint, in order to protect it from harmful effect of ionizing radiation, knowing the paths and ways of transmission of radioactive nuclides through the environment is of essential importance.

By determining the accumulation levels of natural and artificial radionuclides in the organs of wild animals and fishes, as bioindicators of radioactive contamination, as well as in food of animal origin (milk, honey), it is possible to estimate ecological state of geographical areas where the tested samples come from.

The obtained results show that regular control of radioactivity of mineral supplements for feedstuff is necessary, both imported and locally produced. That is a sure way to prevent introduction of radionuclides from anthropogenic sources into the food chain, and with that decrease the share of 'technologically increased natural radioactivity' in the total radiation load of the population.

Also, we can conclude that the inductively coupled plasma with mass spectrometry is a very sensitive method for quantitative determination of very low radiation concentration in the environment, and due to that it can successfully be used as an alternative method.

It is necessary to scientifically determine if there is a direct link between a sharp increase in malignant diseases, depleted uranium and other ecological accidents as a consequence of the bombing of the Republic of Serbia in 1999.

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Жељко Михаљев

Научни институт за ветеринарство "Нови Сад"

E-mail: zelko@niv.ns.ac.rs

РАДИОНУКЛИДИ У ЖИВОТНОЈ СРЕДИНИ И ЊИХОВ УТИЦАЈ НА БЕЗБЕДНОСТ ХРАНЕ И ЗДРАВЉЕ ЉУДИ

Резиме

У раду су приказани резултати гамаспектрометријских испитивања, одређивања специфичне активности ^{90}Sr као и мерења концентрације активности изотопа торијума и уранијума техником индуктивно спрегнуте плазме са масеном детекцијом. Узорци земљишта прикупљени су са локација у Војводини и централној Србији а узорци муља са дна Дунава у реону Новог Сада. Узорци намирница рибе, млечних производа (млеко у праху, сурутка у праху, јаја у праху), меда и меса сакупљени су са различитих продајних места а узорци хране за животиње (рибље брашно, премикси, минерална хранива) из редовне производње. Такође су приказани и резултати одређивања концентрације активности природних и вештачких радионуклида у узорцима унутрашњих органа (бубрега) различитих врста дивљих птица као и у урину дивљачи (узорци срне). Детаљније су разматрани извори контаминације антропогеног порекла, нуклеарни акциденти и њихов утицај на технолошки ланац производње намирница биљног и животињског порекла.

Кључне речи: *радиоактивност, храна, храна за животиње, нуклеарни акциденти*



Sofija Nikolić Popadić

Research Assistant, Institute of Social Sciences Belgrade

E-mail: snikolic@idn.org.rs

USE OF PESTICIDES IN AGRICULTURAL PRODUCTION IN THE EUROPEAN UNION – LEGAL ASPECTS*

Abstract

Inadequate and excessive use of pesticides in agricultural production can pose a significant risk to the environment and human health. In recent years, the European Union has paid special attention to the sustainable use of pesticides in agricultural production. The paper analyzes the problems of implementation of legal regulations on sustainable use of pesticides in the Member States of the European Union. That analysis is also important for Serbia, where the process of harmonization of regulations with the EU law has begun. The procedure for issuing approval for a certain plant protection product, ie the active substance it contains, to be placed on the European Union market has also been analyzed.

Key words: *pesticides, agricultural production, European Union directives, human health*

INTRODUCTION

Producing enough food for a growing world population brings with it numerous challenges. According to the *Food and Agriculture Organization of the United Nations*, the world's population is projected to be above 9 billion by 2050 and over 11 billion by 2100, which will be a significant challenge when it comes to food supply (FAO, 2017, 5). It will be necessary for the production of biomass, food and animal feed to be increased by 50% by 2050 compared to 2012 (FAO, 2017, 46). Changes in the required amount of agricultural products are also reflected in the way of agricultural production.

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Conventional agricultural production, which is today the dominant form of agricultural production, on the one hand contributes to meeting the needs of the population for food, while on the other hand negatively affects the environment leading to land degradation, groundwater and surface water contamination, increases greenhouse gas emissions and contributes to global warming (Rosegrant et al. 2008, 7; Ćikić, Petrović, 2010, 41; Mancini, 2013, 629). The various methods which are used in conventional production in order to achieve higher productivity can have a negative impact on human health. Excessive and inadequate use of pesticides and artificial fertilizers can cause numerous negative consequences. In addition to the direct impact on human health through the consumption of agricultural products, the harmful effects of their application can also affect the state of water, soil and environmental pollution, which can also have a negative impact on the health of the population.

The use of pesticides in agricultural production can pose a significant risk primarily to the health of farmer and consumers of agricultural products. Farmers who directly apply pesticides belong to a very vulnerable group. It is estimated that acute pesticide poisoning affects one in 5,000 agricultural workers annually (IPES-Food 2016, 29). The population located near plots where intensive agricultural production with pesticides is applied is also endangered, especially in the case of aerial spraying (UN Report of the Special Rapporteur on the right to food 2017, 6). The largest part of the population is exposed to potential harmful effects through the consumption of agricultural products that have been treated with pesticides, as well as through the food of animal origin, since feed in conventional production is also produced with use of pesticides (UN Report of the Special Rapporteur on the right to food 2017, 8). Pesticides can lead to poisoning, allergic reactions, skin diseases, asthma, neurological problems, vision impairment, memory loss, Alzheimer's and Parkinson's disease, developmental disorders, hormonal status disorders, sterility, cancer (UN Report of the Special Rapporteur on the right to food 2017, 8; Nicolopoulou-Stamati et al. 2016).

Due to excessive and inadequate use, pesticides can reach groundwater and surface water. According to the 2012 Water Monitoring Report, 20% of groundwater and 16% of rivers in the European Union are in poor chemical status due to the effects of pesticides (European Environment Agency 2012, 56). Poor water conditions exist in 16 member states of the European Union. It is most pronounced in Luxembourg, while water bodies in France, Belgium, Spain, Italy, Germany, the Czech Republic, the Netherlands, Hungary and Romania also have a significant percentage of poor chemical status due to pesticide exposure (European Environment Agency 2012, 56).

In this paper, we will analyze two issues. European Union legislation in the field of sustainable use of pesticides and the procedure for placing plant protection products (and the active substances they contain) on the European Union market. These issues are of great importance in the European Union, especially the process of implementing the directive in the field of sustainable use of pesticides in the Member States, which has proven to be very slow and problematic. These issues are also very important for Serbia, having in mind the started process of harmonization of Serbian regulations with the EU law in this field and the obligations that await the state in the process of joining the European Union.

LEGAL REGULATIONS IN THE FIELD OF SUSTAINABLE USE OF PESTICIDES IN THE EUROPEAN UNION

The negative effects of inadequate and excessive use of pesticides in agricultural production have influenced the adoption of regulations in this field at the level of the European Union. *Directive 2009/128/EC of the European Parliament and of the Council establishing a framework for Community action to achieve the sustainable use of pesticides*, was adopted on 21 October 2009. The aim of the directive is to reduce the risk and impact of pesticides on human health and the environment through the application of integrated pest management, alternative methods, non-chemical means of protection and other measures (Directive 2009/128/EC, Art. 1). It is stipulated that Member States should adopt national action plans which should contain objectives, appropriate measures and time plans that would contribute to reducing the negative impact of pesticides, while encouraging alternative methods of protection (Directive 2009/128/EC, Art. 4). It is necessary for Member States to establish a system for monitoring the use of pesticides, in particular with regard to those containing active substances whose application may cause significant adverse effects (Directive 2009/128/EC, Art. 4). In order to monitor Member States' progress in reducing the risks and adverse effects of pesticide use on human health and the environment, risk indicators need to be defined at European Union level (Directive 2009/128/EC, Art. 15).

The Directive prescribes the basic principles of integrated pest management, which include the control of harmful organisms through crop rotation, appropriate cultivation methods, as well as use of resistant/tolerant cultivars, balanced fertilization, primary application of biological and physical methods versus chemical treatment (Directive 2009/128/EC, Annex III). When using pesticides, it is necessary to respect the threshold levels defined for the region, agricultural crop and climatic conditions, while reducing their use to a minimum (Directive 2009/128/EC, Annex III, 3, 6). A person who uses pesticides should apply adequate measures to protect water from pollution, by forming a protection zone next to watercourses, reduce and avoid the use of pesticides along roads, railways, on watertight surfaces, porous surfaces, etc. (Directive 2009/128/EC, Art. 11). In addition, the user of pesticides should keep records of their use (Directive 2009/128/EC, Annex I, 8)

In order to achieve the objectives set by the directive, professional users, distributors and advisers need to have appropriate knowledge, so the countries need to establish an adequate education system (Directive 2009/128/EC, Art. 5). An appropriate number of persons holding a certificate of acquired knowledge need to be involved in the sale process so that customers can obtain accurate information (Directive 2009/128/EC, Art. 6). In addition, it is necessary to conduct regular inspections of pesticide application equipment in professional use (Directive 2009/128/EC, Art. 8). The directive also prescribes other measures aimed at preventing the negative impact of pesticide application on the environment.

Although the Directive was adopted in 2009, the implementation process in the Member States is not yet completed. Namely, in the report of the European Commission from 2017 on the progress of the member states in the implementation of the

Directive on the sustainable use of pesticides, it was concluded that implementation in practice is not at a satisfactory level. In most member states, the parameters and the manner in which it will be determined whether and in what percentage the goals set by the directive, ie the action plans, have been achieved, have not been determined. Therefore, there are difficulties in perceiving the progress in the implementation of the directive and the need for possible changes of the action plans in certain areas (European Commission 2017, 4). Areas where significant improvements are needed to achieve the objectives set out in the directive are adequate implementation of the systems for gathering information on acute poisoning, as well as the establishment of systems for gathering information on chronic poisoning, more precise and better regulation of aquaculture protection measures (European Commission 2017, 6-7, 10). It was determined that there is a problem of application of integrated pest management in practice. This approach should reduce the use of pesticides. However, although significant progress has been made in educating farmers, economic factors and production results based on this type of protection affect less application in practice (European Commission 2017,13-15).

This conclusion confirms that the financial aspects are the decisive factor in agricultural production. Farmers strive to apply conventional farming methods to provide adequate income. Therefore, it is necessary to provide systemic support that would enable farmers to apply methods that are more favorable for the environment and human health, without significantly affecting their economic position. However, it is necessary to distinguish between the requirements placed on farmers. It is not possible to provide assistance in all cases of deviations from the dominant methods of agricultural production. It is necessary for farmers to give their contribution to the protection of the environment. That is an obligation which is in the public interest. It is also in the interest of the farmer to avoid contamination of land and water and to produce healthy agricultural products.

Areas where there are positive results in the implementation of the Directive on the sustainable use of pesticides are training and certification of professional users, distributors and consultants. Progress has also been made in informing the public about the sustainable use of pesticides and raising awareness of the risks of their application (European Commission 2017, 5, 9-10).

Following the report of the European Commission, on 12 February 2019, the European Parliament adopted a *Resolution on the implementation of Directive 2009/128/EC on the sustainable use of pesticides*. In the Resolution European Parliament also concluded that there is a problem in the implementation of the Directive in the Member States with reference to the conclusions of the European Commission. Progress in promoting innovation and using non-chemical alternatives that are low-risk compared to conventional pesticides has been assessed as insufficient (European Parliament, 2019, 11). It was emphasized that transition towards sustainable agriculture is necessary in order to reduce the contribution to climate change and to provide food security (European Parliament, 2019, 25). Concerns have been expressed about the continuing and potentially irreversible loss of biodiversity in Europe, the alarming decline in the number of winged insects, and the reduction in the number of different bird species, which has been significantly influenced by the use of pesticides.

(European Parliament, 2019, 22). The European Parliament has expressed particular concern about the continued use of pesticides with active substances that are mutagenic, toxic or carcinogenic, or harmful to humans or animals, which use is not in line with the objectives and purpose of the Directive (European Parliament, 2019, 26). The European Parliament called on the member states to complete the implementation of the directive without further delay (European Parliament, 2019, 39).

Applying agricultural practices that deviate from the traditional way of using pesticides in conventional production and turning to sustainable pesticide management is a significant challenge for the Member States of the European Union. Although more than ten years have passed since the adoption of the Directive on the sustainable use of pesticides, the implementation of its provisions is still not at a satisfactory level. From the previous analysis, we can conclude that the process that Serbia will face can be long and complicated. Within the negotiating Chapter 12 *Food Safety, Veterinary and Phytosanitary Policy*, Serbia should harmonize legal regulations with the EU law in the field of pesticide use. So far, only partial compliance of the Law on Plant Protection Products with the Directive on the sustainable use of pesticides has been achieved. One of the new measures which implementation should start from January 1, 2022 is the obligation for a person to have a certificate of training for safe use, handling, storage, transport and disposal of plant protection products in order to purchase a plant protection product that is intended for professional use (Law on Plant Protection Products, Art. 46). It is prescribed that pesticide application equipment must be inspected periodically, in technical and functional terms, and that a risk assessment that may occur during their use must be carried out (Law on Plant Protection Products, Art. 51), which is also one measure of compliance with the Directive. However, it is necessary to emphasize that the harmonization of regulations is not enough. It is only an initial step towards the introduction of changes in agricultural practice. Therefore, the adequate application of regulations in practice is of significant importance.

PLACING OF PLANT PROTECTION PRODUCTS ON THE MARKET IN THE EUROPEAN UNION

Raising awareness of the negative consequences of inadequate pesticide use and changing approaches in agricultural production are very significant. However, the issue of environmental protection and protection of human health from the harmful effects of pesticides can be perceived also from a different perspective, as the availability of plant protection products on the market is a prerequisite for their use in practice.

Regulation (EC) No 1107/2009 of the European Parliament and of the Council of 21 October 2009 concerning the placing of plant protection products on the market, established rules for the approval of plant protection products and active substances. The Regulation contain rules that aim to protect human and animal health, as well as to protect the environment (Regulation No. 1107/2009, Art. 1). Components of the plant protection products must not have a detrimental effect on human health or an unacceptable impact on the environment (Regulation No. 1107/2009, Art. 4). When it comes to obtaining an authorization for a particular active substance, the procedure is

as follows: the producer of the active substance should submit a request to the rapporteur Member State together with documentation containing, inter alia, the results of the research on the application of the substance, after which the competent state examines the request and prepares a draft assessment report, which should be independent, objective and transparent (Regulation 1107/2009, Art. 11). The report should be submitted to the European Commission and the European Food Safety Authority, which will then send it to the applicant and the Member States. The Agency makes the report publicly available (with the possibility of omitting certain parts due to data confidentiality, Regulation 1107/2009, Art. 12), and leaves a deadline for written comments, after which it makes a conclusion based on the latest scientific knowledge. The European Commission submits its assessment report, after receipt of the conclusion by the Agency, to the Standing Committee on the Food Chain and Animal Health for a vote, followed by adoption by the Commission for publication (Regulation 1107/2009, Art. 7-13).

The obtained approval is valid for 10 years, after which it is possible to renew it for a period of 15 or 5 years. The request for renewal of the authorization must be submitted by the producer to the Member State no later than 3 years before the expiry of the deadline (Regulation 1107/2009, Art. 15).

The substance which application has caused numerous controversies is glyphosate. On December 12, 2017, the European Commission renewed the approval for its application for a period of 5 years, ie until December 15, 2022. Germany was the rapporteur country in the procedure of extending the approval. The German Federal Institute for Risk Assessment drafted a report on the health risk reassessment and submitted it to the European Food Safety Authority on 20 December 2013 (EFSA Journal 2015, 2). The report points out the need for a detailed review and evaluation of the results (BfR Communication No 008/2015) published in the 2015 monograph of the International Agency for Research on Cancer of the World Health Organization, in which glyphosate has been assessed as probably carcinogenic to humans and belongs to group 2A (IARC Monograph, 2015, 78). However, a subsequent report by the European Food Safety Authority (EFSA) stated that glyphosate was unlikely to cause cancer in humans and that the evidence was not a basis for listing it as potentially carcinogenic or hazardous substances (EFSA Journal 2015, 1). The Committee for Risk Assessment also assessed that glyphosate should not be classified as a carcinogen according to available data (Committee for Risk Assessment, 2017, 31).

The renewal of the approval for the use of glyphosate has caused numerous debates between scientists and also among the population, which has advocated for a ban on its use. The application for renewal of the approval for the use of glyphosate after 2022 was submitted on December 12, 2019.

CONCLUSION

From the previous analysis, we can conclude that there are two different tendencies in the European Union. Namely, on the one hand, there are requirements for the sustainable use of pesticides in agricultural production, and the desire to apply alter-

native methods of plant protection that do not pose a risk to the environment and human health. Member States have been criticized by the European Union institutions for non-compliance of their regulations and practices with the requirements set by the Directive on the sustainable use of pesticides. The fact that the European Parliament passed a special resolution dedicated to the implementation of the Directive on the sustainable use of pesticides shows how complicated is the situation in this field. On the other hand, the process of approving substances that are an integral part of plant protection products, for which it is not known for sure how much they are or whether they are harmful to human health, takes place almost parallelly. Given that the average implementation of principles and practices related to sustainable pesticide management in EU member states is very slow with various problems, it is necessary that the EU institutions approach the problem of inadequate and excessive use of pesticides from another angle. Preventing the possibility of finding plant protection products on the market which active substances can lead to particularly harmful consequences for human health, such as malignant diseases, can be a type of preventive measure.

The long-standing problems of Member States in implementing the Directive on the sustainable use of pesticides point to the complexity of this field. The existence of regulations is not enough to make changes in a particular area. The experiences of the member states of the European Union should serve as an example for Serbia on its European path. It is necessary to take into account that the harmonization of regulations with the legal regulations of the European Union is only the initial step towards the introduction of changes in practice. When evaluating the level of implementation of directives, the European institutions also require specific results from countries, such as reducing the presence of pesticides in groundwater and surface water. Therefore, it is necessary to pay special attention to the control of the application of regulations in practice, and to the achievement of positive results.

At the end we can conclude that although the legal regulations can direct the activities of persons who use pesticides in agricultural production, it is also necessary to raise awareness of the harmful effects of inadequate and excessive use of pesticides in different ways. In addition to various types of education, it is necessary for information to be available to citizens in everyday life, in order to understand that environmental pollution and impairment of health can be prevented by making different decisions and choices.

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Софија Николић Попадић

Истраживач сарадник, Институт друштвених наука Београд

E-mail: snikolic@idn.org.rs

УПОТРЕБА ПЕСТИЦИДА У ПОЉОПРИВРЕДНОЈ ПРОИЗВОДЊИ У ЕВРОПСКОЈ УНИЈИ – ПРАВНИ АСПЕКТИ*

Апстракт

Неадекватна и прекомерна примена пестицида у пољопривредној производњи може представљати значајан ризик по животну средину и здравље људи. У Европској унији је у протеклим годинама посебна пажња посвећена одрживој употреби пестицида у пољопривредној производњи. У раду су анализирани проблеми имплементације прописа о одрживој употреби пестицида у државама чланицама Европске уније. Оваква анализа је значајна за Србију у којој је започет процес хармонизације прописа са правом Европске уније. Анализиран је и поступак издавања одобрења да одређено средство за заштиту биља, односно активна супстанца коју садржи, буде стављена на тржиште Европске уније.

Кључне речи: *пестициди, пољопривредна производња, директиве Европске уније, здравље људи*

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Tijana Pribičević, Tomka Miljanović, Vera Županec
University of Novi Sad, Faculty of Sciences, Department of Biology and Ecology
E-mail: tijana.pribicevic@dbe.uns.ac.rs

NUTRITION AND FOOD SAFETY TOPICS IN PREVIOUS AND CURRENT BIOLOGY SYLLABI IN PRIMARY SCHOOLS IN THE REPUBLIC OF SERBIA

Abstract

According to the Primary Education Curriculum of the Republic of Serbia Biology is taught from the fifth to eighth grade. Previous syllabi, including some minor changes, were in use for more than fifty years. In these syllabi the contents related to food and food safety, its production, storage and preparation were marginalized, which certainly represented a major shortcoming. New Biology Syllabi for primary schools have been introduced recently. They include more contents related to food storage and preparation, healthy diet and its importance for human health. These topics are included in all grades and cover the segment called Humans and their Health. The new syllabi, however, do not refer to the topic of food safety. This points to the need of including more contents related to food safety in Biology syllabi as it would adjust the syllabi with students' real needs and improve their functional knowledge.

Key words: *primary school, Biology syllabi, contents related to food safety*

INTRODUCTION

A subject syllabus includes the contents that is taught in a certain grade. Previous syllabi for the subject of Biology in our primary schools were in use for more than fifty years and underwent some minor changes during that period. The contents of the syllabi were organized linearly, i.e. in each grade they followed a logically organized order in relation to various biological disciplines. Thus, botanical issues were dominant in the fifth grade, zoology dominated the sixth grade syllabus, the seventh grade contents referred to anthropology, while in the eighth grade an emphasis was on ecology and environmental protection. New Biology syllabi in primary education were introduced in the period 2017-2019. In comparison with the previous syllabi, they have

undergone tremendous changes, both in terms of their concept and the contents taught in all four grades. There are five general topics that appear in the syllabi of all grades: Unity of Form and Function as the Basis for Life; Life in an Ecosystem; Inheritance and Evolution; The Origin and Diversity of Life, and Humans and their Health. The contents of these topics are given a more in-depth insight in each consecutive grade.

The contents related to food safety in earlier and current Biology syllabi in primary schools in Serbia

The aim of the present paper is to analyze the presence of the concept of food safety in previous and current Biology syllabi in primary education in the Republic of Serbia in order to establish similarities and differences in the presence of this content.

The study is of both theoretical and empirical nature and implies the method of theoretical analysis of written documentation including the Biology syllabi and course books used in primary schools in the Republic of Serbia.

RESULTS AND DISCUSSION

The previous Biology syllabus for the fifth grade included the following: Introduction to Biology, Characteristics and Diversity of Living Beings, Plant Kingdom – Form and Living Processes of Plants, Plant Diversity, Importance and Protection of Plants and Kingdom Fungi, Importance of Protection of Fungi (Official Gazette of the Republic of Serbia – Education Gazette 6, 2007). The focus was on fundamental biological concepts, fundamentals of form and function of plants, their systematics and evolutionary development, as well as their endangerment and protection. Thus, the topic Plant Diversity, Importance and Protection of Plants included a lesson on Angiospermae – their Importance and Protection in which students learned about most important families of dicotyledons and monocotyledons, and within them about some species used in plant and animal nutrition. These were species from the cabbage family (cabbage, cauliflower, broccoli, kohlrabi...), then the rose family plants (apple, pear, plum, sweet and sour cherry, peach, strawberry, blackberry, raspberry...), legume family (beans, peas, various sorts of clover...), nightshades (potato, tomato, eggplant, pepper...), asteraceae (sunflower...), grass families (crops such as wheat, barley, rye, oat...) and other grass species eaten by grazing animals. As part of the lesson devoted to Edible plants and herbs students learned about most dominant edible plants, medicinal herbs, spices, industrial plants and weeds. This topic also included a lesson on Cereals where students were given basic information on corn, wheat, oat, barley, rye and rice, in the first place information regarding their nutritional value. All these topics were important for students as these plants are cultivated in our region. Serbia is an agricultural country and these plants can be seen in the nearby fields.

Previous Biology syllabus for the sixth grade included the following topics: Introduction, Protozoa, Animal Kingdom, Animal Endangerment and Protection, and Introduction to Evolution of Living Forms (Official Gazette of the Republic of Serbia – Education Gazette 5, 2008). The topics focused on the structure and function of certain

groups of protozoa and animals (invertebrates and chordates), their systematics and evolutionary development, including basics of organic evolution. Within the topic Animal Kingdom, lessons focused on fish, amphibians, reptiles, birds and mammals, with an emphasis on their role in nutrition of humans and certain animals.

In previous Biology syllabus for the seventh grade the following topics dominated: Origin and Development of Humans, Human Body Structure and Reproductive Health (Official Gazette of the Republic of Serbia – Education Gazette 6, 2009). Seventh graders were introduced to the origin and diversity of man, fundamentals of human anatomy, physiology, hygiene, first aid and reproductive health issues. Thus, the topic Human Body Structure covered lessons devoted to healthy diet and consequences of poor nutrition, including tables of healthy diet, instructing students how to eat healthy and introducing them to the food pyramid, consequences of unhealthy eating and the importance of minerals and vitamins in our diet. There was also a hands-on activity requiring students to create the tables of their daily and weekly diets, paying attention to the caloric values of certain foods. All these topics and activities are important for students' health and acquiring healthy lifestyle. Special attention was paid to the problem of overweight and its health risks.

As for the eighth grade, the previous syllabus comprised these units: Introduction, Ecology and Environmental Protection, Endangerment, Protection and Improvement of Ecosystems and Environment, Global Consequences of Environmental Pollution, Environment and Sustainable Development, and Environment, Health and Culture of Life (Official Gazette of the Republic of Serbia – Education Gazette 2, 2010). These units covered basic ecological concepts, important ecosystems, pollution, protection and improvement of ecosystems and the environment. There were no topics related to food and nutrition.

This part of the analysis was done consulting former Biology syllabi and course books for primary schools (Pribičević et al., 2014; Lazarević et al., 2014; Topić et al., 2014). Based on this analysis, it can be concluded that the contents related to food and nutrition were scarcely represented in the syllabi. This certainly represented one of their shortcomings, as students were insufficiently informed about the topics and issues important for their health and everyday activities.

The new Biology syllabi for primary schools in the Republic of Serbia were introduced in the period 2017-2019. Their concept is completely different in comparison with the previous one. The content is organized spirally, which means that there are five units that appear in each grade, their contents are linked, and deepened and widened in each grade. Healthy diet, food storage and preparation are given more attention in the new syllabi, while the topic of food production is scarcely present. All these topics are included in the unit Humans and their Health in all four grades.

The new fifth grade syllabus, thus, involves a lesson Healthy diet and water and energy drinks consumption (Regulations on the fifth grade syllabus, Official Gazette – Education Gazette 15/2018). The emphasis here is on the importance of regular intake of necessary nutrients. Healthy diet implies the following:

- Daily intakes of food should be balanced with the energy needs of a human organism. Both insufficient and excessive intakes can cause health problems.

- Three main meals and two snacks are required each day. There should be a two-to-three-hour break between the meals.
- Fried and roasted meals, fast food (hamburgers, pizza, doughnuts) should be avoided. Boiled and food prepared with low level of fat and spices should be given priority.

The lesson focusing on the importance of water, the emphasis is on regular intake of water, about two liters daily, for preserving good health. The part on consuming energy drinks that have become very popular among young generation, emphasizes their harmful effect on human health. These beverages cause insomnia, sickness, anxiety, irregular heart functioning, the loss of liquid in the body and addiction. The consumption of energy drinks with alcoholic beverages can cause death. Since all these issues are directly related to students' health, it is important to familiarize the children of this age with them. The presented review is based on the content analysis of the recently published course book for the fifth graders by Pribićević et al. (2018).

As for the six grade syllabus, it comprises a lesson on Pathways of transmission of infectious diseases (Regulations on the sixth grade syllabus, Official Gazette – Education Gazette 15/2018). The emphasis here is on the seriousness of this problem, considering that infectious disease cause death of large number of people. Very often they are transmitted by food. Foods, such as meat, milk and eggs are susceptible to microbial development. Intestinal infectious diseases, as well as some respiratory diseases are mostly transmitted through food. They can also be caused by infected animals or through transporting food from the production site to the consumer. They are transmitted in several ways: by people who produce food with unwashed hands, preparation of food in unclean dishes, irregular transportation and storage, or irregular thermal food processing and preservation. Infectious diseases can also be transmitted by water, air and soil. Their spreading is also caused by certain animals, such as insects and rodents. Students' familiarization with all these issues is of high importance as they are directly related to the preservation of their health. The analysis presented in this paragraph is based on the contents of Biology course book for the sixth grade of primary education by Lazarević et al (2019).

The seventh grade syllabus comprises the units Principles of balanced diet and nutritional disorders and Significance of proper food storage, preparation and hygiene and food poisoning (Regulations on the seventh grade syllabus, Official Gazette – Education Gazette 5/2019).

The unit Principles of balanced diet and nutritional disorders guides students to consumption of variety of foods in order to supply their organism with all necessary nutrients. The quantity of consumed food should be in balance with age, gender, height and weight and physical activity of an individual. The human organism requires regular intake of fats, proteins, sugar, water, vitamins and mineral salts. The lack of any of these for a longer period can cause various diseases. Particular attention should be paid to children's diet as they growth and development are accelerated. Most common disorders caused by improper diet are obesity, anorexia and bulimia. Since obesity is widely spread, this disorder is given a detailed description. It is particularly noticeable

among young generation that sits for long hours in front of computers and TV screens and lacks physical activity. No restriction diet is recommended without consulting a doctor.

The unit Significance of proper food storage, preparation and hygiene and food poisoning emphasizes the significance of proper handling of food for healthy diet. Meat and meat products, milk and dairy products, eggs, fruit and vegetables should be stored in the fridge at the temperature of 4°C for a couple of days, while fresh meat should be stored for no more than two days. For storing food for a longer period of time, the freezer is used at the temperature of -18°C. The storage period is up to three months. Foods such as bread, flour, sugar, potatoes, beans, onions etc. are kept at room temperature, packed in plastic bags or in glass containers out of reach of insects. Their longer storage implies good hygiene conditions and airing. Irregularly kept foods are susceptible to the development of bacteria and fungi and the consumption of such foods can cause certain diseases, such as salmonellosis, infection of respiratory organs and excretion. Referring to food preparation and hygiene, students are informed about the widespread presence of microbes in the soil, water and air, as well as on humans' hands, dishcloths, cutlery, dishes... This enables the transmission of microorganisms and can lead to various diseases. In order to prevent this, special attention should be given to the hygiene of foods and dishes, as well as the spaces where food is stored (larder), prepared (kitchen) and served (dining room). Thermal processing of food (cooking or roasting) destroys microbes that are harmful to our health. The processing at temperatures above 70°C provides food safety. Food kept in the fridge should be tasted before its consumption. The food with plenty of microbes tastes differently (sour taste) and should not be consumed in such a condition. This lesson also focuses on food poisoning. Each room used for food preparation and foods themselves can cause poisoning, particularly in the period of high temperatures. In such conditions food is more susceptible to spoilage, as heat enables proliferation of microorganisms. Food poisoning symptoms are: stomachache and spasms, sickness, vomiting and diarrhea. In case of food poisoning it is necessary to visit a doctor. Familiarizing students with these contents is of great importance as they are given practical knowledge relevant for everyday life. This analysis of the contents is based on the new Biology course book for the seventh grade by Milivojević et al. (2019).

The reformed syllabus for the eighth grade includes an activity of making a poster as part of the unit Effects of unhealthy lifestyle on functioning of organs and organ systems in humans (Regulations on the eighth grade syllabus, Official Gazette – Education Gazette 11/2019).

A group of students is required to explore the effects of healthy and unhealthy diet on the functioning of human organs and systems of organs. The activity comprises two parts:

1. Explore and analyze the significance of healthy diet on normal functioning of organs and systems of organs:
 - Significance of cereals (wheat, corn, rye... for production of bread, pastry and other products of whole-wheat flour),

- Significance of legumes (beans, peas, lentils, green beans...),
 - Significance of green-leaf vegetables (lettuce, spinach, cauliflower, cabbage, broccoli...),
 - Significance of fruit and vegetables,
 - Considering the structure of the above groups of food, what is most important for human nutrition?
2. Explore and analyze bad habits in human nutrition and their effect on organs and systems of organs:
- Harmful effects of consuming fast food (hamburgers, pizza, pastry products, snacks, sweets etc.),
 - Effects of consuming food high in fat, salt and sugars,
 - Effects of unhealthy diet on the function of organs and systems of organs: cardiovascular diseases (high blood pressure), overweight, diabetes, colon cancer and diseases of other organs,
 - Appearance of anemia, rickets and other diseases as a consequence of bad nutritional habits.

Students are instructed to make a poster consisting of two parts: one part includes texts and photos related to the first part of the activity, while the other part of the poster consists of material related to the second part of the activity. They are also required to summarize the main messages of both of the parts and write them at the bottom of the poster.

By completing both parts of this activity, analyzing and comparing the effects of healthy and unhealthy diets on the functioning of human organs and drawing a conclusion makes students understand the significance of good nutrition on human health in an effective way. The present analysis is based on the contents of Biology course book for the eighth grade of primary education by Miljanović et al (2020).

The familiarization of students with the contents related to nutrition and food safety is of great importance as it directly relates to the maintenance of their health. A good aspect is that the presence of these topics is more visible in the new syllabi in comparison with the previous ones. However, even the new syllabi lack more contents related to cereals, fruit and vegetables and various products of both plant and animal origin that are widely used in human nutrition. It is hardly understandable why these issues have not been included in the reformed syllabi. The ideal situation would be that the new syllabi also include the contents from the previous syllabi referring to nutrition and food safety, as this would provide a more comprehensive insight into the topic. Instead of it, the new syllabi mostly focus on the topics related to genetics, evolution and animal physiology which are for students of primary school age very complex and abstract. It would be more effective for the students to learn more about life surrounding them (plants and animals and their mutual relationships, as well as the role of humans), the structure of their own body and the function of certain organs and systems of organs, maintenance of their health, including reproductive health issues as well. The contents related to nutrition and food safety are, from the aspect of health maintenance, also very important.

CONCLUSION

The recently introduced Biology syllabi for primary schools include more contents related to nutrition and food safety than the previous syllabi that were in use for than fifty years. This certainly contributes to higher quality of these new syllabi. Nevertheless, certain issues related to cereals, fruit and vegetables, their production and processing and to various products of both plant and animal origin that are widely used in human nutrition have been excluded from the new syllabi. This gap should be filled in the next reform of Biology syllabi for primary education which should take place in a relatively short period, as biological sciences rapidly develop and the school syllabi should follow this development. The contents related to nutrition and food safety remain equally important as they directly relate to students' everyday life and maintenance of health.

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Тијана Прибићевић, Томка Миљановић, Вера Жупанец
Универзитет у Новом Саду, Природно-математички факултет,
Департман за биологију и екологију
E-mail: tijana.pribicevic@dbe.uns.ac.rs

ПРЕХРАМБЕНА ТЕМАТИКА И ЗДРАВСТВЕНА БЕЗБЕДНОСТ ХРАНЕ У СТАРИМ И НОВИМ ПРОГРАМИМА БИОЛОГИЈЕ ЗА ОСНОВНУ ШКОЛУ У РЕПУБЛИЦИ СРБИЈИ

Резиме

Према Наставном плану за основну школу у Републици Србији биологија је као наставни предмет заступљена од 5. до 8. разреда. Претходни програми биологије за основну школу важили су, без значајниих промена, више од педесет година. У њима су садржаји о храни и њеној здравственој безбедности: њеној производњи, чувању, припреми и значају за здравље људи били минорно заступљени. То је свакако био њихов недостатак. Нови Програми наставе и учења биологије за основну школу усвојени су недавно. У њима је више садржаја о здравом начину исхране, чувању и припреми хране и значају хране за здравље људи. Они се налазе у свим разредима у наставној теми Човек и здравље. У новим програмима биологије ни у једном разреду нема садржаја о производњи и преради здравствено безбедне хране. Зато садржаји о храни и њеној здравственој безбедности треба да буду још више заступљени у програмима биологије у основној школи. Тиме би програми биологије били више усклађени са реалним потребама ученика и доприносили њиховом стицању функционалних знања.

Кључне речи: *основна школа, програми биологије, садржаји о здравственој безбедности хране*

CLIMATE AND SAFE FOOD PRODUCTION



**G. Jovtchev¹, S. Gateva¹, Ts. Angelova¹, K. Katrandzhiev¹, N. Nikolova²,
D. Dimitrov³, Ch. Angelov²**

¹ Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences,
2 Gagarin Street, 1113 Sofia, Bulgaria,

² BEO-Moussala, Institute for Nuclear Researches and Nuclear Energy,
Bulgarian Academy of Sciences, 72 Tzarigradsko Chaussee Blvd,
1784 Sofia, Bulgaria

³ National Museum of Natural History, Bulgarian Academy of Sciences,
1 Tsar Osvoboditel Blvd, 1000 Sofia, Bulgaria
E-mail: gjovtchev@yahoo.de

IMPACT OF UV RADIATION ON THE DNA OF PLANTS AT DIFFERENT ALTITUDES IN RILA MOUNTAIN, BULGARIA – A THREE YEARS STUDY

Abstract

With the increase of altitude the environmental factors change notably. One of these factors is the UV radiation. The plants are constantly exposed to it because of their fixed position. UV radiation is essential for the photosynthesis, but its increased intensity can cause serious damages to some vital cell molecules, such as DNA. Some plants are more sensitive to UV radiation, while others successfully adapt to the changes. The aim of the study was to investigate the effect of UV radiation on DNA of different wild plant species from three altitudes in Rila Mountain, Bulgaria (1500, 1782, and 2925 m a.s.l.) for a period of three years and to compare the effect with that of UV-irradiation in plants grown in controlled laboratory conditions. The evaluation of genotoxic effects (DNA damage) in 7 plant species from 5 families was performed by comet assay. Surface solar radiation downwards and downward irradiation on the surface values were obtained for the growing seasons in the three years period for all the experimental sites. The results showed variation in the sensitivity of DNA from different plant species to UV radiation. It was found that the degree of adaptation depends on the genotype and altitude. Plants of the Poaceae family showed the lowest sensitivity and the highest degree of adaptation than other plants to UV radiation in the natural environment at all three altitudes. The effect is especially pronounced at the highest altitude. The results would contribute to select sensitive species suitable for monitoring or assessment of environmental impact.

Key words: *UV irradiation, mountain sites, wild plant species, genotoxic effect, comet assay*

INTRODUCTION

Ultraviolet radiation (UV) represents a natural source of irradiance as a part of the non-ionizing radiation with an electromagnetic spectrum comprising approximately 8-9% of the total solar radiation (Rai and Agrawal, 2017). Three wavelengths of the natural UV radiation are important: UV-A (320-400 nm), UV-B (280-320 nm) and UV-C, with the shortest wavelength (100-280 nm) (Fig.1). UV-A and UV-B have biological activity, as part of them reach the Earth's surface, while UV-C is completely blocked by the ozone layer and atmospheric oxygen.

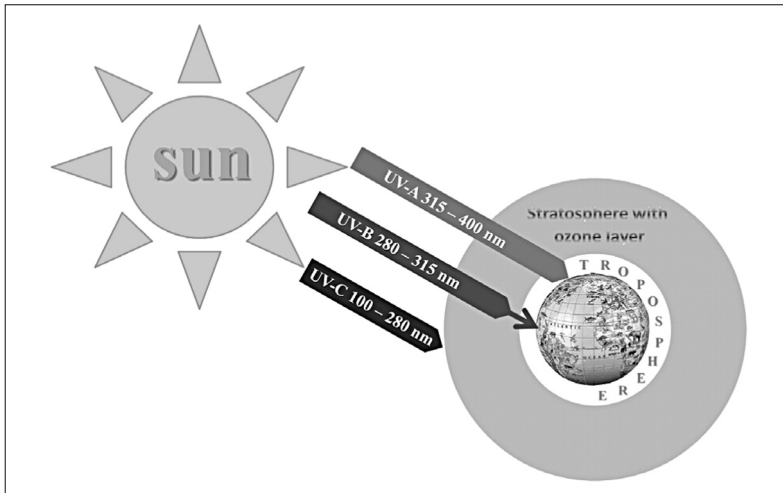


Figure 1. Different types of UV radiation and their biological effectiveness

The stratospheric ozone layer is an efficient filter of the most detrimental UV radiation with a wavelength shorter than 280 nm. The absorbance coefficient of ozone decreases rapidly at longer wavelengths and approaches zero at about 330 nm. Therefore, UV-A radiation is virtually unaffected by changes in ozone concentration. At the Earth's surface radiation between 290-315 nm wavelengths becomes significant (Rai and Agrawal, 2017). A small decrease in ozone layer may cause a large relative increase in biologically effective UV-radiation. For this reason, each 1% reduction in ozone concentration causes an increase of 1.3 to 1.8% in UV-B radiation reaching the biosphere. In the last few decades, a continuous depletion of the stratospheric ozone layer led up to 7% increase in biologically active UV-B radiation in northern mid latitude (Madronich et al., 1998; Yang et al., 2007).

Clouds and aerosols scatter UV radiation. Thin and thick cloud layers differ in their effect on UV radiation. Depending upon the type and height of clouds, light water content and particle distribution, cloud cover can attenuate over 70% of the incident UV-B radiation (McKenzie et al., 2007). Under a cloudless sky, altitude is another

influencing parameter. The quantity of UV radiation passing through the ozone layer is dependent not only on its concentration, but also on the elevation above the sea level.

The wild plant species have evolved under different solar UV-B levels and may have experienced significantly higher UV-B irradiance during course of evolution than current Earth surface UV-B level, because of the lack in the protective ozone column (the total amount of ozone in a column between the Earth's surface and the top of the stratosphere) in the Archean era (3.8–2.5 Ga ago) (Cockell and Horneck, 2001). This UV-B tolerance acquired earlier could explain why plants that are distributed at higher elevations, with a greater UV-B irradiance, are less sensitive to high levels of the UV-B radiation than those at lower elevations (Turunen and Latola, 2005). The plants growing at higher altitude additionally to higher UV-irradiation suffer dehydration and low temperature. Thus way the plants at high altitude are under continuous induced stress by UV radiation and other abiotic factors. The protection strategies developed by the plants at higher elevation include on one hand some morphology changes such as smaller and thicker leaves, by increasing the thickness of the epidermal wall, waxes, leaf hairs, and on the other hand, production of more flavonoids and activation of the antioxidant defense system (Agrawal and Mishra, 2008).

In summary, it can be said that UV-B represents an important environmental stress factor and it has a decisive influence on DNA integrity and metabolism of plants, as well as on the content of photosynthetic pigments, biomass and productivity (Tevini and Teramura, 1989).

The aim of the present study was to investigate aspects of natural UV radiation related to biological effects, namely a DNA damage in different wild plant species characteristic to the ecosystems at different altitudes in Rila Mountain, Bulgaria (1500, 1782 and 2925 m a.s.l.) and to compare the effect with that induced by UV-irradiation in plants grown in controlled laboratory conditions. For this purpose the molecular test-comet assay was used.

MATERIAL AND METHODS

Wild plant species: Plants from three experimental areals at different altitudes in habitats of Rila Mountain, Bulgaria in August–September were utilized.

Three plant species from three families were collected in three consecutive years (2017, 2018, 2019) at the altitudes 1500 m a.s.l. and 1782 m a.s.l.: *Epilobium angustifolium* L. (Onagraceae), *Dactylis glomerata* L. (Poaceae) and *Achillea clusiana* Tausch (Asteraceae).

The following four plant species were collected in 2017 and 2019 on the highest altitude – Moussala Peak at 2925 m a.s.l.: *Festuca valida* (R.Uechtr.) Pénzes (Poaceae), *Saxifraga pedemontana* All. (Saxifragaceae), *Achillea multifida* (DC.) Boiss. (Asteraceae) and *Pedicularis orthantha* Griseb. (Orobanchaceae).

The plant material was stored at 4°C immediately after sampling for further use.

UV parameters: Data for parameters of UV irradiation in the experimental areals, a namely site–downward irradiation (uvb) on the surface and surface solar radiation

downwards (ssrd) of all three examined experimental areas are obtained using the database of European Centre for Medium-Range Weather Forecasts (ECMWF) <https://apps.ecmwf.int/datasets/data/interim-full-daily/levtype=sfc/received> by multi-frequency imaging detectors on meteorological satellites and processed by ArcGIS 10.3 software.

Model plant test-system and laboratory UV-conditions: Five days old plants (*Hordeum vulgare*) were irradiated for periods of 10, 20, 30 and 43 days with a daily UV dose 90 mW.h/m² for 5 hours/day illumination (total accumulated dose 3870 mW.h/m²) in a ventilated container with approx. area 1 m² and solar UV light simulator (UV A light source: UV LED diodes; total installed power 15 W; max emitting wavelength 395 nm; UV B light source: UV fluorescent tube of 8 W; max emitting wavelength 310 nm) (Angelova et al., 2019).

Comet assay: The molecular method comet assay was adapted for the wild plant species mentioned above. After isolation of the nuclei from the fresh leaf material, the suspension was prepared for electrophoresis using the method of Jovtchev et al. (2002; 2019). Comets were examined from slides under 25-fold magnification using a fluorescence microscope equipped with a filter for acridine orange (at 480–490 nm) and a digital camera (Canon, Power Shot A95). The COMET image analysis system CASP (Comet Assay Software Project, www.casp.of.pl) was used for measurement of DNA content in the head and tail of each comet. More than 200 cells from 6 microgels per plant species and experimental area were evaluated. The experiments were duplicated. The values of DNA in tail are presented as (%) mean ± SD.

Statistical data analysis: Statistical analysis of migrated DNA in the tail by comet assay was carried out using two-tailed Fisher's exact test for group comparison of different plant species (Jovtchev et al., 2001).

RESULTS AND DISCUSSION

The values of surface solar radiation downwards (ssrd) and downward irradiation (uvb) were obtained for the growing seasons in the three year period for all the experimental sites (Fig. 2). The amount of ssrd both direct and diffuse that reaches the Earth's surface clearly depends on clouds fraction and aerosol particles in the atmosphere. They can absorb or scatter the solar radiation, decreasing or increasing the downward shortwave radiation at the surface. This amount of radiation could vary during the season and the day. In our study both downward irradiation on the surface and surface solar radiation downwards showed the high values in June/July 2017 at all three altitudes, where ssrd varied within extremely narrow ranges (from 87.2 ± 15.4 to 87.9 ± 15.7 Wm⁻² per day) and uvb varied from 30.6 ± 6.1 to 31.4 ± 5.2 Wm⁻² per day for the respective year.

For the first time we succeeded in adapting and applying comet analysis to test genotoxic effect of UV radiation on DNA of three different species: *E. angustifolium*, *D. glomerata* and *P. orthantha*. In the following two years we were able to adapt 4 further species (*F. valida*, *S. coeruleans*, *A. chusiana* and *A. multifida*) for the use of the

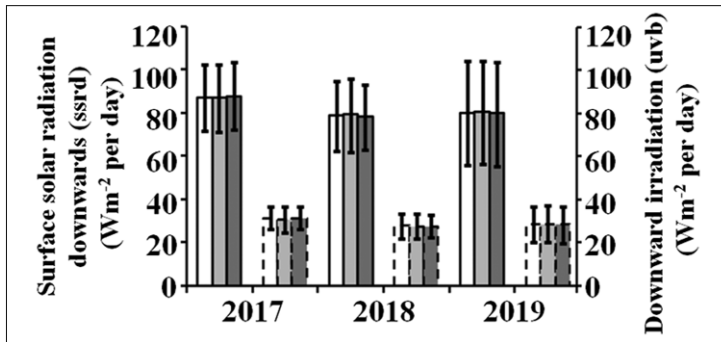


Figure 2. Surface solar radiation downwards (ssrd) are represented by solid-line columns and downward irradiation (uvb) is represented by dashed-line columns

comet assay. The results from three years investigations are summarized in figure 3A. The DNA of *E. angustifolium* grown at 1500 m a.s.l. was more susceptible to damage than the other tested species and had the highest percent of DNA migrated in the comet tail (Fig. 3A). The cereal *D. glomerata* was less susceptible to DNA injuries. The wild plant species can be arranged in the following order according to their sensitivity to UV radiation: *E. angustifolium* > *A. clusiana* > *D. glomerata*.

At 1782 m a.s.l. DNA of *E. angustifolium* also showed the highest sensitivity compared with the other plant species at the same altitude. The order of DNA sensitivity to UV radiation assessed by DNA migrated in the tail was: *E. angustifolium* > *A. clusiana* > *D. glomerata* (Fig. 3A).

Molecular analysis of wild plants growing at 2925 m a.s.l. was carried out on *F. valida* ($11.50 \pm 1.15\%$ tail DNA), *A. multifida* (level of DNA in the tail $10.94 \pm 1.57\%$), compared to *P. orthantha* ($28.33 \pm 1.12\%$ migrated DNA for 2017). At this high altitude the cereal was also less susceptible to injuries than other plant species. *S. pedemontana* (comet tail DNA $10.94 \pm 1.57\%$) also showed low DNA injuries. Thus way, species specificity in terms of sensitivity to UV radiation has been established in plants grown in mountain and alpine areals. Probably different strategies are developed by the plants to overcome stress induced by UV radiation and other abiotic factors.

There have been previous publications on some physiological characteristics of the wild plant species growing at high-altitudinal sites we investigated. Cui et al., (2018) reported the role of photosynthetic pigments to decrease damage effect of UV radiation and other abiotic stress in plants at high altitude. In Poaceae species on the high mountain Qinghai-Tibetan Plateau, China, the chlorophyll content is reduced with increasing the elevation whereas the carotene content increased. On this way the light absorption is limited and photo damage induced by oxidative damage to the chloroplasts is largely prevented. On the other hand Öncel et al., (2004) come to the conclusion that the high carotenoid/chlorophyll ratios in alpine plants were a result of the increase in carotenoid amount, not the decrease in chlorophyll content. Laureau et al., (2015) shows that at the epidermal level, some species synthesize flavonoids, pigments that absorb high-energy UV radiation. This flavonoid screen thus protects the photo-

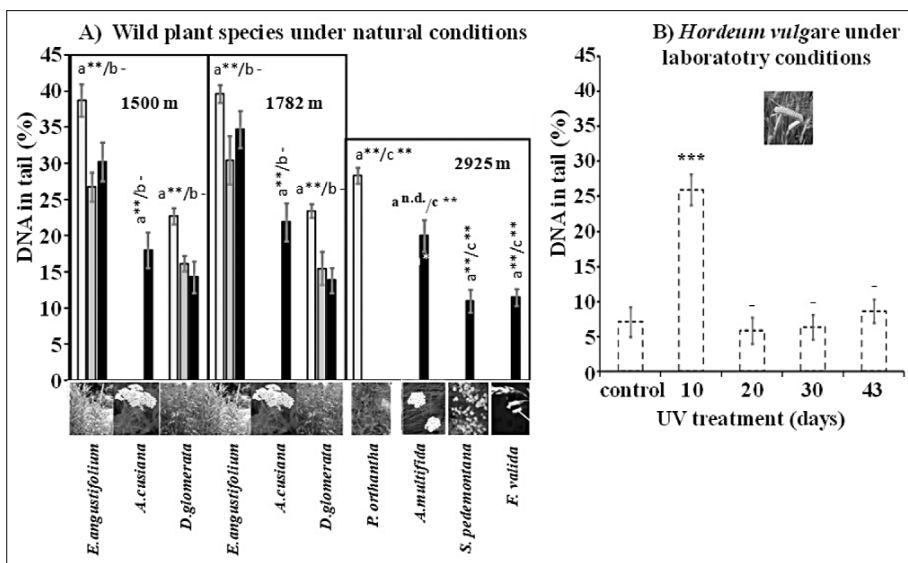


Figure 3. Frequency of DNA damage induced in wild plant species, grown at different altitudes in Rila Mountain (A) compared to *H. vulgare* irradiated under laboratory conditions (B).

A) Significance level: ^a differences between species at the same altitude /cereals versus other grasses/; ^b differences between the same species at different altitudes /cereals versus other grasses/; ^c differences between species at different altitudes /cereals versus other grasses/; n.d. – not done; ** $p \leq 0.01$; – not significant
 B) Significance level in barley leaves: * $p < 0.05$, *** $p < 0.001$, – not significant

systems and prevents the destruction of the DNA of chlorophyll-containing parenchymes. The protection by high flavonoid content is induced by strong light and increases proportional with altitude. The alpine plants, such as some *Achillea* species protect themselves in different ways. One of them increased the essential oil content based on dry weight with increasing the height, and decreased the biomass in higher altitudes (Sardrodi et al., 2014). Tusevski et al., (2010) reported that *Epilobium angustifolium* and *Achillea millefolium* grown at the high altitude in Jablanica Mountain (1500-2000 m a.s. l.) - stretching north-south direction across the border of Albania and North Macedonia develop 50% higher antioxidant activity. According to Munné-Bosch et al., (2016) some alpine plant species from genus *Saxifraga* show an increasing level of α -tocopherol, reduction in lipid peroxidation, and/or changes in reproductive strategy.

Saxifraga longifolia grown at high elevation have developed also certain morphological features that have protective functions (Munné-Bosch et al., 2016). In this context Liu and Osborne, (2015) indicate the following advantages of Poaceae such as stomatal size and densities. These properties make the leaves more adaptive to changing light intensity, as well as to cold and drought.

All of these statements from the various publications support our results.

As a comparison to the results of the wild plant species, we carried out a laboratory experiment with our model test-system *Hordeum vulgare*. In this experiment, the plants were exposed to UV radiation under controlled conditions for 43 days (see Fig. 3b). Unexpectedly, the plants can adapt relatively quickly. After an initial increase in DNA damage after 10 days of UV exposure, the value of DNA migration (DNA in tail) after 20 days of irradiation was close to that of the untreated plants (control level). The higher value of DNA damage observed in wild plants is a result of combined effect of UV irradiation and other abiotic factors.

Exploring more parameters in the future, such as photosynthetic pigments, would contribute to improve our results regarding DNA damage and the adaptability of wild plants to the environmental conditions in the in mountainous and alpine areas.

CONCLUSION

Following the studies of the past three years, it can be concluded that the cereals are less sensitive than other grasses in the natural environment at all three altitudes.

Comparing the model plant UV-irradiated in laboratory conditions with the wild plant species that are exposed to natural environmental factors (UV radiation and other abiotic stresses) it can be said that in both kinds of burden occurs adaptation.

The results would contribute to select sensitive species suitable for monitoring or assessment of environmental impact.

Further studies are needed to understand the mechanism by which different factors interact and induce plant response/adaptation to the changing environmental conditions.

Acknowledgments

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**G. Jovtchev¹, S. Gateva¹, Ts. Angelova¹, K. Katrandzhiev¹, N. Nikolova²,
D. Dimitrov³, Ch. Angelov²**

¹ Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences,
2 Gagarin Street, 1113 Sofia, Bulgaria,

² BEO-Moussala, Institute for Nuclear Researches and Nuclear Energy, Bulgarian
Academy of Sciences, 72 Tzarigradsko Chaussee Blvd, 1784 Sofia, Bulgaria

³ National Museum of Natural History, Bulgarian Academy of Sciences,

1 Tsar Osvoboditel Blvd, 1000 Sofia, Bulgaria

E-mail: gjovtchev@yahoo.de

УТИЦАЈ УВ ЗРАЧЕЊА НА ДНК БИЉАКА НА РАЗЛИЧИТИМ НАДМОРСКИМ ВИСИНАМА НА ПЛАНИНИ РИЛА, БУГАРСКА – ТРОГОДИШЊА СТУДИЈА

Резиме

Са повећањем надморске висине фактори животне средине се значајно мењају. Један од тих фактора је и UV зрачење. Биљке су стално изложене овом зрачењу због свог фиксног положаја. UV зрачење је неопходно за фотосинтезу али његов повећани интензитет може изазвати озбиљна оштећења неких виталних молекула ћелије, као што је ДНК. Неке биљке су осетљивије на UV зрачење док се друге успешно прилагођавају променама. Циљ студије био је да се истражи утицај UV зрачења на ДНК различитих дивљих биљних врста са три надморске висине у планини Рила, у Бугарској (1500, 1782, и 2925 метара надморске висине) током три године и да се упореди ефекат UV зрачења у односу на биљке које се гаје у контролисаним лабораторијским условима. Процена генотоксичних ефеката (оштећење ДНК) извршена је тестом комете код 7 биљних врста из 5 породица. Добијене су вредности површинског сунчевог зрачења наниже и површинског силазног зрачења за вегетационе сезоне у периоду од три године за сва експериментална места. Резултати су показали варијације у осетљивости ДНК на UV зрачење код различитих биљних врста. Утврђено је да степен адаптације зависи од генотипа и надморске висине. Биљке породице *Rosaea* показале су најмању осетљивост и највиши степен адаптације на UV зрачење у природном окружењу од свих биљака на све три надморске висине. Ефекат је посебно изражен на највећој висини. Резултати би допринели селекцији осетљивих врста погодних за надгледање или процену утицаја на животну средину.

Кључне речи: *UV зрачење, планинске локације, дивље биљне врсте, генотоксични ефекат, тест комете*

**SOIL AND WATER AS THE BASIS
OF AGRICULTURAL PRODUCTION**



Zora Lujic^a, Stanko Milić^a, Snežana Jakšić^a, Jordana Ninkov^a, Dragan Milić^b,
Jovica Vasin^a, Milorad Živanov^a

^a Institute of Field and Vegetable Crops, National Institute of the Republic of Serbia,
Laboratory for Soil and Agroecology

^b Faculty of Agriculture, Department of Agricultural Economics
and Rural Sociology, Novi Sad
E-mail: zora.lujic@ifvns.ns.ac.rs

SOIL FERTILITY CONTROL OF STATE OWNED AGRICULTURAL LAND IN VOJVODINA PROVINCE

Abstract

The paper presents the results of soil fertility control of the public land in AP Vojvodina. A total of 514 soil samples were collected in 2018 from the depth of 0-30cm. The majority of the collected samples (70%) had slightly alkaline reaction. Low-humus soil class was found in 54% of the samples, which indicated the need for harvest residue plowing down and organic fertilization, so as to enhance soil humus content and thus preserve soil fertility. The analysis of readily available phosphorus revealed an optimum P content in only one third, while optimum potassium content was found in all of the collected soil samples.

Key words: *soil fertility, humus, Vojvodina Province*

INTRODUCTION

Soil is a natural resource of the utmost strategic importance (Yang et al., 2020). Soil is created by a group of pedogenetic factors: climate, parent material, terrain, organic matter and terrain age (Sekulić et al., 2003). Soil functions are numerous; besides enabling food production and species survival, soil is the habitat of various animals and microorganisms (Yang et al., 2020) and a reservoir of essential nutrients with an important role in the carbon cycle. Soil is considered a non-renewable resource, as the damages, once incurred, can no longer be repaired during an average human lifespan (Yang et al., 2020). Various factors cause soil degradation, among which agricultural intensification, i.e. increase in agricultural production per surface unit,

plays a major role (Kopittke et al., 2019). According to the estimates of the UN Food and Agriculture Organization, the global population will have risen to 9 billion by 2050, thus enhancing human and animal food and fiber requirements by 60% (FAO, 2015). Intensive soil use without the adequate fertilization can significantly reduce soil fertility (Smith et al., 2016). To preserve crop yields and soil quality, a steady supply of essential soil macro-elements must be provided after soil chemical analyses. Excessive mineral fertilization can lead to over-accumulation of nutrients in soils, ground water and plants, thereby turning soil nutrients from plant growth and yield boosters into environment pollutants. The Law on Agricultural Land (Official Gazette of RS No. 95/2018) governing planning, protection, arrangement and use of agricultural land, obliges the owner or user of arable land to control its fertility and record the amount of introduced mineral fertilizers and pesticides.

The paper aims to share the results of quality control of the public land leased to large agricultural producers, in order to prevent inadequate use and preserve soil as a natural resource.

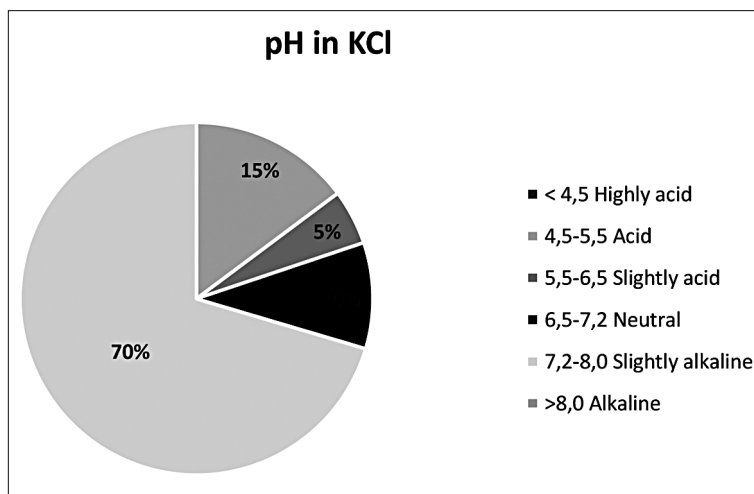
MATERIALS AND METHODS

For the purpose of conducting soil quality control of public land at the territory of AP Vojvodina, a total of 514 soil samples were collected from the depth of 0-30 cm, in 2018. The soil samples were collected using an agrochemical probe, where one average sample was composed of 20-25 individual samples, according to the principles of the fertility control system. Soil samples were analyzed at the Laboratory for Soil and Agroecology, Institute of Field and Vegetable Crops, National Institute of the Republic of Serbia, using the following methods:

- pH-value in soil suspension with potassium chloride
- CaCO₃ content – using the Scheibler calcimeter
- humus content – by the Turin method
- readily available phosphorus – by AL method
- readily available potassium – by AL method

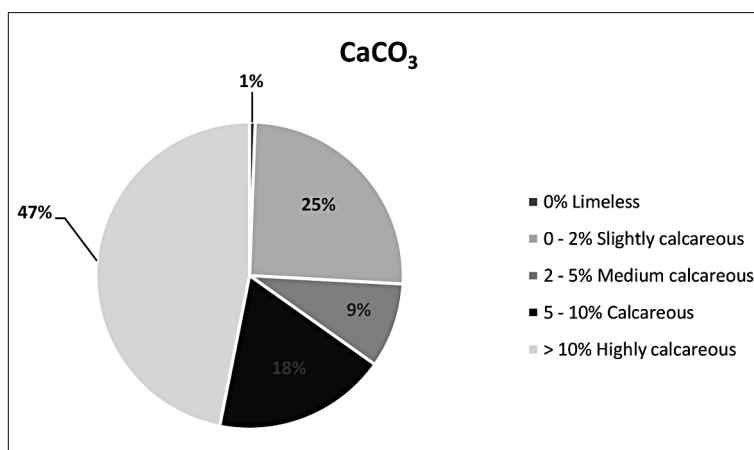
RESULTS AND DISCUSSION

Soil reaction. Soil pH is an important factor of soil fertility control and fertilization. Based on the average results of soil analysis (Table 1.) soil pH value ranged from 4.55 to 7.97, while mean soil pH was 6.98. The values of substitutional acidity of the tested soil samples, as shown in Graph 1, lead to the conclusion that the majority of the soil samples (70%) are slightly alkaline. Prevalence of alkaline soils limits crop production due to higher nutrient (Fe, Mn, Zn) availability in acidic soils, as compared to slightly alkaline or alkaline soils (Deshmuk, 2015). Acidic soils were found in 15% collected soil samples. Crop production favors soils with a neutral pH reaction, observed in only 10% of the analyzed samples. The adoption of microelements allows slightly acidic soils with a pH of 5.5-6.5 (Bogdanović et al., 2004), found in only 5% of the samples.



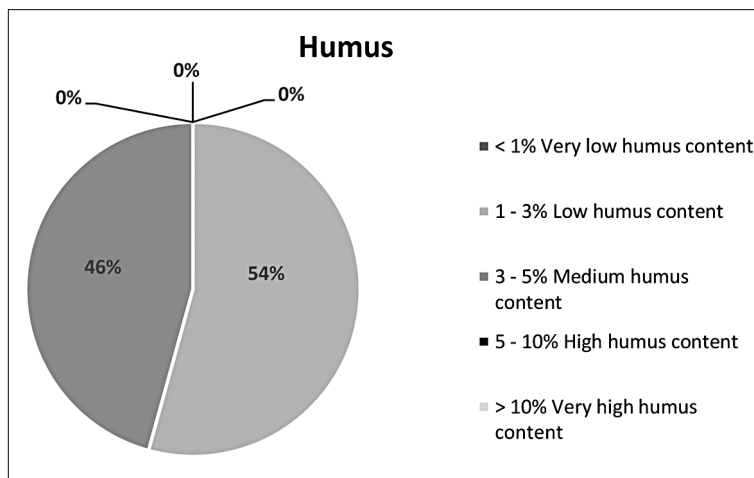
Graph 1. Soil prevalence according to pH value

CaCO₃ content. Analysis of the obtained results in Graph 2 shows that the highest number of samples (47%) belongs to the class of strongly carbonate soils with over 10% CaCO₃. The next most common is soil with a low share of free CaCO₃. The class of low-carbonate soils, with a CaCO₃ content of less than 2%, includes 25% of samples. Calcareous soils make up 18%, medium calcareous 9%, and non-calcareous 1% of the total number of analyzed samples. CaCO₃ negatively affect the uptake of micro-elements by plants, while its positive impact on soil structure decreases in soils with a low content of Ca²⁺ ions (Vasin et al., 2005). The CaCO₃ content (Table 1) ranges from 0 to 23, while the average value is 8.16% for all the analyzed samples.



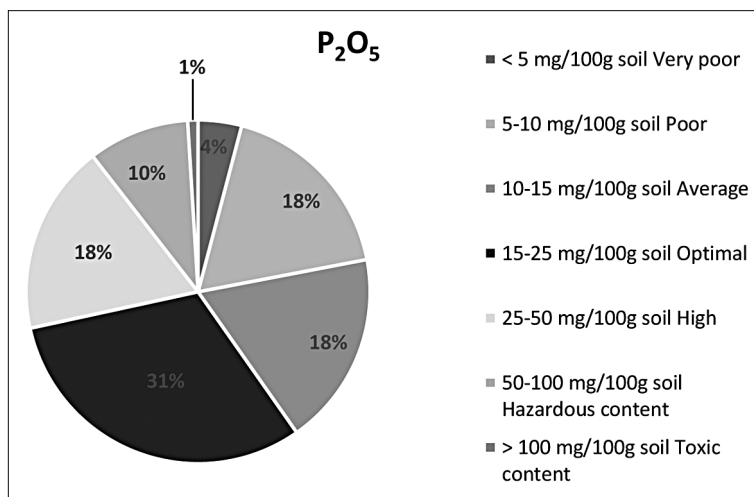
Graph 2. Soil prevalence according to CaCO₃ content

Humus content. Humus is essential for soil fertility preservation because of its favorable effect on the physical, chemical and biological soil properties. Graph 3, containing the results of humus content analysis, shows that as much as 54% of the analyzed soil samples of public land belong to the low-humus soil class. Good soil humus availability was found in 46% of the analyzed samples. The average humus level was at 2.94% for all analyzed samples (Table 1). Low humus availability results from inadequate cultivation practices, insufficient application of organic fertilizers and removal of crop residues (Sekulić et al., 2010).



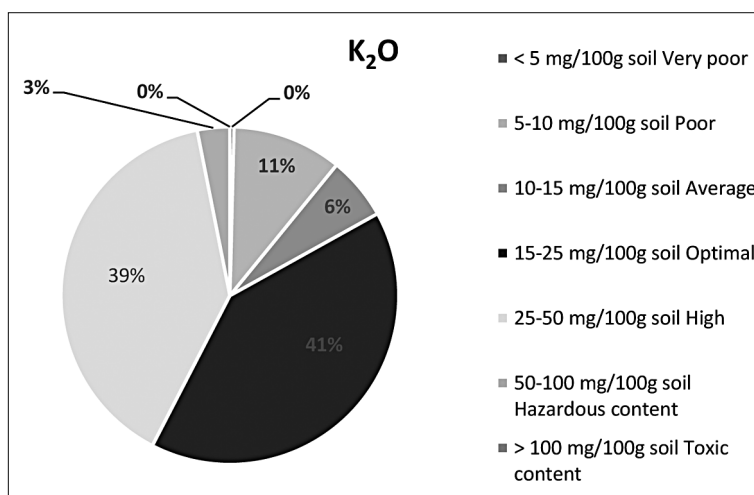
Graph 3. Soil prevalence according to soil humus content

The content of readily available phosphorus. Phosphorus belongs to the group of essential macronutrients, whereby growth, development and reproduction of plants depend on its concentration in the soil (Wagh et al., 2013). According to the average content of readily available phosphorus, which is 23.61 mg / 100 g of soil (Table 1), the analyzed soil samples exhibited an optimal supply of this macronutrient. Of the total amount of analyzed samples, as shown in Graph 4 only 31% belongs to the class with optimal soil phosphorus content for the production of most field and vegetable crops. According to Milić et al. (2011) the same results were obtained from the analysis of privately owned land. A total of 18% of the samples belong to the class with a medium content of readily available phosphorus. What causes concern is that 18% of the samples exhibited low content, while 4% of the samples exhibited very low content of readily available phosphorus. with toxic, very high, or high content of readily available phosphorus, indicates inadequate application of mineral fertilizers or application of fertilizers without prior soil quality control. These classes belong to almost a third of the total number of analyzed samples. Toxic phosphorus content was found in 1% of samples, very high phosphorus content in 10% of samples, and high content in 18% of samples.



Graph 4. Soil prevalence according to the content of readily available phosphorus

The content of readily available potassium. According to the content of readily available potassium, most analyzed samples exhibited an optimum or high content of readily available potassium, as shown in Graph 5. The optimum content of readily available potassium was found in 41% of the samples, while high content of readily available potassium was observed in 39% of the samples, which indicates the influence of pedogenesis in soil formation. The soils of Vojvodina were mostly formed on the



Graph 5. Soil prevalence according to the content of readily available potassium

parent substrate rich in potassium (Vasin et al., 2006). The content of readily available potassium ranged from 3.49 to 73.80 mg / 100 g of soil (Table 1). The difference between the minimum and maximum values indicates the impact of anthropogenic activity on soil quality.

Table 1. Mean values for the analyzed soil samples

Parameter	pH KCl	CaCO₃(%)	Humus(%)	Al P₂O₅(mg/100g soil)	Al K₂O(mg/100g soil)
Average	6.98	8.16	2.94	23.61	24.06
Min.	4.55	0.00	1.16	3.10	3.49
Max.	7.97	23.86	4.52	121.50	73.80

CONCLUSION

The following conclusions can be drawn based on the examination of the main chemical properties of public land at the territory of AP Vojvodina:

– The tested samples predominantly belong to the class of soils with a slightly alkaline reaction. The application of acidic mineral fertilizers is required in order to prevent further alkalization of the soils.

– Prevalence of highly calcareous soils, as a potential limiting factor of agricultural production, indicates a lack of trace elements because their uptake by plants is significantly hampered under such conditions.

– Prevalence of low-humus soils indicates the need for adequate cultivation practices, plowing down crop residues and controlled organic fertilization.

– A relatively high percentage of soils with inadequate content of readily available phosphorus indicates inadequate application of mineral fertilizers.

– The majority of analyzed samples exhibited optimum or high content of readily available potassium

– The results of the study indicate the need for further systematic monitoring of soil fertility status at the examined agricultural plots, in order to preserve the land as a natural resource of national interest.

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**Zora Lujic^a, Stanko Milić^a, Snežana Jakšić^a, Jordana Ninkov^a, Dragan Milić^b,
Jovica Vasin^a, Milorad Živanov^a**

^a Institut za ratarstvo i povrtarstvo, Laboratorija za zemljište i agroekologiju

^b Poljoprivredni fakultet, Departman za ekonomiku poljoprivrede
i sociologiju sela Novi Sad

E-mail: zora.lujic@ifvcns.ns.ac.rs

KONTROLA PLODNOSTI ZEMLJIŠTA U DRŽAVNOM VLASNIŠTVU NA TERITORIJI AP VOJVODINE

Abstract

U radu su prikazani rezultati kontrole plodnosti zemljišta na području AP Vojvodine, koje u državnom vlasništvu. Tokom 2018. godine prikupljeno je ukupno 514 uzorka sa dubine 0-30 cm. Najveći broj uzoraka zemljišta (70%) ima blago alkalnu reakciju, što predstavlja potencijalno ograničavajući faktor u biljnoj proizvodnji. Klasi slabo humoznog zemljišta pripada čak 54% uzoraka, te je neophodno zaoravanje žetvenih ostataka i primena organskog đubriva kako bi se sadržaj humusa u zemljištu povećao, a time sačuvala plodnost. Analizom lakopristupačnog fosfora, utvrđeno je da samo trećina uzoraka ima optimalnu koncentraciju, dok je obezbeđenost zemljišta kalijumom optimalna.

Key words: *plodnost zemljišta, humus, AP Vojvodina*



Ana Tasić¹ MSc, Vladan Ugrenović² PhD, Stojan Jevremović³ PhD

¹ University of Belgrade, History and Philosophy of Science and Technology

² Institute of Soil Science "Teodora Drajzera"

³ Bayer AG

E-mail: ana.tas@live.com

COMPOSTING OF MUNICIPAL ORGANIC WASTE FOR THE PURPOSE OF SUSTAINABLE FOOD PRODUCTION

Abstract

A significant increase in the generation of municipal waste and the limited capacity of the environment have led to invention of new ways to treat waste in order to reduce the amount of its disposal. Organic waste is the most important component of municipal waste and is treated by biological degradation processes, producing useful products such as compost, which has a significant role in food production. Waste composting varies significantly from country to country. Research has shown that the use of compost in agricultural is very important due to its contribution to increasing plants' yield. Also, it provides better availability of nutrients for a long period of time.

Key words: *waste generation, organic waste, composting, food production*

INTRODUCTION

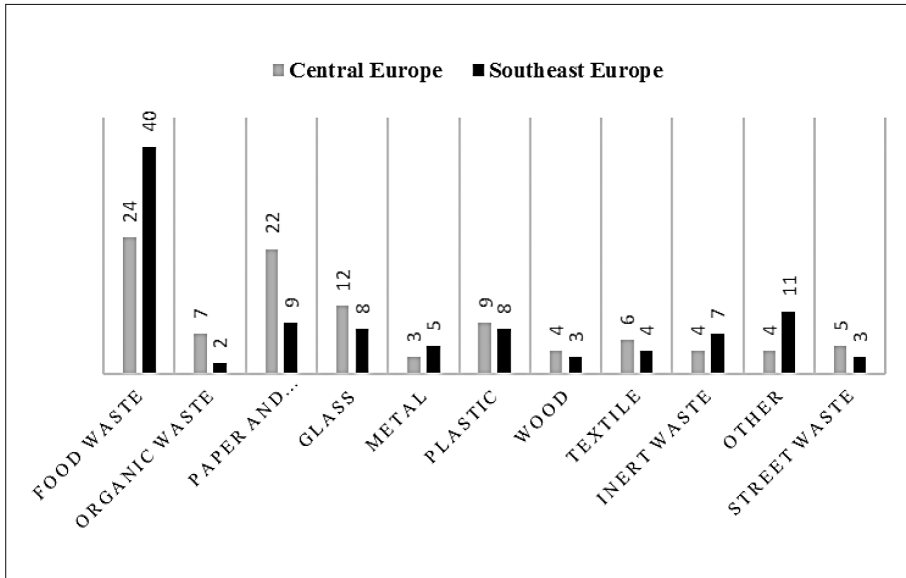
Waste generation begins with the development of human activities. Formation of settlements, beginning of the communal activities and demographic expansion greatly affect the problem of waste accumulation and thus begins to significantly affect the environment. The largest component of municipal waste is organic waste. Observing the data from the Organization for Economic Cooperation and Development (2005) and the European Environment Agency (2016) during the second half of the 20th century and the beginning of the 21st century, one could notice growth trend of generating household and municipal waste. Unlike during the 1990s, in the year of 2004 countries that generated more than 400 kg per capita of waste were no longer a rarity in Europe

and as many as eight EU Member States exceeded 600 kg per capita (EEA, 2016). The highest amount of waste recorded in 2004 was 737 kg per capita in Ireland, while the smallest was in Serbia 233 kg per capita (EEA, 2016). In 2018 members states of the EU on average generated 489 kg per capita of municipal waste (EC, 2019, a). Although the total amount of generated waste in certain years varies, in Serbia growth trend was also recorded. (RZS, 2019). According to the World Bank (2018) 2.01 billion tons of municipal solid waste is generated in the world today. It is estimated that, due to population growth and urbanization, the total amount of waste in the world will increase by 70% in 2050 and will reach 3.4 billion tons (World Bank, 2019b). It is necessary to take steps to reduce and prevent the impact of the generated waste on the environment. Generating and landfilling of large amounts of waste could lead to an ecological imbalance and a limiting self-purification ability of the environment. Acceptable solution for this upcoming problem could be recycling of the waste.

ORGANIC WASTE AS A MAJOR COMPONENT OF THE MUNICIPAL SOLID WASTE

Organic material stands out as a significant component of municipal solid waste. One could notice that during 1980s the majority of municipal waste in Europe was composed of biodegradable waste. The largest percentage of organic waste was recorded in 1985 in Greece with a total share of 58%, followed by Denmark with 55%, the Netherlands with 54% and 53% collected in 1980 and Spain with share of 52% measured in 1985 (OECD, 2005). During the last decade of the 20th century minor changes in the trend occurred. The major share in total waste still has organic waste, especially in countries such as the Netherlands (52% in 1990 and 41% in 1995), Spain (49% and 44%, respectively in 1990 and 1995), Greece (49% in 1995) and Belgium (45% in 1990 with a significant decline to 18% in 1995). More than 30% of the organic waste during the 1990s was also recorded in Poland, Portugal, Hungary, Finland and Switzerland. Some changes of the share of the organic waste could be noticed at the beginning of the 21st century. In some countries that percentage still exceeds 40% such as Spain, Hungary, and the Netherlands. In most countries, the share of biowaste is still above 30%, while a slightly smaller share have Belgium (22%), Austria (23%) and Ireland (24%). During the observed period, it could be noticed that although the amount of biowaste varies, the share of organic waste in municipal waste decreases. However, biodegradable waste is still the substantial component of the collected municipal waste. Thus, in Denmark in 2015 the largest percentage of household waste was organic waste, with the share more than 42% (Edjabou et al., 2015). According to Yildiz et al. (2013) in the European part of Istanbul, at three transfer stations where municipal waste is collected, 54.45% of total amount was made up of organic waste. For case studies of municipal solid waste composition Ionescu et al. (2013) selected two regions according to the level of the development of waste management system. The two regions, Dambovită in southern Romania and Trentino in northeastern Italy, represented similar regions of Southeast and Central Europe. The differences in the

composition of the collected waste are shown in Graph 1. It can be noticed that the largest share of solid municipal waste is biodegradable waste, such as food waste and organic waste, followed by paper and cardboard, glass, plastic and others.



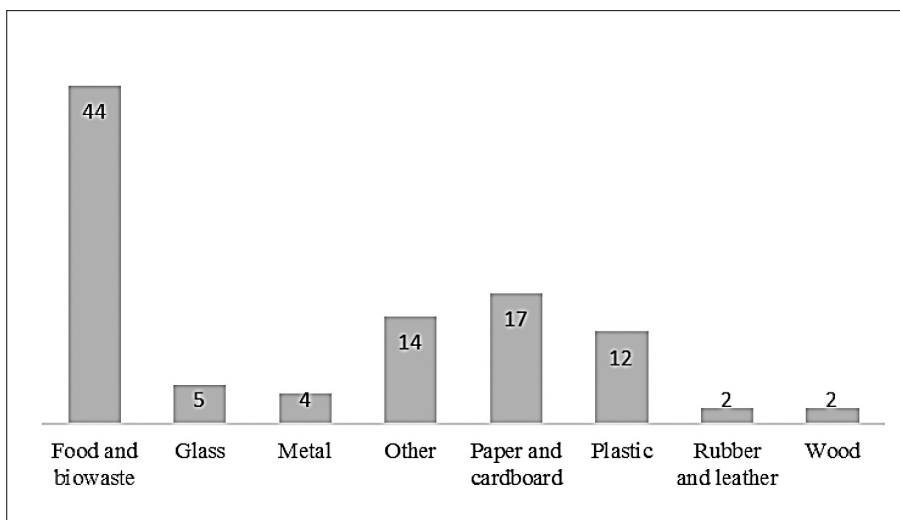
Graph 1. Composition of municipal solid waste in Central and Southeast Europe (Ionescu et al., 2013)

Data from the World Bank (2018) show that biowaste and food waste are predominant at the global level, with a share of 44%, followed by paper and cardboard (17%) and plastics (Graph 2). The same research concludes that differences in the composition of waste are influenced by the economic development of the country. The share of organic matter in the total amount of waste decreases with the raise of income.

The World Bank (2012) estimates that by 2025 the composition of municipal solid waste will partially change. In high-income countries, the composition of municipal solid waste will remain almost unchanged, while in other countries there will be a slight decrease in the share of organic waste in the total amount of municipal waste.

The research conducted by the Faculty of Technical Sciences in Novi Sad (2009) indicates that the morphological composition of municipal solid waste in the Republic of Serbia is similar to composition of waste in other European countries. Biodegradable waste (30.96%) has the largest share in the total amount of municipal waste, and together with garden waste (11.88%) predominates in the solid municipal waste.

Determining the composition and characteristics of municipal waste directly influences decision-making process in the waste management and effects the selection of waste treatment.



Graph 2. Waste composition at the global level (World Bank, 2018)

BIOLOGICAL WASTE TREATMENT AND THE IMPORTANCE OF COMPOSTING THE ORGANIC WASTE

Biological waste treatment is a type of treatment that most resembles natural processes. In fact it is the decomposition of biodegradable organic waste, in the presence or without the presence of air, in order to obtain useful materials such as compost, used for soil improvement (Law on Waste Management, 2018). During aerobic process composting occurs. The main role in the decomposition of waste and its conversion into usefull by-product of cellular metabolism have microorganisms such as bacteria, fungi, yeasts and actinomycetes. It is necessary to provide certain environmental conditions such as temperature, humidity, pH, absence of toxic substances and continual mixing or turning of the compost pile. After decomposition, the product is transported, stored and prepared for placing on the market (Ilić & Miletić, 1998).

According to Border (2003) composting is the main tretamant for organic municipal waste in EU. However, it use varies significantly from country to country. One should notice that countries that use biological waste treatment collect waste sorted at the source, while countries with conventional collection systems don't use this treatment. (Border, 2003)

Composting is a controlled bio-oxidation process of decomposing solid heterogeneous organic matter. The Law on Waste Management (2018) defines it as "treatment of biodegradable waste affected by microorganisms, in order to create compost, in the presence of oxygen and under controlled conditions." This aerobic thermophilic microbiological degradation includes organic matter such as manure, plant residues, food residues (Škobalj, 2008). The composting process releases oxygen and creates carbon dioxide, water and stabilized organic matter (Ilić & Miletić, 1998). Depending

on the climate of the observed area, it could be obtained from about 350 kg to about 500 kg of compost from a ton of municipal waste (Škobalj, 2008). The main product of composting is indeed humus, mineralized nutrients that are suitable for plant nutrition and do not harm the environment. The characteristics of humus depend on: the decomposing material, especially suitable is unpolluted organic matter such as waste from parks and gardens, the conditions under which composting takes place and the degree of decomposition (Ilić & Miletić, 1998).

The main advantages of composting are (Škobalj, 2008): the production of matter that is used for soil quality improvement, compared to other waste treatment methods it may be more economically and environmentally acceptable and biological decomposition of hazardous waste and disinfection of pathogen-infected waste.

Composting as a waste treatment is an excellent alternative to incineration or landfilling of organic materials since the obtained product is useful, especially in agriculture and is suitable for soil. Although increasing amount of attention is being paid to composting, process development varies from country to country. Some European countries such as the Netherlands, Denmark, Austria, Germany at the beginning of the 21st century treated more than 50% of organic waste by composting (Table 1), while other countries (eg France, Italy) treated less than 5% of waste. On the other hand countries such as Greece, Ireland, Portugal and Spain did not use composting as an organic waste treatment (Border, 2003). In the 1990s in the EU 29 kg per capita of organic waste was composted, whereas in 2018 83 kg per capita was treated with the same method (EC, 2019, b). This clearly indicates a growth trend.

Table 1. Composting of separately collected organic waste in some EU member states at the beginning of the 21st century (Border, 2003)

Country	Treatable organic waste (10 ³ t/year)	Treated organic waste (10 ³ t/year)	Recovery rate (%)	Compost production (10 ³ t/year)
Germany	9000	4000	45	2000
The Netherlands	2000	1800	90	650
Austria	2200	1100	50	500
Denmark	900	500	55	250

USEGE OF COMPOST IN AGRICULTURAL PRODUCTION

The use of compost in modern agricultural production is extremely important (de Bertoldi et al., 1996). Compost enriches the soil with organic matter (Soumare et al., 2003), affects its quality (Amlinger et al., 2007). In addition increases the yield of numerous field crops and vegetable plant species (Shiralipour et al., 1992; Ikanović and Popović, 2020). According to Bauduin et al. (1987) the use of 27.5 t ha⁻¹ of compost led to a significant increase in rye yield compared to the control (without compost).

Different amounts of compost, manure and mineral fertilizers were applied individually and in combinations during 3 years in the corn crop. All variants in which compost was applied had as a result a higher amount of nitrogen, phosphorus and potassium, as well as a higher yield of maize compared to untreated plots (del Zan et al., 1987). The application of 27.5-110 t ha⁻¹ compost for 3 years in the pea and potato crop led to an increase in the yield of these crops (Purves and MacKenzie, 1973), whereas the application of 16.5 and 33 t ha⁻¹ compost led to an increase in cucumber yields of 17.6 and 20.6% compared to untreated plots (Manios and Syminis, 1988).

In addition to being used as a natural fertilizer for the soil and an additive in plant nutrition in agricultural production, compost also has the ability to gradually release nutrients over a longer period of time, thus preventing excessive accumulation of nutrients in the soil, ie. pollution of the environment (Zhimang et al., 2011). Sullivan et al. (2003) proved that a single use of high amounts of compost (155 t ha⁻¹) has a long-lasting fertilization effect. Namely, nitrogen from compost is released during the period of 7 years. In addition to nitrogen, compost can be a significant source of phosphorus. Evanylo et al. (2008) found that the application of compost in the amount of 144 t ha⁻¹ increases the availability of phosphorus in soil by 225%.

CONCLUSION

Solid waste management is a management system that includes the activities and actions aimed to reduce and possibly eliminate waste from the environment, ie. to apply the strategy of reducing the amount of waste landfilling and achieving the "zero waste" goals. An important step in planning is the composting of the organic part of municipal solid waste. It has a significant role in sustainable development, as it reduces the landfill disposal of biodegradable waste. Also, in controlled conditions participates in reducing the greenhouse gases emissions, thus reducing their impact on the environment (Law on Waste Management, 2018). Composting, as a waste treatment, attracts considerable attention, because various types of microorganisms have the ability to transform organic matter, through their metabolism, into not only harmless but also useful products, especially for agricultural production. Compost has the ability to provide higher crop yields on treated plots and thus provide more food for the population. Positive effects in the production of rye, corn, peas, potatoes, cucumbers have been proven. Also, the use of compost provides a long-lasting effect of fertilization.

Composting of organic waste is useful both for the environmental protection (by reducing the use of land for solid waste landfilling or by reducing the uncontrolled emissions of greenhouse gases) and for improving soil properties and food production, which reflects its importance for society and sustainable development.

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мр Ана Тасић^{1*}, др Владан Угреновић², др Стојан Јевремовић³

¹ Универзитет у Београду, Историја и филозофија
природних наука и технологије

² Институт за земљиште "Теодора Драјзера"

³ Бајер д.о.о.

* Одговорни аутор; E-mail: ana.tas@live.com

КОМПОСТИРАЊЕ КОМУНАЛНОГ ОРГАНСКОГ ОТПАДА У ЦИЉУ ОДРЖИВЕ ПРОИЗВОДЊЕ ХРАНЕ

Резиме

Значајан пораст генерисања комуналног отпада и ограничен капацитет животне средине довели су до проналажења начина третирања отпада како би се смањила количина депоновања истог. Органски отпад, као најзначајнија компонента комуналног отпада, третира се биолошким методама, чиме се добијају корисни производи као што је компост, који има значајну улогу у производњи хране. Компостирање отпада значајно варира у појединим државама. Истраживања су показала да је употреба компоста у пољопривредној производњи од изузетне важности и доприноси повећању приноса биљних врста, као и бољој доступности нутријената будући да их ослобађа у дужем временском периоду.

Кључне речи: генерисање отпада, органски отпад, компостирање, производња хране



**M. Sc. Dusan Stevanovic¹, M. Sc. Bratimir Nestic², M. Sc. Predrag Umicevic²,
B. Sc. Nenad Nestic³, B. Sc. student Luka Nestic², M. Sc. Nemanja Petrovic¹,
M. Sc. Natalija Totic¹, B. Sc. Dusan Milincic¹, B. Sc. Aleksandar Aleksic¹**

¹ Academy of Technical-Educational Vocational Studies – Department,
Nis, Serbia

² University in Nis, Occupational Safety Faculty, Nis, Serbia

³ City Administration, Krusevac, Serbia

E-mail: bratimir@gmail.com

POTENTIALS OF COMPOST BASED PRODUCTS FOR ORGANIC AGRICULTURE

Abstract

In organic agricultural production, compost is very often used. Composting is recommended in organic agriculture as an agrotechnical measure, primarily for the treatment of waste generated in plant production and from households, but also for the control of weeds, pests and diseases. Compost serves as a growth agent or as a porous, absorbent material, which retains moisture and soluble minerals, providing protection for the nutrients necessary for the growth of most plants. To accelerate plant growth, it is sometimes necessary to dilute the compost by combining it with soil or peat, to reduce salinity, add neutralizers to reach pH = 7, or supplements such as fertilizers, wetting agents and materials that improve drainage and aeration, such as which are sand, gravel, sawdust, vermiculite (hydrated silicate), clay granules, etc. The paper presents a literature review of the potential of compost products for possible application in organic agriculture.

Key words: *potential, compost products, agriculture, food*

INTRODUCTION

In short, waste can be defined as material that has been used and discarded as worthless or unwanted. A synonym for biodegradable waste is organic, and it actually means that it is waste that can be biodegradable, aerobically or anaerobically. About 1.3 billion tons of organic waste is collected in Europe every year, and if about 700 million tons of agricultural waste are added to that, it is clear why waste management is becoming one of the main activities that should contribute to reducing the negative

impact on the environment. In many countries today, there are obligations to reduce the amount of biodegradable municipal waste (BMW), which also applies to landfills, due to lack of available space, but also growing concerns about climate change [1]. In countries such as Austria, the Netherlands and Denmark, very little of this waste ends up in landfills, and a "waste-free strategy" is increasingly being adopted in Europe.

APPLICATION OF PRODUCTS BASED ON COMPOST

Composting is an aerobic process where different microbial populations gradually perform the process of organic matter transformation with simultaneous synthesis of humic substances, and the physical and chemical properties of the starting materials determine the further course of the process [2].

By accepting waste as a resource that can be used for useful purposes, serious environmental problems could be prevented and at the same time a quality product can be obtained that can be used as a feed in plant production and for land and landfill reclamation. Numerous studies also indicate the possibility of obtaining compost products that also have positive effects on soil fertility, control of plant diseases, germination of plant species, etc. Compost is a raw material for obtaining liquid compost products: compost extracts and compost tea. The terms "compost extract" and "compost tea" were used interchangeably. However, in some works, compost extract and compost tea are considered separate products. The term "compost extract" is used in the literature to define aqueous extracts prepared using a number of different methods [3]. Extracts, as compost products, consist mainly of enzymes, hormones and soluble nutrients. Extracts increase plant growth by improving soil structure, soil nutritional value and retaining water capacity.

Leachate from compost also contains large amounts of plant nutrients and can be used as a liquid fertilizer, but also as a dilute solution to avoid damage to plants [4]. Therefore, the quality of the compost extract depends on the origin, quality and quantity of water added. There is strong evidence that the use of compost tea also produces measurable benefits. These effects depend on the quality of the compost used to make compost tea. The terms: compost extract, aqueous fermented compost extract, soaked compost, improved extract and compost liquid manure have, in the past, referred to fermentation without the use of aeration. "Compost extract" [5], "aqueous fermented compost extract" [6] and "soaked compost" [7] are approximate synonyms defined as a volume ratio of 1: 5 to 1:10 of compost and water, fermented without mixing on room temperature over a period of time. "Improved extracts" are compost extracts that are fermented with the addition of nutrients or microorganisms before application [6]. The term "compost liquid manure" refers to non-aerated compost teas before the filtration process [8]. Today, compost extracts are increasingly referred to as "filtered compost" products mixed with any solvent (usually water) but not fermented [3].

Compost tea is a term used in the scientific community (in the USA and Europe) to denote a filtered compost product fermented in water [3,9,10]. Compost teas are obtained by re-circulating water through loose compost or a porous bag or compost box hung above or inside a tank to maintain aerobic conditions [10]. The product obtained

by this method is also called "aerated compost tea" and "organic tea". The methods used in the production of compost tea can be divided into two groups: with the use of aeration or without the use of aeration. Aeration systems involve the continuous addition of air, with shorter production times (usually 24 hours). There are many patents that apply this production method. The addition of nutrients (molasses, soluble seaweed, rock powder) is often used in these systems, with the aim of increasing the number of microbial populations. In production methods where aeration is not applied, the mixture is not mixed or is minimally mixed after the initial mixing [3], and the concentration of dissolved oxygen in the extract falls below 5.5 ppm.

Compost tea also contains nutrients from various organisms and can be applied to the soil or directly to crops. In this sense, compost teas are considered as a potential alternative to the use of synthetic chemical fungicides, as well as being a means of controlling plant pathogens that are considered safer for health and the environment. There is evidence that the Romans used compost teas, and the ancient Egyptians used preparations based on compost extracts 4,000 years ago. Interest in compost teas has declined with the introduction of pesticides in the 20th century, as pesticides generally provide better, more reliable control of most leaf diseases (foliar diseases). However, the recent increase in the use of sustainable and organic production methods, together with problems related to the application of pesticides, have led to an increase in the number of scientific papers and publications on compost teas [10].

Increasing attention in the world is paid to the problems related to the use of harmful chemicals in the control of plant diseases. Also, pathogens become resistant to pesticides, which increases the concentration of pesticide application, which causes increased environmental pollution and disturbed ecological balance. In sustainable agricultural systems, non-renewable petrochemical resources should be replaced by biologically renewable resources [11].

Numerous studies have examined the ability of compost tea to control plant diseases, but there is little data on the possible influence of certain factors related to the production process, such as extraction time, aeration, temperature and pH, on tea quality [12]. By composting food and grass residues, most leachate is separated. Microorganisms, mainly bacteria and fungi, play a crucial role in providing nutrients for plants. Composts and compost extracts activate genes for resistance to plant diseases that arise in response to the presence of pathogens. They trigger chemical defense mechanisms against pathogen invasion, although it is often too late for the disease to be avoided. In plants growing in compost, these disease prevention systems are probably already activated [13].

Research on compost teas in relation to their development and application in the control of fungi of plant pathogens such as potato blight has been performed. It was found that the main factors influencing the efficiency and maturity of compost: extracts obtained from more mature compost are more efficient than those obtained from younger compost and the properties of the ingredients of the original raw materials [9].

Numerous studies indicate the ecological and economic justification of the use of compost in the control of plant diseases, but it should be borne in mind that the use of compost can not eliminate the use of fungicides but can contribute to reducing their use.

The current trend in food quality that does not tolerate pesticide residues in fresh fruits and vegetables encourages the use of biological, ie, non-chemical pest and disease control agents [14].

CONCLUSION

It should be borne in mind that the safe use of these products in agricultural production, and having in mind the starting material, implies chemical and microbiological characterization of the product. The tested compost products, due to their nutritional value, diversity of microbial populations, safety in terms of potentially pathogenic bacteria, antagonistic effect against some phytopathogenic fungi, have significant potential for use in modern agricultural production and at the same time contribute to waste management and environmental quality.

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**M. Sc. Dusan Stevanovic¹, M. Sc. Bratimir Nestic², M. Sc. Predrag Umicevic²,
B. Sc. Nenad Nestic³, B. Sc. student Luka Nestic², M. Sc. Nemanja Petrovic¹,
M. Sc. Natalija Tasic¹, B. Sc. Dusan Milincic¹, B. Sc. Aleksandar Aleksic¹**

¹ Academy of Technical-Educational Vocational Studies – Department, Nis, Serbia

² University in Nis, Occupational Safety Faculty, Nis, Serbia

³ City Administration, Krusevac, Serbia

E-mail:bratimir@gmail.com

ПОТЕНЦИЈАЛИ ПРОИЗВОДА ОД КОМПОСТА ЗА ОРГАНСКУ ПОЉОПРИВРЕДУ

Абстракт

У органској пољопривредној производњи компост се врло често користи. *Компостирање се препоручује у органској пољопривреди као агротехичка мера, првенствено за третирање отпада насталог у производњи биља и из домаћинства, али и за контролу корова, штеточина и болести.* Компост служи као средство за раст или као порозни, апсорпциони материјал, који задржава влагу и растворне минерале, пружајући заштиту нутријентима неопходним за напредовање већине биљака. Да би се убрзао раст биљака, понекад је неопходно разблажити компост сједињујући га са земљом или тресетником, ради редукције салинитета, додају се неутрализатори ради достигања рН = 7, или суплементи као ђубриво и гнојиво, влажни агенси и материјали који побољшавају дренажу и аеризацију, као што су песак, шљунак, струготина, вермикулит (хидрозни силикат), грануле од глине, итд. У раду је дат литературни преглед потенцијала производа компоста за могућу примену у органској пољопривреди.

Кључне речи: *потенцијал, производи компоста, пољопривреда, храна*



M. Sc. Predrag Umičević¹, Ph. D. Nenad Zivkovic¹, M. Sc. Bratimir Nesic¹, B. Sc. Nenad Nesic², B. Sc. student Luka Nešić¹, B. Sc. student Nikola Kostic¹

¹ University in Nis, Occupational Safety Faculty, Nis Serbia

² City Administration, Krusevac, Serbia,

E-mail: bratimir@gmail.com

COMPOST AS A PRIMARY BASIS FOR SAFE FOOD PRODUCTION

Abstract

Sustainable use of natural resources includes sustainable management of solid biodegradable municipal and agro-industrial waste and contributes to the protection of the environment and human health. Industrialization and population growth have created numerous problems in waste management and the lack of financial resources has further complicated waste management. Therefore, in Serbia, biodegradable waste is treated as a low-value material, ie something that needs to be discarded. In order to achieve sustainable management of biodegradable municipal and agricultural waste, new methods must be found, innovative technologies must be applied in order for biodegradable waste to become a valuable bioresource. One of the ways to reduce the amount of biodegradable waste, but also to reduce environmental pollution while obtaining a valuable product, is the application of recycling composting biotechnology, which is an important area of organic agriculture. The paper gives a concise and brief overview of the definitions of compost, composting process, composting goals, composting methods, composting materials as well as a review of the literature on composting.

Key words: *compost, composting, organic agriculture, food*

INTRODUCTION

In organic agricultural production and especially in safe food production, compost is very often used. Composting is recommended in organic agriculture as an agrotechnical measure, primarily for the treatment of waste generated in plant production and from households, but also for the control of weeds, pests and diseases. Compost serves as a growth agent or as a porous, absorbent material, which retains moisture and soluble minerals, providing protection for the nutrients necessary for the growth of most plants.

To accelerate the growth of plants, it is sometimes necessary to dilute the compost by combining it with soil or peat, to reduce salinity, add neutralizers to reach pH = 7, or supplements such as fertilizer, wetting agents and materials that improve drainage and aeration, such as which are sand, gravel, sawdust, vermiculite (hydrated silicate), clay granules, etc.

DEFINITIONS OF COMPOST AND COMPOSTING PROCESS

Compost is a mature product of composting, a controlled process of bio-oxidation of a solid heterogeneous organic substrate that includes a thermophilic phase [1]. In addition to the above definition, there are a number of definitions of the composting process and products themselves. Some authors [2] state that composts are organic fertilizers obtained by composting various organic, primarily plant residues mixed with substances of mineral origin such as limestone, ash, mineral fertilizers (organomineral composts) and other substances. The authors of the "Support document for compost quality criteria" [1] present different definitions of compost:

- "Homogeneous loose mixture of partially decomposed organic matter with or without soil" [3];
- "Solid waste subjected to biodegradation of organic matter, disinfected by composting or similar technology, stabilized to a degree potentially useful for plant growth, used as a soil improver, as an artificial surface layer of soil, as a substrate for growing seedlings or for similar purposes" [4];
- "All organic matter (vegetable or animal), with or without additives (organic or inorganic), subjected to elevated temperature (40°C) in the form of aerobic activity of microorganisms and a certain degree of stabilization (humification) of organic matter" [5];
- "Organic conditioner obtained by fermentation of a mixture which initially mainly contains various plant residues, possibly also organic matter of animal origin, with a limited content of mineral matter" [6];
- "Organic soil conditioner (improver) obtained by decomposition of a mixture consisting mainly of various plant residues, possibly organic matter of animal origin, with a limited content of mineral matter" [6].

The above definitions contain elements of the definition of the composting process. On the other hand process composting can be defined very briefly:

- "Aerobic thermophilic degradation of organic matter for compost production" [7];
- "Biological decomposition of organic waste in controlled conditions" [8].

Somewhat more complex definitions include a partial description of the process or properties of the final composting product:

- "Biological decomposition of organic matter under controlled aerobic conditions into a stable humus-like product" [9];

- "The process of biological decomposition of organic solid waste under controlled conditions for the production of humus-like product without harmful substances" [9];
- "Aerobic thermophilic decomposition of the organic mass of unused residues with its transformation into relatively stable humus" [10].

The introduction of descriptions of starting components or processes that more closely define composting results in even more complex definitions of composting:

- "Controlled aerobic, thermophilic, microbiological degradation of solid organic matter such as raw or treated waste sewage sludge, manure, plant residues, food residues and their mixtures to stabilized humus-like matter" [11];
- "A process in which the biological decomposition of solid organic waste takes place under controlled aerobic conditions and which stabilizes the organic fraction into a substance that can be easily and safely stored, manipulated and used in environmentally friendly ways." The existence of anaerobic zones within the compost mass does not mean that the process is not composting. Simply exposing solid waste to uncontrolled conditions that result in natural decay or decay is not composting" [4].

Almost all definitions imply controlled conditions which mean that the process is managed or optimized in order to achieve the goal of composting. The main goals of composting various organic substances are [9]:

- decomposition of organic matter subject to putrefaction processes into a stable state and production of substances that can be used as soil improvers or for some other useful purposes,
- decomposition of waste into a useful product; composting can be more economically viable compared to alternative waste disposal and can be more environmentally friendly than conventional waste disposal methods,
- disinfection of organic waste infected with pathogens, so that it can be used in a safe way,
- biological decomposition of hazardous waste by composting.

COMPOSTING TECHNOLOGY APPLICATION METHODS

Composting can be carried out in different ways. According to the US Composting Council, there are 5 different composting technologies [12]:

- compost material is unprotected from atmospheric influences, collected on ordinary pile, passive process without overturning or other treatment of pile, without adjusting C: N ratio, degree of ventilation, pH value, humidity and temperature, and composting time is 12-14 months.
- compost material is unprotected from atmospheric influences, properly placed in long piles resembling fringed pyramids, active process with compost mass inversion, with convective ventilation, with initial adjustment of C: N ratio, humi-

dity control by mixing and adding water, temperature control by mass inversion, and the composting time is 2-12 months.

- compost material is protected from atmospheric influences (covering or some other way), collected in piles or located in tunnel spaces, active process with static structure of compost mass, with forced ventilation, with initial adjustment of C: N ratio, humidity control by mixing and adding water, temperature control by blowing air, and the composting time is 2-6 months.
- compost material is protected from atmospheric influences (covering or some other way), placed in long fenced (concreted, masonry, lined) spaces similar to trenches or pools, active process with overturning of compost mass, with mechanical ventilation, with initial adjustment C: N ratio, humidity control by mixing and adding water, temperature control by blowing air, and composting time is 2-5 months.
- compost material is protected from atmospheric influences, placed in closed tunnels or chambers, active process with overturning of compost mass, with forced ventilation, with initial adjustment of C: N ratio, humidity control by mixing and adding water, temperature control by air blowing, and composting time is 2-4 months.

The quality of the produced compost and the time of composting depend on the applied technology but also on the composition of the initial compost mass. There are six basic types of source materials or raw materials for composting [12]:

- food processing residues: composting material resulting from the processing of fruit, vegetables, cereals and meat,
- manure and agricultural by-products produced in pig farms, fattening farms, incubators, farms, greenhouses, hothouses and other large agricultural areas,
- residues from forestry and wood industry including bark, sawdust and fibrous residues from paper production,
- bio-waste or waste sludge generated by biological treatment of waste sludge in wastewater treatment and recycling plants,
- leaves, bushes, twigs and other plant remains as well as waste from yards, backyards and gardens,
- separated organic waste containing sorted composting fractions of municipal waste.

INFLUENTIAL FACTORS ON THE COMPOSTING PROCESS

The composting process is influenced by many factors, but the most important factors in the decomposition of organic matter are oxygen and water. Temperature is also a very important factor but it is the result of microbiological activity. Other important factors that can limit the composting process are nutrients and pH reactions. Nutrients, especially carbon and nitrogen, play a significant role because they are necessary for microbiological activity and growth. Carbon is a source of energy and

nitrogen is necessary for building cells. Phosphorus and sulfur are also important, but their role in the composting process is less known. Trace elements such as Cu, Ni, Mo, Fe, Zn, then the macroelement Mg and useful Na, are necessary for enzymatic activities, but little is known about their role in the composting process. The basic composting process can also be represented by the following chemical equation [13]:



Self-heating of organic matter during composting is the result of microbiological respiration. The increase in temperature affects the microbiological population by changes in mesophilic and thermophilic organisms, which affects the degree and speed of decomposition of organic matter. Therefore, microbiological respiration can be used as an indicator of compost decomposition and stability [9].

The process of self-heating of the compost mass has a certain dynamics and the temperature curve can be divided into mesophilic (<45°C) and thermophilic zone (>45°C) within which 4 phases can be distinguished: 1) initial phase (mesophilic), 2) temperature rise phase (thermophilic phase), 3) maximum phase (thermophilic phase), 4) cooling.

Oxygen is necessary for microbiological activity because composting is an aerobic process. Ventilation and oxygen supply of the compost mass can be carried out by mass inversion, convection air flow and mechanical ventilation. Passive convection ventilation is highly dependent on the porosity of the compost mass. Lack of oxygen results in putrefaction processes. Oxygen consumption during composting depends on humidity, which significantly affects the microbiological activity, and the maximum consumption is at 65% humidity.

LITERATURE REVIEW REGARDING COMPOSTING TECHNOLOGY

An important raw material for compost production are various forms of manure, and a particularly big problem is the large amount of liquid and semi-liquid manure that is produced as a by-product on large farms with intensive breeding of cattle, pigs, horses, rabbits or poultry. All forms of solid manure are suitable for composting, and semi-liquid and liquid manure must be pre-treated with a separator to separate the solid fraction from the liquid phase. The solid phase is particularly suitable for composting, and the liquid phase is disposed of in other ways (biogas production, wastewater treatment plants). Also, manure can be used directly as an organic fertilizer, where solid manure is the most favorable and ecologically the most problematic and economically least profitable is the direct use of semi-liquid and liquid manure in fertilization.

The composting of the solid phase separated from pig manure and the change of its properties during composting were studied by Hsu and Lo [14,15]. During 122 days of long composting, they studied the changes in C: N ratio, ash, metal and humus components content in the compost mass in order to determine the criteria that indicate the maturity of the compost.

Increased public interest and environmental problems related to solving the manure problem direct farmers towards alternative solutions, and composting enables a significant reduction of environmental problems related to the use of different manures [4]. Also, unfavorable properties of manure such as e.g. high pH value, conductivity as well as high biological need for oxygen can be improved by the process of vermi-stabilization, ie. microbiological decomposition of organic matter through the digestive system of the California earthworm (*Eisenia fetida*) [16].

The use of California earthworm to decompose organic matter results in fragmentation of the organic substrate, acceleration of decomposition, change of physical and chemical properties of the substrate and the final effect very similar to composting in which unstable organic matter is oxidized and aerobically stabilized [17]. The final product, most commonly called vermicompost, is very different from the initial organic matter mainly due to enhanced decomposition and humification [18]. The same product of vermicomposting is often called: biohumus [19], lumbripost [2,10,20], lumbrihumus, lumbrikompost, earthworm or orbig [10]. Unfortunately, the cost of composting can be significantly higher compared to the use of fresh manure [21], so continuous production of quality compost is needed to recoup production costs [11].

Significant indicators of compost quality are its stability and maturity. Stability refers to the degree of stability of organic matter during composting and can be determined respirometrically [22]. Maturity implies non-limitation of plant growth in compost substrates [23] and maturity is best determined by vegetation (biological) experiments. Nevertheless, various authors have proposed a number of chemical and biological tests to evaluate compost quality, and many have investigated the different physical and chemical properties of compost.

Some authors [24] state that vermicompost is similar to peat, high porosity and water holding capacity. Compared to the starting material, vermicomposts contain less soluble salts, higher cation exchange capacity and increased total humic acid content [8] and also contain nutrients in forms that are easily absorbed by plants such as nitrates, exchangeable phosphorus, soluble potassium, calcium and magnesium. [24]. In general, on these physical, chemical and biological properties, vermicomposts have significant commercial potential in horticultural production as a container medium for growing vegetable and pot seedlings [18].

CONCLUSION

The use of waste for composting instead of their disposal, largely depends on the degree of socio-economic development, awareness of citizens and environmental policy. In our country, apart from small quantities of classic plant composts that are used as organic fertilizers, other organic waste was not used for the composting process. The advantages of composting are: simple technology, cheap and long-lasting; on average 40-45% of the total mass of input raw material can be further used; maximum utilization of nutrients necessary for use in agriculture (P, K, Mg and trace elements); production of humic substances, beneficial microorganisms and slow-decomposing nitrogen bacteria needed for landscape construction; eliminates weeds

and pathogens in waste material; possibility of process control (except in the case of composting without aeration). The benefits that can be achieved by applying composting of biodegradable waste are:

- protection and improvement of the environment (healthier and better quality),
- reduction of the total amount of waste based on composting,
- reduction of the volume of organic waste incineration,
- expansion of composting to wastewater and other organic fractions,
- application of compost in primary agricultural production and land reclamation.

Due to the high content of organic matter, compost has a favorable reclamation effect on improving water, air, heat and biological regime. Due to the increased content of mineral substances in relation to manure, it can replace mineral fertilizers. It can be used to "revive" devastated and improve the productive capacity of degraded areas, in forestry, and as a substrate in the production of various plant species. From the attached it can be concluded that the multiple benefits of composting are biodegradable waste and that it is necessary to gradually introduce the composting process in each individual household.

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**Мр Предраг Умичевић¹, др Ненад Живковић¹, мр Братимир Нешић¹,
дипл. инж. Ненад Нешић², студент Лука Нешић¹, Студент Никола Костић¹**

¹ Универзитет у Нишу, Факултет заштите на раду, Ниш Србија

² Градска управа, Крушевац, Србија

E-mail: bratimir@gmail.com

КОМПОСТ КАО ПРИМАРНА ОСНОВА ЗА ПРОИЗВОДЊУ ЗДРАВСТВЕНО БЕЗБЕДНЕ ХРАНЕ

Абстракт

Одрживо коришћење природних ресурса укључује и одрживо управљање са чврстим биоразградивим комуналним и агроиндустријским отпадом и доприноси заштити животне средине и здравља људи. Индустријализација и пораст броја становника створили су бројне проблеме у управљању са отпадом а недостатак финансијских средстава додатно је отежао управљање отпадом. Због тога се у Србији биоразградив отпад третира као нисковредан материјал односно нешто што је потребно одбацити. Како би се постигло одрживо управљање биоразградивим комуналним и пољопривредним отпадом, морају се пронаћи нове методе, применити иновативне технологије како би биоразградиви отпад постао вредан биоресурс. Један од начина смањења количина биоразградивог отпада али и смањења загађења животне средине уз добијање вредног производа је примена рециклажне биотехнологије компостирања која представља значајну област органске пољопривреде. У раду је дат сажет и кратак преглед дефиниција компоста, процеса компостирања, циљева компостирања, начина компостирања, материјала за компостирање као и преглед литературе у вези компостирања.

Кључне речи: *компост, компостирање, органска пољопривреда, храна*



**B. Sc. Aleksandar Aleksic¹, M. Sc. Bratimir Nesic², M. Sc. Predrag Umicevic²,
B. Sc. Nenad Nešić³, B. Sc. student Luka Nešić², M. Sc. Nemanja Petrovic¹,
M. Sc. Natalija Tosic¹, B. Sc. Dusan Milincic¹, M. Sc. Dusan Stevanovic¹**

¹ Academy of Technical-Educational Vocational Studies - Department, Nis, Serbia

² University in Nis, Occupational Safety Faculty, Nis, Serbia

³ City Administration, Krusevac, Serbia

E-mail: bratimir@gmail.com

POTENTIALS OF COMPOST FOR ORGANIC AGRICULTURE

Abstract

In order to achieve sustainable management of biodegradable municipal and agricultural waste, new methods must be found, innovative technologies must be applied in order for biodegradable waste to become a valuable bioresource. One of the ways to reduce the amount of biodegradable waste, but also to reduce environmental pollution while obtaining a valuable product, is the application of recycling composting biotechnology, which is an important area of organic agriculture. The paper presents a literature review of the potential of compost for possible application in organic agriculture.

Key words: *potential, compost, agriculture, food*

INTRODUCTION

The Waste Framework Directive [1] states that "waste is any substance that the owner intends or must discard. Annex I of this Directive defines 16 categories of waste. Most organic waste is classified in category Q14 (agricultural waste, household waste, office and commercial, etc.). Every year, about 1.3 billion tons of this waste is collected in Europe, and when about 700 million tons of agricultural waste are added, it is clear why waste management is one of the main activities to reduce the negative impact on the environment. In many countries today, there are obligations to reduce the amount of biodegradable municipal waste (Biodegradable Municipal Waste – BMW) for landfill, due to lack of available space and growing concerns about climate change. In

Slovenia, Austria, the Netherlands and Denmark, very little of this waste is disposed of, and in Europe, the "zero-waste strategy – Zero Waste" is increasingly accepted.

CURRENT SITUATION

According to the Law on Waste Management [2], the disposal and incineration of reusable waste is prohibited. Biological treatment of waste is performed in order to reduce the disposal of biodegradable waste at the landfill, ie to reduce the emission of gases with the effect of "greenhouse". It is estimated that 12.5 million tons of biomass are produced annually, with the energy potential of biomass in Serbia being 63-80%, of which about 40% is the potential of wood and 60% of agricultural biomass. In Bulgaria, for example. the amount of unused agricultural residues is estimated at 5,000,000 tons per year. Given that the thermal power of plant residues is between 15 and 20 MJ / kg, unused agricultural residues can be estimated at 80.8 PJ, which is equivalent to 1.9 Mt of oil [3].

Recycling and composting are an alternative option for waste management, with several negative effects on the environment [4]. For example, primary selection – the classification of municipal solid waste at the place of origin, was regulated by law by the German Federal Government in 1993, so biogenic waste is collected every or every other week and includes waste from food, branches, grass, leaves and other fractions. waste from the yard and individual fractions of paper. Until 1995, the sorting of biodegradable waste that went to composting was done in 380 facilities, which is about 40% of the total amount of organic waste [6]. This concept of waste management is expected to play a significant role in resource conservation [7].

Market demands for high quality compost exceed current market supply. On the other hand, landfilling is expensive (about \$ 40 per ton, including transportation costs) and is considered an unfavorable environmental solution due to the greenhouse effect, in anaerobic conditions prevailing in landfills [8]. The use of compost has proven to be an excellent substitute for peat in floriculture [9]. In Israel, the cost of producing quality compost is one third of the price of imported peat for floriculture. Mature compost suppresses a wide range of soil pathogens, so it is an excellent solution to this problem [10]. In the near future, agricultural and agro-industrial waste management will play an important role in the conservation of natural resources, including the Balkan region [3].

WASTE COMPOSTING

Composting is an aerobic process where different microbial populations gradually perform the process of transformation of organic matter with the simultaneous synthesis of humic substances and the physical and chemical properties of the starting materials determine the further course of the process [11]. Composting is a lucrative field of agricultural biotechnology. Therefore, the basic goals of agricultural waste management are: reduction of waste production and environmental pollution with improvement of substrate recycling methods [12]. During composting, part of the

organic matter is mineralized to carbon dioxide, ammonia and water and part is converted into humic substances structurally very similar to those present in the soil. The process takes place thanks to different microorganisms, whose population dynamics vary in time and space, which leads to an increase in temperature as a consequence of the activity of thermophilic microorganisms [13].

Composting municipal solid waste is a method of disposing of biodegradable waste that would otherwise be disposed of, at relatively low prices, resulting in compost that is suitable for agricultural purposes [14], soil and stimulating plant growth [15]. Also, compost can increase plant growth on degraded soils of industrial zones, improve quality and structural stability as well as reduce the risk of soil erosion [4]. The primary benefit of this compost is the high content of organic matter [16] which also contributes to the quality, aggregate stability and water capacity of the soil and all together affect the growth of plants [17].

Green waste can have agricultural, industrial and urban origins and is most often heterogeneous and seasonal. Composting this material is considered to be a good way to reuse agricultural waste [18]. The value of this waste is, above all, the low content of pollutants [19]. By composting tobacco waste, which belongs to specific agro-industrial waste, hazardous waste is reduced and a useful product is obtained [20]. Some authors [21] state that tobacco waste is rich in nitrogen (2.35%), potassium (1.95%), and phosphorus (973 $\mu\text{g}\cdot\text{g}^{-1}$). On the other hand, certain soil microorganisms, such as *Arthrobacter nicotianae*, *A. nicotinovorans*, *A. globiformis*, *Enterobacter cloacae*, *Pseudomonas putida*, *Cellulomonas* sp., Can degrade nicotine [22,23]. The use of tobacco waste on artificially drained alkaline soils contributes to the improvement of physical and chemical properties, including the availability of plant nutrients [24]. On alkaline soils where tobacco waste was applied, there was an increase in nitrate and carbon dioxide content, as well as an increase in wheat grain yield compared to the use of other organic materials [25].

There is a proposal [26] to mix tobacco waste with mineral fertilizers or use it as a raw material for composting, because it contains <2.5% N and > 15% lignin, but also warnings [27] that tobacco waste has a negative effect on soil microorganisms due to nicotine present. Nicotine is considered to be an insecticide and causes toxic effects in plants and animals [28], so direct application can adversely affect the ecological balance in the soil. Also, composting accelerates the decomposition of nicotine and compost contains less toxic and more useful substances [29]. It is possible to use tobacco waste due to the high content of organic matter and low content of toxic elements [30]. Tobacco compost can be used as an alternative to manure for higher and earlier yields [31]. Some research [21] has confirmed that the use of tobacco waste provides the soil with carbon and nutrients, which is probably the cause of increased levels of nutrients such as lycopene.

COMPOST APPLICATION

Compost is widely used as a natural fertilizer for the soil and as a dietary supplement for gardens and agricultural production. The ability of compost to release nutrients gradually over a long period of time allows for the potential use of optimal

amounts of nutrients that reach the environment [32]. The application of compost: improves the aggregate structure of the soil, which increases productivity, increases soil porosity and water retention (better water-air regime), better forms soluble micronutrient compounds, which increases their availability to plants, increases soil cation exchange capacity, increases soil buffer capacity due to addition of colloids and humic substances [33].

Compost from municipal waste is also used in a mixture with soil or industrial waste to create anthropogenic soils in the reclamation of gravel mines, locations with coal residues, stop lanes on the road, abandoned open pits [34,35]. The study [36] states that the optimal characteristics of the mixture of food waste for composting are the following: moisture content 55 to 60%, volatile matter 60 to 90%, density 900 to 1,200 kg / m³, C / N ratio 25-40: 1, pH 6.0-7.5, porosity > 35% pore filling with air.

The best way to reduce the metal content and improve the quality of municipal solid waste compost is to sort the waste before composting [37]. The quality of compost is determined based on the analysis of numerous chemical and microbiological parameters. There is an absolute level of organic matter whose content is ideal in terms of compost quality and when applying a larger amount of compost must take into account the maturity of the compost, nitrogen content and its purpose [38]. The application of this compost is usually over 50 t / ha because only a small part of the total N in the compost is available to plants in the first year after application [39]. Such application can lead to excessive intake of other nutrients and microelements. Instead, the type and ratio of the raw material for composting and the composting process should be focused on increasing the content of inorganic N in the compost if used as a fertilizer. Mineralization of organic N in compost depends on many factors, including C / N ratio, composting conditions, compost maturity, application time, and compost quality [40]. Studies have shown that in mature compost, the C / N ratio is 12-14: 1.

DISADVANTAGES OF COMPOST APPLICATION

High concentrations of micronutrients in compost can be a problem and a limiting factor. Root absorption is one of the main routes for heavy metals to enter the food chain [41]. Food-producing plants, whose exploitation system is based on intensive and constant production, have a great ability to extract elements from the soil [42]. Growing these plants in contaminated soils can pose a risk as heavy metals can accumulate in plant tissues as there is a high content of heavy metals and trace metals are often mentioned, which remain in the finished compost product [43,44]. The variety of waste materials in large cities is much higher than those from small cities, so the contamination of compost is greatest in cities with a large population.

The use of compost to improve crop yields without taking into account the possible negative consequences is a problem because compost is mostly used for growing vegetables. Having in mind the edible parts of plants in most vegetable species, special attention should be paid to the risks of transferring heavy metals from the soil through plants to humans. The uptake of metals by plants, through the roots, depends on their concentration and the form in which the metal ions are found in the soil solution.

Increased concentrations of easily soluble ions result in increased transport to the aboveground parts of plants and thus the entry of metals into the food chain of animals and humans [45].

The availability of metals to plants decreases due to the formation of compounds with humic substances [46]. Another influential factor is the time elapsed between the application of compost and the growth of the plant. Immediately after the compost is introduced into the soil, the metals present in the compost are mobilized through the soil fractions. It was found [47] that the presence of copper wires, galvanized nails and alkaline batteries leads to increased levels of Cu, Zn, As, Pb, and Co in the compost. These trace elements accumulate in the soil if applied in the long term and can potentially be toxic to humans and animals, especially if they are found in high concentrations [37]. In order to protect public health and the environment, the Canadian Food Inspection Agency has established standards for acceptable maximum metal concentrations in compost and acceptable maximums for cumulative long-term soil content, ie. for 45 years [48].

The Canadian Council of Ministers of the Environment has proposed restrictions on the content of microelements in compost, ie it has been specified that compost products can be classified into two groups (A category – unlimited use and B category – limited use) based on compost quality, which refer to microelement concentrations. In order for compost to have unlimited use, it is necessary to have a low level of microelements, ie in traces [37].

CONCLUSION

Composting waste instead of landfill largely depends on the degree of socio-economic development, citizens' awareness and environmental policy. The advantages of composting are: simple technology, cheap and long-lasting; on average 40-45% of the total weight of the input raw material can be further used; maximum utilization of nutrients necessary for use in agriculture (P, K, Mg and trace elements); production of humic substances, beneficial microorganisms and slow-decomposing nitrogen bacteria required for landscape construction; eliminates weeds and pathogens in waste material; possibility of process control (except in the case of composting without aeration). The benefits that can be achieved by applying composting of biodegradable waste are:

- protection and improvement of the environment (healthier and better quality environment),
- reduction of the total amount of waste based on composting,
- reduction of the volume of organic waste incineration,
- expansion of composting to wastewater and other organic fractions,
- application of compost in primary agricultural production and land reclamation.

Compost has numerous potentials for the production of healthy food. Due to the high content of organic matter, it has a favorable reclamation effect on the improvement of water, air, heat and biological regime. Due to the increased content of mineral substances in relation to manure, it can replace mineral fertilizers. It can be used to "revive"

devastated and improve the productive capacity of degraded areas, in forestry, as a substrate and in the production of various plant species. The benefits of composting biodegradable waste are manifold and it is necessary to gradually introduce the composting process in each individual household.

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**Инж. Александар Алексић¹, мр Братимир Нешић², мр Предраг Умичевић²,
дипл. инж. Ненад Нешић³, студент Лука Нешић², мр Немања Петровић¹,
мр Наталија Тошић¹, инж. Душан Миљинчић¹, инж. Душан Стевановић¹**

¹ Академија техничко-васпитачких струковних студија – одсек Ниш, Србија

² Универзитет у Нишу, Факултет заштите на раду, Ниш, Србија

³ Градска управа, Крушевац, Србија

E-mail: bratimir@gmail.com

ПОТЕНЦИЈАЛИ КОМПОСТА ЗА ОРГАНСКУ ПОЉОПРИВРЕДУ

Абстракт

Како би се постигло одрживо управљање биоразградивим комуналним и пољопривредним отпадом, морају се пронаћи нове методе, применити иновативне технологије како би биоразградиви отпад постао вредан биоресурс. Један од начина смањења количина биоразградивог отпада али и смањења загађења животне средине уз добијање вредног производа је примена рециклажне биотехнологије компостирања која представља значајну област органске пољопривреде. У раду је дат литературни преглед потенцијала компоста да за могућу примену у производњи здравствено безбедне хране.

Кључне речи: *потенцијал, компост, пољопривреда, храна*



**B. Sc. Student Nikola Kostic¹, M. Sc. Bratimir Nestic¹,
M. Sc. Predrag Umičević¹, B. Sc. Nenad Nestic², B. Sc. Student Luka Nestic¹**

¹ University in Nis, Occupational Safety Faculty, Nis Serbia

² City Administration, Krusevac, Serbia,

E-mail: bratimir@gmail.com

COMPOST QUALITY ANALYSIS FOR APPLICATION IN ORGANIC AGRICULTURE AND SAFE FOOD PRODUCTION

Abstract

As a partially decomposed organic matter, compost can have a number of characteristics. Compost can vary due to the use of raw materials, degree of decomposition, moisture content, nutrient content, solids content, acidity / alkalinity and contaminants (organic and non-environmental materials or heavy metals). Not only mere quality, such as carbon / nitrogen ratio, odour and particle size, indicate some of the best characteristics or efficiencies of process composting. Large particle sizes indicate incomplete decomposition. Bad smell is a sign of too moist or too pile of compost. The finished compost is dark in colour, chopped and has a earthy odour. Original source materials should not be recognizable. Inert materials such as glass or plastic should ideally not be present for more than 1 compost volume process. The aim of this paper is to determine and use quality 3 types of compost of different origin for use in organic agriculture.

Key words: *compost, quality, analysis, organic agriculture*

INTRODUCTION

Composting, as a controlled process of stabilization of organic matter, can turn biodegradable or organic waste into a valuable soil additive. Compost can return nutrients and organic matter to the soil, which is a proven practice for improving soil health. It can improve crop growth and provide environmental benefits by improving soil slope and the ability of the soil to absorb and retain water and plant nutrients. Properly managed composting process can destroy weed seeds, plant, animal and human pathogens.

MATERIAL AND METHOD

The starting raw material for the production of vermi-compost is beef manure from a family farm with the use of wheat straw as a mat. Fresh manure was deposited on dry and draining soil, forming a pile 70 cm high, 5 m wide, 10 m long, covered with a layer of straw 20 cm thick and surrounded by bales of straw to reduce drying. The manure matured in piles for 6 months without aeration and after that it was used as a substrate for composting with the use of California worms (*Eisenia fetida*). The composting site was prepared on dry and draining soil in the form of fenced boxes at the bottom and laterally lined with white waterproof canvas, 2 m wide, 50 cm high and 20 m long. Inoculation of the compost bin with California earthworms was carried out by placing a previously produced mature vermi-compost with California earthworms on the bottom of the compost bin in a layer 5 cm thick, and then the manure was distributed after six months of maturation to a total thickness of 40 cm. Vermicompost was sampled and analysed after 6 months [1,2].

The pig manure separator was placed on dry and draining terrain in piles 1 m high, unprotected from atmospheric influences, composted by passive process without overturning or other treatment of the pile, without adjusting C: N ratio, without controlling the degree of ventilation, pH, humidity and temperature. The compost mass of the pig manure separator was sampled fresh, after 1 month, after 3 months and after 6 months. Thus, 4 series of samples of different ages were collected [1,3].

In order to reduce the variability of the samples, each sample was composed of 10 subsamples taken by the method of random sampling on the composting site and evenly over the entire depth. After that, the sample is thoroughly mixed in order to achieve maximum homogeneity. The whole procedure was performed four times, so four average samples of individual volume of about 5 litres were collected [1,3].

QUALITY ANALYSIS PROCEDURE

All analyses of physical, chemical and biological properties required for quality analysis were performed on vermi-compost samples (4 average samples), on 4 sets of samples of pig manure separates of different ages (0, 1, 3 and 6 months) after composting started (4 times 4 average sample) and on a commercial substrate for growing vegetable seedlings to compare the stability, maturity and levels of plant nutrients.

Analysis of the physical properties of compost included the determination of the percentage of moisture, solids content, ash content and organic matter content. Dry matter content, i.e. the content of total solids in the samples was determined by drying 100 g of fresh fertilizer in a dryer at 75°C to constant weight [1]. Total solids and moisture percentage were calculated from measurement data of fresh and dry matter samples after drying:

$$\text{Total solids (\%)} = [\text{net dry matter (g)} / \text{net fresh sample (g)}] \times 100$$

$$\text{Humidity percentage (\%)} = [1 - \text{net dry matter (g)} / \text{net fresh sample (g)}] \times 100$$

The total ash and organic matter content were determined by annealing at 550°C for 2 hours [1] in an annealing furnace, using dry matter samples after drying at 75°C and the following formulas:

$$\text{ash (\%)} = [\text{net mass of ash after 550}^\circ\text{C (g)} \div \text{net dry sample (g)}] \times 100$$

$$\text{organic matter (\%)} = [1 - \text{net ash after 550}^\circ\text{C (g)} \div \text{net dry sample (g)}] \times 100$$

The following chemical properties of compost were analysed: pH reaction, electrical conductivity, total carbon, total nitrogen, C: N ratio, total P, K, Ca, Mg and heavy metal concentration of Fe, Mn, Zn, Cu, Pb and Cr.

Electrometric measurement of the pH of the compost reaction was performed in a filtrate of 10 g of fresh sample shaken on a rotary shaker for 1 hour in 100 ml of deionized water (1:10 w / v sample: water, [2]).

Electrical conductivity was measured with a conduct meter in an extract prepared with 20 g of fresh sample shaken on a rotary shaker for 1 hour in 100 ml of deionized water (1: 5 w / v sample: water, [2]).

Total carbon was determined by wet destruction: 50 mg of the dry sample was weighed into destruction cuvettes, filled with 5 ml of 0.27 mol dm⁻³ K₂Cr₂O₇ and 7.5 ml of concentrated H₂SO₄ and destroyed for 1/2 hour in a destruction block at 135°C, quantitatively. transferred to measuring vessels, made up to 100 ml with deionized water, poured into centrifuge tubes, centrifuged for 10 minutes at 2000 g, filtered and measured with a spectrophotometer at 585 nm with calibration with standard glucose solutions.

Total nitrogen was determined by distilling a solution of fresh manure in a "template" of boric acid: 10 g of crushed fresh homogenized sample was weighed, 30 ml of a mixture of sulfuric and salicylic acid was added and left to stand overnight; 5 g of Na-thiosulphate are added, heated, cooled, 10 g of catalyst mixture are added, heated to foaming, and after foaming is cooked for 3 hours at 375°C, cooled, 100 ml of deionized water are added, transferred to a measuring vessel and made up to 1000 ml deionized water;

A volume of 50 ml of the sample solution was transferred to a Kjeldahl vessel, 20 ml of 10 mol dm⁻³ NaOH was added and distilled in a "template" with 10 ml of a mixture of boric acid and indicators to a total volume of "template" and distillate of about 40 ml, titrated with 0.01 mol dm⁻³ HCl until green to pink; the percentage N in the fresh matter of the fertilizer was calculated according to the formula:

$$\% \text{ N} = 14 \times \text{ml HCl} \div [\text{fertilizer measure (mg)} \times \text{distilled solution (ml)} \div \text{total volume (ml)}]$$

The C:N ratio was calculated on the basis of data on total carbon in dry matter and total nitrogen in fresh matter according to the formulas:

$$\% \text{ C in fresh matter} = \% \text{ C in dry matter} \times \% \text{ dry matter} \div 100$$

$$\text{C: N} = \% \text{ C in fresh matter} \div \% \text{ N in fresh matter}$$

The basic solution of the compost sample for determining the phosphorus concentration was prepared by destroying the dry sample by digestion of ash with nitric and hydrochloric acid [1,3]. The concentration of total phosphorus in the stock solution was determined by the spectrophotometric phosphorus-molybdenum method.

The basic solution of the compost sample for determining the concentration of K, Ca and Mg was prepared by destroying the dry sample by digestion of ash with nitric and hydrochloric acid [3]. The concentration of total potassium, calcium and magnesium was determined by atomic absorption spectrometry [2,3].

The basic solution of the compost sample for determining the concentration of microelements Fe, Mn, Zn and Cu as well as toxic heavy metals Pb and Cr was prepared by destroying the dry sample by digestion with the help of royal water. The concentration of these heavy metals in the stock solution was determined by atomic absorption spectrometry [1].

The analysed biological properties of compost are the intensity of respiration and the biological test carried out by sowing lettuce in Styrofoam containers.

Intensity of compost respiration, i.e. degree of CO₂ emission, was measured by capturing the emitted carbon dioxide in a vessel with NaOH. Fresh samples of fertilizer weighing 50 g after two days of incubation were used [3,4].

The biological test of the suitability of samples for growing seedlings was carried out by sowing lettuce (*Lactuca sativa* L.) in styrofoam containers with 40 seats and a substrate volume of 50 ml. Compared were tested composted pig manure of different ages [5,6], vermi-compost [4], commercial substrate for growing seedlings, as well as different mixtures of composted separator of different ages, vermi-compost and substrate in a volume ratio of 1: 1, all in four replications. The test was performed by sowing two lettuce seeds at each sowing place, and 14 days after germination, fresh aboveground mass was measured for each individual treatment and repetition [4,5,6].

CONCLUSION

Compost can be used in organic agriculture only under the condition that all sanitary rules are observed and if the control and analysis of compost quality is performed, namely: physical, chemical and biological. The value of compost is reflected in the existence of microorganisms and substances that cannot harm human health during its contact with the soil, through plant crops that are used for human and livestock nutrition, through water, air and insects. Waste compost contains heavy metals and rare elements, which calls into question the usability of compost as manure on agricultural land. On the other hand, some micro elements, which are found in compost, are physiologically necessary for the development of plants (copper, zinc, manganese, chromium, boron). Heavy metals, such as mercury, cadmium and lead from compost can get into the soil. Due to the high content of organic matter, compost has a favourable reclamation effect on improving water, air, heat and biological regime. Due to the higher content of mineral substances in relation to manure, it can replace mineral fertilizers. It can be used to "revive" devastated and improve the productive capacity of degraded areas, in forestry, and as a substrate in the production of various plant species.

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**Студент Никола Костић¹, мр Братимир Нешић¹, мр Предраг Умичевић¹,
дипл. инж. Ненад Нешић², студент Лука Нешић¹,**

¹ Универзитет у Нишу, Факултет заштите на раду, Ниш Србија

² Градска управа, Крушевац, Србија

E-mail: bratimir@gmail.com

АНАЛИЗА КВАЛИТЕТА КОМПОСТА ЗА ПРИМЕНУ У ОРГАНСКОЈ ПОЉОПРИВРЕДИ И ПРОИЗВОДЊИ ЗДРАВСТВЕНО БЕЗБЕДНЕ ХРАНЕ

Абстракт

Као делимично разграђена органска материја, компост може имати читав низ карактеристика. Компост може да варира због коришћених сировина, степена разградње, садржаја влаге, садржаја хранљивих материја, садржаја соли, киселости / базности и загађивача (органских и несеколошких материјала или тешких метала). Неке мере квалитета, као што су однос угљеник/азот, мирис и величина честица, указују на неке од горе наведених карактеристика или ефикасност процеса компостирања. Велике величине честица указују на непотпуно распадање. Лош мирис је знак превише влажне или преуске гомиле компоста. Готов компост је тамно смеђе боје, уситњен и има земљани мирис. Оригинални полазни материјали не треба да буду препознатљиви. Инертни материјали попут стакла или пластике у идеалном случају не смеју бити присутни више од 1 процента запремине компоста. Циљ овог рада је да се утврди и упореди квалитет 3 врсте компоста различитог порекла за примену у органској пољопривреди.

Кључне речи: *компост, квалитет, анализа, органска пољопривреда*



**Jovan Dimishkovski¹, Dragica Stojiljković², Biserka Dimishkovska³,
Isidora Rajic⁴**

¹ Brandenburg University of Technology Cottbus-Senftenberg,
Environmental Engineering; Cottbus, Germany

² "Tehnohidrosfera" Beočin, Serbia

³ "Ss.Cyril and Methodius" University; Institute of Earthquake Engineering and
Engineering and Seismology North Macedonia

⁴ Master Psychologist, Independent Researcher
E-mail: dragica.ths@gmail.com

GROUNDWATER QUALITY IN THE IRRIGATION SYSTEMS OF BACKA REGION

Abstract

An analysis of the irrigation water quality has the great importance in the preservation of productive soil characteristics, and it also influences the amount and quality of the expected yield of irrigated plants. In the process of evaluating the usability, there are numerous classifications, which limit values are not adapted to the prevailing conditions in Serbia. The laws that apply in Serbia does not prescribe or recommend the manner and timing estimates usability of irrigation water to users. The consequence of this is that it gives users the option of comparative application of different classification, but it is preferable to use additional assessment using some of the suggested parameters.

Key words: *groundwater, irrigation plants, water quality*

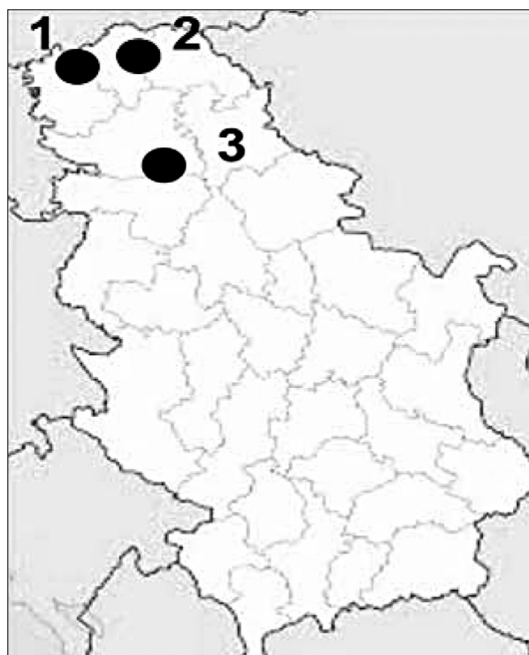
INTRODUCTION

Irrigation systems of the pivot center type and linear wings with two wings were built on three locations with agricultural areas over 100 ha. Assessment of irrigation water quality should be a necessary measure to prevent adverse impacts on both natural resources such as land and groundwater, and on cultivated plants and applied equipment (Joshi et al., 2009). In Serbia, the Law on Agricultural Land, the Law on Waters and the Law on Environmental Protection provide for monitoring the usability of water

for irrigation, but not the manner in which this should be done or a certain classification according to which irrigation water would be classified according to usability. It is common to use classifications that are known in the world for this purpose, such as the FAO classification and the classification of the American Laboratory for Salt Soils (USSL). The Negebauer classification was developed for the area of Vojvodina, which is also used. It is common for the listed classifications to give different assessments of usability, so it is sometimes good to introduce an "additional" assessment of the usability of irrigation water quality and thus remove existing doubts. This "supplementary" assessment implies the content or ratio of cations and anions of the underlying water mineralization (Gungor and Arslan, 2016). This paper provides a comparative overview of known classifications and an "additional" assessment of the usability of water quality in order to see the possible consequences of the use of groundwater for irrigation.

MATERIAL AND METHOD

Groundwater quality is not monitored systematically, so there is no continuous monitoring of basic parameters. Groundwater samples were taken from 6 wells in the Stanišić irrigation system, 4 wells in Čantavir and 6 wells in the Novi Sad irrigation system (Figure 1).



*Figure 1. Locations of water sampling points from irrigation systems:
1) Stanišić, 2) Čantavir and 3) Novi Sad*

The results of chemical analyzes (Institute of Public Health Sombor, Novi Sad and Subotica 2018-2019) were used to assess the usability of water for irrigation using the following classifications: according to Negebauer, modified FAO classification and USSL classification. The basis of these classifications is primarily the degree and type of salinity of the water used. To form a better assessment of water usability, an "additional" assessment was used, which contains the determination of the value of residual sodium carbonate (RSC). (Pfeifer et al., 1999; Seilsepour et al., 2009). Good quality of irrigation water according to the "supplementary" classification implies acceptable ranges of the stated values of parameters and their relations.

RESULTS AND DISCUSSION

The results of basic mineralization, EC, three bit anions and cations are given for all three sites as average values from a total of 32 analyzes of groundwater samples in Tables 1, 2 and 3. The obtained results of chemical analyzes were used further in assessing the usability of irrigation water using classification groundwater according to Neugebauer, modified FAO classification and USSL classification. The general assessment according to all three classifications is that water can be used for irrigation, but with control. The classification according to Negebauer was proposed for the conditions prevailing in Vojvodina. With this in mind, this classification is adapted to the prevailing conditions and can be expected to give the most realistic assessment. According to this classification, the analyzed samples are classified in Ia and III class.

This indicates that although there is a small increase in mineralization, this would not affect the quality of the irrigated water, because class Ia belongs to the "perfect" waters (Tables 1 and 2), and class IIIb (Table 3) is classified as water to be tested in our irrigation conditions. In Table 1.2. the results of the classification according to Negebauer and the modified FAO classification are presented. FAO classification, gives homogeneous results. According to this classification, water belongs to class I according to the degree of salinity and toxic effects of sodium and chloride, while according to the influence on the infiltration properties of the soil, water is classified in class I and II.

Table 2 shows the results that the USSL calcification gives. Water from samples from the Cantavir irrigation system is classified in class C2-S1, i.e. the water is moderately saline, and the danger of harmful sodium adsorption is not significantly expressed. The additional assessment of the usability of the quality of irrigation water begins with the definition of the EC value (dS / m) on which the danger of salinity depends. For the third irrigation system, this value belongs to the moderate danger of salinization, which indicates that plants that are moderately tolerant to the presence of salt in the water can be watered with this kind of water. All parameters of the "supplementary" usability assessment are shown in Tables 1, 2 and 3.

Table 1. Classification of groundwater in the Stanisic irrigation system as an average of 12 samples

Parameters	Irrigation water quality (Ayers & Westcot, 1985)	Stanišić classification
pH	6,0 – 8,5	7,5
Elec. conductivity	0 – 3000 μ S/cm	764
Dry residue mg/l	0 – 2000 mg/l	452
CO ₃ mg/l	0 – 3 mg/l	0
HCO ₃ mg/l	0 – 610 mg/l	539
Cl mg/l	0 – 1.064 mg/l	9,64
SO ₄ mg/l	0 – 961 mg/l	0,1
Ca mg/l	0 – 401 mg/l	99,5
Mg mg/l	0 – 61 mg/l	34,8
K mg/l		1,7
Na mg/l	0 – 920 mg/l	38,4
SAR mmol/l	0 – 15	1,19
RSC meq/l	< 1,25	1,01
Stebler coefficient	> 18 – good water 18 – 6 – satis factory 5,9 – 1,2 – unsats factory < 1,2 – bad water	18,78
Nejgebauer	I – IV	I a
US Salinity Laboratory	C1 – C4 S1 – S4	C3S1
Modified FAO	I – III	Salinity I category
		Infiltration I category
		Na (surface area) I category
		Na (sprayer) I category
		Cl (surface area) I category
		Cl (sprayer) I category
		HCO ₃ III category

Table 2. Classification of groundwater in the Čantavir irrigation system as average values of 8 samples

Parameters	Irrigation water quality (Ayers & Westcot, 1985)	Čantavir classification
pH	6,0 – 8,5	7,32
Elec. conductivity	0 – 3000 μ S/cm	531
Dry residue	0 – 2000 mg/l	276

CO ₃ mg/l	0 – 3 mg/l	0
HCO ₃ mg/l	0 – 610 mg/l	366,6
Cl mg/l	0 – 1.064 mg/l	4,95
SO ₄ mg/l	0 – 961 mg/l	3,75
Ca mg/l	0 – 401 mg/l	60,38
Mg mg/l	0 – 61 mg/l	30,24
K mg/l		1,18
Na mg/l	0 – 920 mg/l	23,6
SAR mmol/l	0 – 15	0,88
RSC meq/l	< 1,25	0,51
Stebler coefficient	> 18 – good water 18 – 6 – satis factory 5,9 – 1,2 – unsats factory < 1,2 – bad water	31,25
Nejgebauer	I – IV	I a
US Salinity Laboratory	C1 – C4 S1 – S4	C2S1
Modified FAO	I – III	Salinity I category
		Infiltration I category
		Na (surface area) I category
		Na (sprayer) I category
		Cl (surface area) I category
		Cl (sprayer) I category
		HCO ₃ II category

Table 3. Classification of groundwater in the flooding system of Novi Sad as the average values of 12 samples

Parameters	Irrigation vater quality (Ayers & Westcot, 1985)	Stanišić classification
pH	6,0 – 8,5	6,91
Elec. conductivity μS/cm	0 – 3000 μS/cm	996
Dry residue mg/l	0 – 2000 mg/l	752
CO ₃ mg/l	0 – 3 mg/l	0
HCO ₃ mg/l	0 – 610 mg/l	715
Cl mg/l	0 – 1.064 mg/l	25,2
SO ₄ mg/l	0 – 961 mg/l	32,7
Ca mg/l	0 – 401 mg/l	73,44
Mg mg/l	0 – 61 mg/l	62,46
K mg/l		2

Na mg/l	0 – 920 mg/l	103
SAR mmol/l	0 – 15	2,02
RSC meq/l	< 1,25	2,92
Stebler coefficient	> 18 – good water 18 – 6 – satis factory 5,9 – 1,2 – unsatsl factory < 1,2 – bad water	7,54
Nejgebauer	I – IV	III b
US Salinity Laboratory	C1 – C4 S1 – S4	C3S1
Modified FAO	I – III	Salinity II category
		Infiltration II category
		Na (surface area) II category
		Na (sprayer) II category
		Cl (surface area) I category
		Cl (sprayer) I category
		HCO ₃ III category

The value of relative sodium content (SAR) at all three locations is classified as water of "excellent" quality. When it comes to the relative sodium content according to other indicators such as RSC, SAA and KR, also for the first two locations, water is classified as "excellent" quality, and in the third location is not responsible for irrigation. RSC and RSBC values represent residual sodium carbonate concentrations and the ratio of hydrocarbons to calcium. These values affect the usability of irrigation water by increasing the pH value (Oladeji et al., 2012). The values related to soil permeability are primarily related to the use of irrigation water loaded with salts of sodium, calcium, magnesium and hydrocarbons. In the case of all three locations, the values are such that the water is assessed as "good" quality, ie the infiltration is of the category I, on the Stanišić and Čantavir irrigation system. On the Novi Sad irrigation system, the infiltration is of the category II. Such results on the examined irrigation systems indicate the possibility of using water for irrigation of agricultural areas without negative impacts on both land and plants, but with mandatory control at location no. 3.

CONCLUSION

Analyzes of the usability of water for irrigation with two irrigation systems in Bačka indicate a generally good quality. By using known classifications, there is no greater deviation from the excellent or good quality of irrigation water. An additional assessment of water usability indicates also small deviations from excellent quality. The

only deviations that occur on the irrigation system number 3 where the water according to the classification of Negebauer belongs to group IIIb and is not usable for irrigation without control, RSC is 2.92 irrigation coefficient is 7.54 and water quality is satisfactory. According to the USSL classification, water belongs to C3S1. This means that the danger of alkalization is small, and of salinization is great. Water cannot be used on poorly drained soils. For the climatic conditions of Vojvodina, the classification of irrigation waters according to Negebauer is the most acceptable. By applying this approach to the assessment of irrigation water quality, it is possible to monitor water quality in detail and systematically, which could minimize possible damage to land, plants and equipment.

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**Јован Димишковски¹, Драгица Стојиљковић², Бисерка Димишковска³,
Исидора Рајић**

¹ Бранденбург Универзитет технологије Cottbus-Senftenberg, Инжењеринг
животне средине; Котбус, Немачка

² "Технохидросфера" Беоцин, Србија

³ Универзитет "Ss. Cyril and Methodius"; Институт за Еарткуаке инжењеринг
и инжењеринг и сеизмологију Северна Македонија

E-mail: dragica.ths@gmail.com

КВАЛИТЕТ ПОДЗЕМНИХ ВОДА НА ЗАЛИВНИМ СИСТЕМИМА БАЧКЕ

Резиме

Анализа квалитета воде за наводњавање има велики значај за очување карактеристика продуктивног тла, а такође утиче на количину и квалитет очекиваног приноса наводњаваних биљака. У поступку процене употребљивости постоје бројне класификације, чије граничне вредности нису прилагођене условима који важе у Србији. Закони који се примењују у Србији не прописују или не препоручују начин и време процене употребљивости воде за наводњавање корисницима. Последица тога је да корисницима даје могућност упоредне примене различитих класификација, али је пожељно да користе додатну процену користећи неке од предложених параметара.

Кључне речи: *подземне воде, наводњавање биљака, квалитет воде*



Assoc. Prof. Dr. sc. Lenche Velkoska-Markovska*,

Prof. Dr. sc. Biljana Petanovska-Ilievska

Ss. Cyril and Methodius University in Skopje

Faculty of Agricultural Sciences and Food - Skopje, Republic of North Macedonia

* Corresponding author: levemar@gmail.com; lencevm@fznh.ukim.edu.mk

HPLC METHOD FOR DETERMINATION OF SOME PESTICIDE RESIDUES IN WATER SAMPLES

Abstract

A new, accurate and suitable high-performance liquid chromatography (HPLC) method with ultraviolet-diode array detection (UV-DAD) for determination of some herbicide and organo-phosphorus insecticide residues in different water samples has been developed and validated. Separation and quantitative determination of the analytes were carried out using a Purospher STAR RP-18e (30 x 4 mm; 3 m) analytical column, under the isocratic elution with mobile phase consisted of acetonitrile/water (47/53, V/V), flow rate of 1 mL/min, constant column temperature at 25 °C and UV-detection at 220 nm. The obtained results showed that analysed water samples did not contain detectable residues of investigated pesticides.

Key words: *HPLC-method, pesticide residues, water samples*

INTRODUCTION

It is well known that pesticides are used to increase crop yields, but due to their widespread use, their residues are present in the environment, such as soil, water and air, and from there can easily pass into agricultural products for human consumption. Due to the adverse effects of pesticides, environmental pollution from pesticides is a cause for concern locally, regionally, nationally and globally. For these reasons, the need to develop new analytical methods for the determination of pesticide residues in the environmental samples, and especially in water, is obvious.

To control the presence of pesticides in the environment and to ensure the safety of human health, the Maximum Residue Levels (MRLs) for pesticides in food and water are legally regulated in most countries. MRLs of pesticides in I and II class of

waters, including drinking water, mineral waters and some surface waters in the EU are governed by Directive 98/83/EC (1998) and are estimated at 0.1 µg/L individually for each pesticide or the total amount of all present pesticides not to exceed 0.5 µg/L.

The most commonly used pesticides are phenoxy-carboxylic acids (e.g., 2,4-D), organonitrogen, among which triazines (e.g., atrazine), and organophosphorus (e.g., malathion, fenitrothion, parathion). Owing to the fact that they are soluble in water they can lead to serious pollution to the environment (soil, water and air) and to impact on human health (Cserháti and Szőgyi, 2012).

The most widely used analytical methods for analysis of phenoxy-carboxylic acids, triazines and organophosphorus residues in water samples are Gas Chromatography (GC) with Mass Spectrometry (MS) (Rocha et al., 2012), Flame Photometric Detector (FPD) (National Measurement Institute, 2013), Nitrogen Phosphorous Detector (NPD) (Food safety and standards authority of India, 2016), and Liquid Chromatography (LC) with Tandem Mass Spectrometry (MS/MS) (Donato et al., 2015) and fluorescence detector (National Measurement Institute, 2013). In spite of that they are less sensitive, HPLC (High Performance Liquid Chromatography) methods with diode array detection (DAD) are also used (Cappellini et al., 2012). In the previous papers the HPLC methods for determination of 2,4-D, atrazine, malathion, fenitrothion and parathion residues in water samples with ultraviolet diode array detection (UV-DAD) were developed and validated (Velkoska-Markovska and Petanovska-Ilievska, 2018, 2019). The previous methods were developed using analytical columns with higher length of 125 and 250 mm, and particle size of 5 µm. The aim of this paper was to develop a new HPLC method for qualitative and quantitative determination of 2,4-D, atrazine, malathion, fenitrothion and parathion residues in water samples using short, but more efficient analytical column with particle size of 3 µm. In this way, the duration of the chromatographic analysis would be reduced, and thus the consumption of organic solvents would be reduced as well.

MATERIAL AND METHODS

Reagents and Chemicals. The Pestanal analytical standards of 2,4-D (98.6 % purity), atrazine (98.8% purity), malathion (97.2 % purity), fenitrothion (95.2 % purity) and parathion (98.8 % purity), as well as, HPLC-grade acetonitrile and water were purchased by Sigma-Aldrich (Germany). Samples for the analysis of pesticide residues were taken from tap water, non-carbonated water, purchased from local supermarket and water from the Vardar River.

Equipment. The HPLC analyses were performed using an Agilent 1260 Infinity Rapid Resolution Liquid Chromatography system equipped with: vacuum degasser (G1322A), binary pump (G1312B), autosampler (G1329B), a thermostatted column compartment (G1316A), UV-VIS diode array detector (G1316B) and ChemStation software. The experiments were carried out on Purospher STAR RP-18e (30 x 4 mm; 3 m) analytical column produced by Merck (Germany). A vacuum manifold Visiprep (Supelco, Sigma-Aldrich) was used for the solid phase extraction (SPE).

Preparation of Stock Solutions. Stock solutions of 2,4-D, atrazine, malathion, fenitrothion and parathion were prepared by separately dissolving 0.0253, 0.0113, 0.0330, 0.0225 and 0.0188 g, respectively, of the pure analytical standards in acetonitrile in 25 mL volumetric flasks. The solutions were degassed for 15 min in an ultrasonic bath and stored in a refrigerator at 4 °C. Stock solutions were used for the fortification of water samples in order to test the method validation.

Sample preparation. The samples from the river Vardar were taken in brown glass bottles of 2.5 L. Immediately upon arrival in the laboratory, the samples were filtered through 0.45 µm nitrocellulose membrane filter.

Method Validation. Linearity, precision, recovery and limit of quantification (LOQ) were tested for the method validation. For realising that purpose, spiking samples were prepared by fortifying 1 L distilled water with three sets of concentrations (0.1, 0.2 and 0.5 µg/L for each analyte). Unspiked samples were used for blanks. After that, the samples were subjected to solid-phase extraction through the Supelclean ENVI-18 columns (0.5 g, 6 mL), before the HPLC analysis, and each sample was injected with volume of 5 µL.

RESULTS AND DISCUSSION

Chromatographic analyses were accomplished using the Purospher STAR RP-18e (endcapped) analytical column. It is suitable for efficient separation of base, neutral and chelating compounds by applying simple mobile phases, resulting in symmetrical chromatographic peaks without tails. This sorbent is made of extraordinarily pure silica gel, which surface is completely covered with C-18 radicals (ChromBook, 2011).

In order to obtain optimal conditions for separation of the analytes, a series of preliminary tests were implemented by changing the volume ratio of acetonitrile and water in the mobile phase. The best separation of the investigated pesticides with symmetrical peak shapes and satisfy purity indexes was achieved under an isocratic elution with mobile phase consisting of acetonitrile and water (47/53, *V/V*), a flow rate of 1 mL/min, a constant column temperature at 25 °C and UV detection at 220 nm. Compared to the results described in previous papers obtained using longer columns of the type LiChrospher 60 RP-select B with a length of 125 mm (Velkoska-Markovska and Petanovska-Ilievska, 2018) and 250 mm (Velkoska-Markovska and Petanovska-Ilievska, 2019), under these chromatographic conditions were obtained shorter retention times for the target pesticides, thus reducing the duration of the chromatographic analysis and the consumption of organic solvents as well.

The developed method was validated by testing specificity, selectivity, linearity, precision, accuracy, and limit of quantification (LOQ) according to the Guidance document on pesticide residue analytical methods (2010).

To confirm the specificity of the developed method, UV-diode array detection was used to check the peak purity and analyte peak identity. The purity index for all analytes was greater than 999 (the maximum value for the peak purity index (PPI) should be 1000), which means that the chromatographic peak was not affected by any other

compound. Identification of the analytes was done using the values for the retention time and match factor obtained by overlaid spectra of a pure analytical standard and absorption spectra of the same analyte in the water samples.

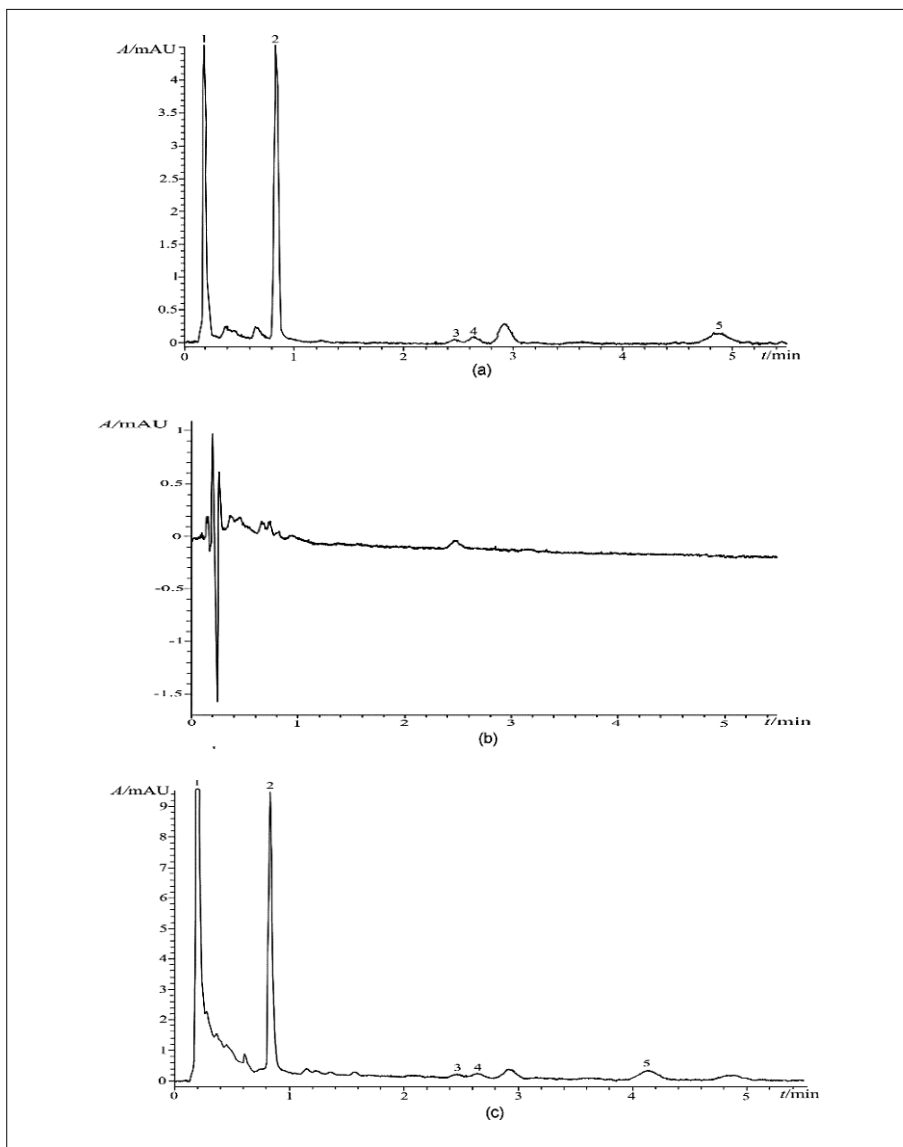


Figure 1. Chromatograms from standard mixture of 2,4-D (1), atrazine (2), malathion (3), fenitrothion (4) and parathion (5) at the concentrations which correspond to MRLs (a), blank sample (distilled water) (b) and samples of distilled water fortified at the concentration equal to MRL for each analyte (c)

Additionally, to prove selectivity of the method, in Figure 1 are presented chromatograms of standards at the concentrations which correspond to MRLs (a), blank sample (distilled water) (b) and sample of distilled water fortified at the concentration equal to MRL for each analyte (c). The chromatographic peak that appears near the expected peak of 2,4-D (Fig. 1b) in the blank sample has a completely different spectrum and much lower intensity than the 2,4-D.

The linearity of the method was determined using calibration curves obtained by triplicate injection of samples of distilled water enriched with the examined pesticides in 3 concentrations levels (0.1, 0.2 and 0.5 µg/L for each pesticide analysed) after a solid-phase extraction through the Supelclean ENVI-18 column. Each solution was injected with 5 µL. The obtained results for multiple correlation coefficients ($R^2 \geq 0.99$) suggested that the method has a satisfactory linearity for all analytes (Table 1).

Table 1. Statistical data for linearity of the method.

Compound	Linearity range (µg/L)	Regression equation	R^2
2,4-D	0.1 – 0.5	$^1y = 52.359x + 10.744$ $^2y = 26.394x + 10.555$	0.9999 0.9905
atrazine	0.1 – 0.5	$^1y = 85.298x + 16.621$ $^2y = 32.074x + 6.1532$	1 0.9997
malathion	0.1 – 0.5	$^1y = 3.9476x + 0.8652$ $^2y = 0.729x + 0.0645$	0.9995 0.9983
fenitrothion	0.1 – 0.5	$^1y = 14.64x + 0.7439$ $^2y = 1.8267x + 0.0972$	0.9973 0.9969
parathion	0.1 – 0.5	$^1y = 19.632x - 0.032$ $^2y = 1.3088x + 0.0394$	0.9999 0.9999

1y = peak area, 2y = peak height

The signal-to-noise ratio (S/N) at the lowest concentration level for each compound was found to be ≥ 10 for all investigated pesticides. Hence, the LOQ was estimated to be 0.1 µg/L for all examined pesticides. These obtained values for LOQs are acceptable for determining the pesticide residues in water samples according to the rules of Guidance document on pesticide residue analytical methods (2010).

To determine the precision of the developed method, five consecutive injections (5 µL) of a distilled water sample fortified with the investigated pesticides at the MRL level (0.1 µg/L) were done. The precision of the method was expressed as the repeatability of the results obtained for the retention time and the peak area for each analyte. The computed values of RSD (Table 2) for retention time (0.06 – 0.27 %) and peak area (0.39 – 4.51 %) indicated an excellent precision of the proposed method.

The recovery of the developed method was determined by adding 0.1, 0.2 and 0.5 µg/L of each analyte in 1 L distilled water. Samples of distilled water in which pesticides have not been added were used as blank samples. For each concentration level,

4 samples were prepared ($n = 4$). Subsequently, the samples were subjected to solid-phase extraction and HPLC analysis, and each sample was injected with 5 μL .

Table 2. Statistical data for Intra-day precision of retention time and peak area ($n = 5$)

Compound	t_R (min) \pm SD	RSD (%)	peak area \pm SD	RSD (%)
2,4-D	0.21 ± 0.004	0.22	16.09 ± 0.35	2.18
atrazine	0.83 ± 0.005	0.06	25.08 ± 0.10	0.39
malathion	2.62 ± 0.006	0.24	1.26 ± 0.04	3.14
fenitrothion	2.92 ± 0.004	0.13	2.38 ± 0.09	3.97
parathion	4.88 ± 0.01	0.27	1.90 ± 0.08	4.51

Table 3. Results from recovery experiments ($n = 4$)

Compound	Fortification level ($\mu\text{g/L}$)	Total analyte found ($\mu\text{g/L} \pm$ SD)	Recovery (%)	RSD (%)
2,4-D	0.1	0.102 ± 0.007	102.15	6.56
	0.2	0.200 ± 0.012	100.22	6.02
	0.5	0.495 ± 0.008	99.04	1.55
atrazine	0.1	0.096 ± 0.002	95.51	1.75
	0.2	0.202 ± 0.007	101.16	3.72
	0.5	0.498 ± 0.001	99.61	0.22
malathion	0.1	0.099 ± 0.010	99.30	10.06
	0.2	0.198 ± 0.019	99.14	9.59
	0.5	0.499 ± 0.041	99.75	8.31
fenitrothion	0.1	0.111 ± 0.006	111.47	5.78
	0.2	0.186 ± 0.006	92.87	3.03
	0.5	0.505 ± 0.003	98.55	4.43
parathion	0.1	0.098 ± 0.004	107.15	8.16
	0.2	0.207 ± 0.014	103.66	6.74
	0.5	0.496 ± 0.006	99.27	1.31

The obtained values for recovery and for relative standard deviation (Table 3) were within the following ranges 92.87 – 111.47 % and 0.22 – 10.06 %, respectively. The mean recovery at each fortification level in the range of 60 – 120 % and relative standard deviation (RSD) \leq 30 % per level are acceptable according to the Guidance document on pesticide residue analytical methods (2010). Consequently, it can be concluded that the proposed method was accurate and suitable for the determination of the target pesticide residues in water samples.

The developed high-performance liquid chromatography method was applied for the determination of 2,4-D, atrazine, malathion, fenitrothion and parathion residues in different water samples (tap water (a), non-carbonated water (b) and water from Vardar River (c)). Before HPLC analysis, samples were concentrated and clean-up using SPE. Each analysis was repeated five times, and each sample was injected with 5 μL . Typical chromatograms of the tested water samples are presented in Figure 2.

As can be seen from Figure 2, a chromatographic peak (X) was noticed at the beginning of all three chromatograms, with a retention time of 0.2 min (similar to 2,4-D), but with overlapping of its UV spectrum and that of the standard it was proved that this peak was not originate from the 2,4-D. Chromatographic peak (X_1) with a retention time of 0.79 min (similar to atrazine, $t_R = 0.83$ min) was present in the samples of drinking water (Figure 2b) and that of the Vardar River (Figure 2c), but the presence of this component has not been proven, because their spectra were quite different. The analysis performed by comparison of retention times and UV spectra shows that in the analysed samples no residues of the examined pesticides were found in a concentration corresponding to MRL or higher.

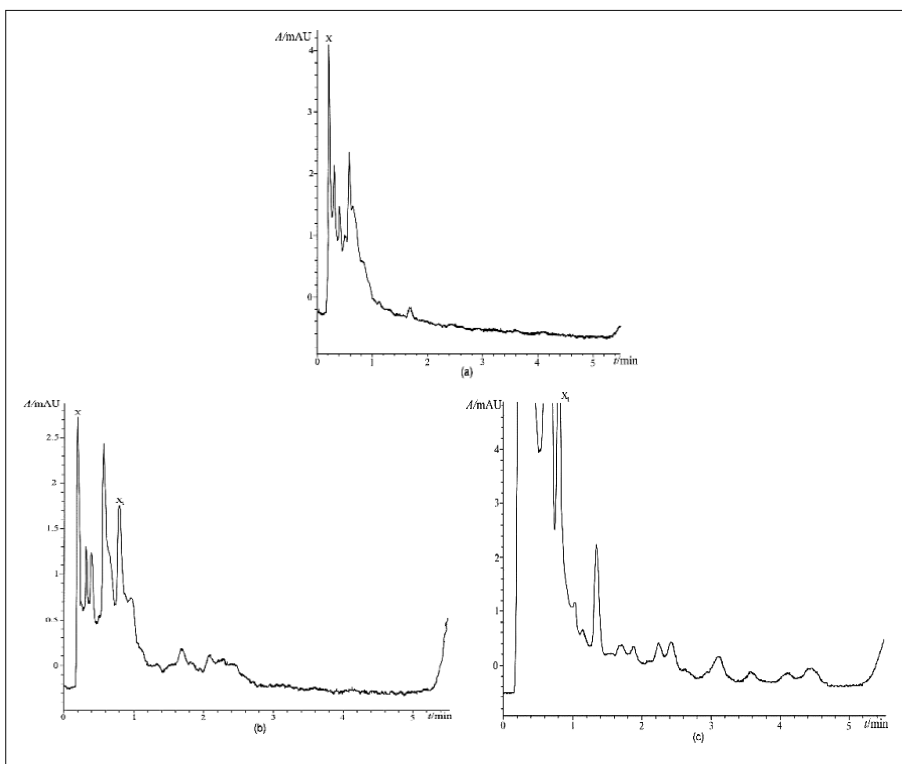


Figure 2. Typical chromatograms of water samples obtained from tap water (a), non-carbonated water purchased at the local market (b) and water from the Vardar River (c) at 220 nm

CONCLUSIONS

This paper describes a new possibility of successful determination of 2,4-D, atrazine, malathion, fenitrothion and parathion residues in water samples using high-performance liquid chromatography (HPLC) method and ultraviolet – diode array detection (UV-DAD). Specificity, selectivity, linearity, precision, recovery and limit of quantification (LOQ) were examined to assess the validity of the developed method. The developed method was successfully applied for the determination of target pesticide residues in tap water, non-carbonated water and water from Vardar River. The obtained results showed that analysed water samples did not contain detectable residues of investigated pesticides.

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**Ванр. проф. др Ленцче Велкоска-Марковска*,
проф. др. Биљана Петановска-Илиевска**

Сс. Кирил и Методије у Скопљу
Факултет пољопривредних наука и хране – Скопље,
Република Северна Македонија

* Одговорни аутор: levemar@gmail.com; lencevm@fznh.ukim.edu.mk

ХПЛЦ (HPLC) МЕТОДА ЗА ОДРЕЂИВАЊЕ НЕКИХ ОСТАКА ПЕСТИЦИДА У УЗОРЦИМА ВОДЕ

Извод

Развијена је и потврђена нова, тачна и погодна течна хроматографија високих перформанси (ХПЛЦ) са детекцијом ултраљубичасто-диодне матрице (УВ-ДАД) за одређивање остатака органофосфорних инсектицида и хербицида у различитим узорцима воде. Одвајање и квантитативно одређивање анализата извршено је употребом Пуроспхер СТАР РП-18е (30 x 4 mm; 3 m) аналитичке колоне, под изократском елуцијом са мобилном фазом која се састојала од ацетонитрила / воде (47/53, V/V), брзина протока од 1 mL / мин, константна температура колоне на 25 °C и УВ детекција на 220 nm. Добивени резултати су показали да анализирани узорци воде не садрже остатке испитиваних пестицида.

Кључне речи: *ХПЛЦ метода, остаци пестицида, узорци воде*



**Prof. dr Jasna Grabić, Msc Radoš Zemunac, Msc Senka Bubulj,
Mcs Bojana Dabić**

Department for Water Management, Faculty of Agriculture,
University of Novi Sad, Serbia
E-mail: jasnap@polj.uns.ac.rs

IMPORTANCE OF WATER FOR SAFE FOOD PRODUCTION AND PUBLIC HEALTH PROTECTION UNDER COVID-19 PANDEMIC

Abstract

The global COVID-19 pandemic during 2020 has led to the infection of 25 million people, causing deaths to 850000 and a serious economic crisis. Despite the fact that due to the pandemic economic growth and production was decreased, leading to a decrease in pollution in general, some specific pollution have emerged as a result of efforts to fight COVID-19. In such situation water can be waived as means of enabling hygienic conditions and raw material for industry, while at the other side wastewater can be assumed as a media for infection spreading. In this context, food production, considering it from field to shelf, food can be affected and contaminated. Risk occurs when contaminated water is used for food production, or when people engaged in production are proven to be infected. Therefore, special care has to be taken respecting safety measures during drinking water preparation and food production, as well as conducting proper wastewater treatment.

Keywords: *coronavirus, water resources, safe food production, public health*

INTRODUCTION

Water is an irreplaceable substance upon which all living forms on our planet are dependent. Sufficient quantities and good quality of water are necessary preconditions for the overall wellbeing of wildlife, and preservation of human health, as well as the progress of the economy. Nowadays, on a global level, it is evident that there is a water shortage, and in order to alleviate this, alternative sources of water are recommended, such as the use of grey and black water. These types of water, even of lower quality, but applied under controlled conditions successfully can be used for irrigation of crops

and outdoor greenery (Dabić et al., 2018). Recently, the global COVID-19 pandemic has posed new challenges to societies, and in this context water can play a significant role in mitigating the COVID-19 pandemic.

COVID-19 pandemic was announced by the WHO on 11th March 2020 (WHO, 2020a) and it represents a global threat. At the moment (end of August) there are more than 25 million infected people, above 850.000 deaths, across 215 countries and territories around the world (Worldometer, 2020). The pandemic has been caused by the virus SARS-CoV-2, which belongs to the SARS family, and thus representing enveloped viruses, more susceptible to environmental conditions and shorter survival out of the hosts' body in comparison to non-enveloped ones (WHO, 2020b). There are two main transmission routes of the COVID-19 virus: respiratory droplets and contact (WHO, 2020b). The major advantage in the fight against COVID-19 is its characteristic of short life outside the host from 7 (Chin et al., 2020) to 9 days (Kampf et al., 2020). In general countries with lower GDP (gross domestic product) and lower sanitation conditions are more prone to spreading infection. According to UNESCO and WHO (2019), in 2017 only nearly 60% of the global population had proper sanitation for providing enough drinking water and safe treatment/disposal of wastewater.

In circumstances of COVID-19 pandemic, clean water is essential not only for safe food production but also for maintaining hygienic/uncontaminated conditions in all links in the chain, starting from field/farm until it reaches customers. The aim of this paper is to indicate critical points where water is crucial for safe food production implicating the preservation of public health under conditions during the COVID-19 pandemic. In addition, the inappropriate quality of water can contribute to the infection spreading.

WHAT WATER CAN DO FOR ALLEVIATING AND OVERCOMING COVID-19 PANDEMIC?

Water has specific nature, being a universal solvent, it circulates in nature through the hydrological cycle, and the roles it plays in natural ecosystems and human societies, all the mentioned makes its importance multilateral. Water users are diverse, interconnected and tied by multiple bonds forming a complex nexus, In addition, water circulates not only in the inorganic environment but also through living organisms. Because of the complexity of the phenomena of water and its multiple pathways, the beneficial role of water, during the COVID-19 pandemic, can be viewed through: (1) clean potable water for drinking and keeping the general immune system at a high level – where intake of sufficient quantity of water (free of bacteria and other pathogens) represents undisputable precondition, (2) means for maintaining hygienic conditions (washing exposed parts of the body, indoor and outdoor cleaning), (3) production of disinfectants and drugs, etc., and (4) clean (good quality) water for the production of safe food.

On the other side, water can be considered as a medium for virus transmission and thus facilitating the COVID-19 pandemic spreading. With respect to the mentioned, there are two kinds of threats related to water.

Direct spreading of the virus by water

This kind of spreading can be achieved through:

- Direct transmission from an infected person by droplets after sneezing and coughing, and by aerosol (WHO, 2020).
- Presence of the virus in potable water – so far there was no evidence that coronavirus was found in potable water after preparation, but concern has been raised to continue providing sufficient quantities of clean water for maintaining other sanitation issues. Duration of survival of coronaviruses in tap water according to Gundy et al. (2009) is 10 days at 23°C.
- Presence of coronavirus in wastewater (WW): The virus had been confirmed in untreated wastewater and in receiving rivers (Ahmed et al., 2020; Gigantiello et al. 2020). Duration of coronavirus's survival in wastewater according to Gundy et al. (2009) is 2-4 days. Therefore, if surface water bodies are polluted by fecal water containing the virus there is a risk of infection spreading. In this respect, developing countries are especially vulnerable because in most cases wastewater treatment facilities (WWTF) are absent, and the most frequent solution is the deposition of WW in septic tanks, and if leaking this may also contaminate groundwater (Josimov-Dundjerski et al., 2015). On the other side developed countries, where majority of WW is properly treated are less exposed to such a risk, although in most cases secondary treatment represents the final stage in the treatment, and disinfection is not included. However, an argument in favor of WWTF is duration of the purification process, which takes 20-22 hours for huge facilities of e.g. about 100 000 inhabitants, thus affecting virus survival.

Pollution originating from efforts to fight pandemics

The second kind of threats is related to the production of substances and wastes resulting from the efforts of suppressing the pandemic.

- Increased use of drugs, such as antipyretics or antibiotics for treatment of infected patients, the speed of their degradation products in the environment can affect other organisms. For example, the antimicrobial activity of antibiotics can, not only affect the number of beneficial microorganisms in soil and water but also can decrease the number of bacteria in wastewater treatment plants – leading to lower efficiency of the purification process.
- Increased production and use of disinfectants for cleaning a variety of indoor and outdoor surfaces - cleaning surfaces represent the major measure in prevention from infection. The survival rate of the virus is different on a variety of surfaces and is dependent on surface type, i.e. the shortest on copper vs. the longest on plastic (Van Doremalen et al., 2020). The disinfectants are used for cleaning the most exposed parts of the human body, i.e. regular and thorough washing hands, washing working spaces, washing and disinfection of streets.
- Water is also used in the production process of protective clothes (facial masks and shields, clothes, gloves and boots) and equipment necessary in the prevention of COVID-19 spreading.

RECOMMENDATIONS FOR SAFE FOOD PRODUCTION AND SALES

In general, it is considered that COVID-19 cannot be transmitted by food, but this assumption cannot be taken as a rule, since there is no conclusive study reported in this regard (Makroo, et al. 2020). However, it is investigated that the virus can survive different periods on a variety of surfaces. If our food is considered as surface, with which humans can get into contact with the virus, then it is important to elaborate even on this issue. There are a few aspects associated with the issue of safe food: food production (including plant breeding and animal husbandry), storage, and putting groceries on stands for sale (on the grocery stores, the market places, and at the meat sellers). During crop breeding, the choice of irrigation method could be critical in protecting the farmers and the consumers from possible infections during the pandemic. Especially, sprinkler irrigation that generates airborne droplets (leading to aerosols), may be operated with caution in the vicinity of public spaces, because virus particles can spread over a greater distance depending on the environmental factors. Moreover, in developing countries surface irrigation practice based on pumping water from polluted rivers has to be regulated during the pandemic (Oliver et al., 2020). Other measures may include exposure to UV radiation, solar radiation or artificial, is proven to be a safe way to kill pathogens and extend the shelf life of food and beverages. Moreover, thorough

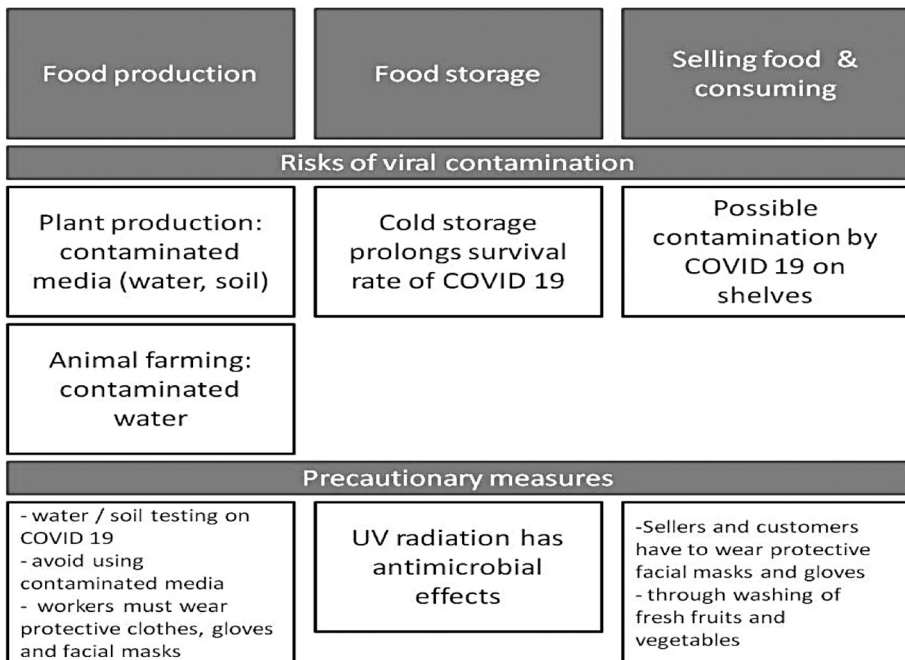


Figure 1. Possible hotspots of food contamination by COVID-19

washing of fresh fruit and vegetables is one of the unavoidable measures, and in some cases peeling. Possible hotspots of food contamination by COVID-19 are presented in Figure 1.

There are questions concerning the safety application of grey and black water. In both cases persons manipulating mentioned liquids that are potentially contaminated with the virus must obligatory respect safety measures, i.e. wearing protective clothes, gloves, and facial masks (Dabić et al, 2018). Therefore it is recommendable to:

- Avoid using for irrigation water and soil/manure contaminated by the virus (originating from human excreta or greywater).
- During the pandemic application of greywater has to be restricted only to the irrigation of outdoor greenery, not plants intended for food. As a precaution measure testing of these media on the presences of COVID-19 would be recommendable.
- If contaminated water/soil is used for plant or cattle breeding, there is a possibility for workers during manipulation, i.e. harvesting fruits or vegetables, or conducting regular on animal farm operations, to get in touch with the virus. Therefore, clean water – virus free is essential for the production of safe food in COVID-19 pandemic conditions.
- According to the literature it seems that temperature and storage time play an important role in virus survival (Gandy et al. 2009). Namely, in general, low temperatures are favorable for virus survival, while higher temperatures shorten the life of viruses out of the hosts' body. Besides, longer storage also contributes to reducing the virus's survival rate. Therefore, it is for recommendation to pay attention for on food that is stored in cold condition.
- Finally, food displayed on shelves also poses a certain risk to become contaminated; therefore both salesmen and customers need to wear at least protective facial masks.

CONCLUSION

Water is not just an essential substance that sustains life, but it has to be seen as the major agent in the process of prevention, but also in alleviation and finally alleviating COVID 19 pandemic. Given the importance of handwashing and adequate water supply provision in disease prevention generally, and in slowing the spread of COVID-19 in particular, it is imperative that service providers can rapidly adapt to their capabilities to the existing situation. Due to all elaborated aspects of water use in the COVID-19 pandemic, there is no doubt that water has a crucial role, whether clean in prevention, or contaminated – representing a potential threat. Therefore, special attention has to be paid to clever usage and management of this precious substance in order to overcome the COVID-19 pandemic in the shortest possible time.

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**Проф. др Јасна Грабић, мастер Радош Земунац, мастер Сенка Бубуљ,
мастер Бојана Дабић**

Департман за уређење вода, Пољопривредни факултет,
Универзитет у Новом Саду
E-mail: jasnap@polj.uns.ac.rs

ЗНАЧАЈ ВОДЕ ЗА БЕЗБЕДНУ ПРОИЗВОДЊУ ХРАНЕ И ЗАШТИТУ ЈАВНОГ ЗДРАВЉА УСЛЕД ПАНДЕМИЈЕ COVID-19

Сажетак

Глобална пандемија COVID-19 током 2020. године довела је до заразе 25 милиона људи, узрокујући смрт преко 850000 људи и економску кризу. Упркос чињеници да су због пандемије економски раст и производња смањени, што је довело до смањења загађења, појавило се специфично загађење као резултат напора у борби против COVID-19. У таквој ситуацији вода се може посматрати као средство за обезбеђивање хигијенских услова и сировина за индустрију, док се на другој страни отпадне воде могу сматрати медијумом за ширење инфекције. У том контексту, производња хране може бити угрожена, узимајући је у обзир пут од поља до рафова, а храна контаминирана. Ризик се јавља када се загађена вода користи за производњу хране, или када се покаже да су људи који се баве производњом заражени. Због тога се мора водити посебна пажња, поштујући мере безбедности током припреме воде за пиће и производње хране, као и правилно спровођење третмана отпадних вода.

Кључне речи: *коронавирус, водени ресурси, безбедна производња хране, јавно здравље*



Lazić G.^{1*}, Samojlović M.¹, Lupulović D.¹, Petrović T.¹, Lazić S.¹

¹* Scientific Veterinary Institute "Novi Sad"

* corresponding author: gospaval@gmail.com, goga@niv.ns.ac.rs

ENTERIC VIRUSES IN SURFACE WATER IN VOJVODINA AS A RISK FOR HEALTHY FOOD PRODUCTION

Abstract

The quality of water used for drinking, irrigation, industrial food processing or for recreational purposes, has a very important impact on human and animal health. So far, 33 surface water localities have been examined in territory of Vojvodina for the presence of 7 different viruses. The prevalence of enteric viruses in the total number of examined localities was up to 60%. These results unequivocally confirm that there is a risk to the health of animals and humans in the area that gravitates to the examined surface water. The risk to public and animal health is particularly significant in areas and localities where the tested surface water are used for agricultural purposes.

Key words: *surface water, viruses, qPCR, qRT-PCR, Serbia*

INTRODUCTION

The role of water in nature is more than significant. Water quality, whether used for drinking or irrigation, industrial food processing or for recreational purposes, has a very important impact on health. Viruses are of particular importance for human and animal health due to their wide distribution, rapid transmission, and great economic impact (Barardi et al., 2012). The presence of pathogenic viruses of humans and animals in the water reflects fecal contamination and indicates a danger to human and animal health. In addition to causing acute diseases, viruses are very important for public health due to their low infectious dose (Fong and Lipp, 2005). Although several viruses can cause acute gastroenteritis, human norovirus (NoV) has been shown to cause most epidemics of non-bacterial gastroenteritis worldwide. The direct source of human norovirus is feces of human origin. Several other RNA viruses such as rotavirus, sapovirus, astrovirus, and enterovirus can also cause epidemics of gastroenteritis

(Bosch et al., 2008; Petrovic, 2013). Adenoviruses can cause a variety of respiratory infections, eye infections, urogenital tract infections, gastroenteritis, and encephalitis. Human adenoviruses (HAdV) have been proposed as indicators of human fecal environmental pollution (Girones, 2013; Wyn-Jones et al., 2011). Swine adenovirus infection (PADV) is usually asymptomatic, with cases of mild diarrhoea or mild respiratory infection (Fong and Lipp, 2005). Bovine poliomyoviruses (BPyV) are relatively resistant to environmental factors and inactivation processes and have been proposed as indicators of animal fecal pollution in the environment (Girones et al., 2013). Hepatitis E virus (HEV), as a zoonotic virus that causes acute icteric hepatitis in humans, is a serious health problem in developing countries. Epidemics and sporadic infections in these countries are the result of fecal contamination of drinking water (Erker et al., 1999). Hepatitis E virus is significantly widespread in the pig population in Serbia (Lupulovic et al., 2010) and therefore may be present in surface water. Hepatitis A virus (HAV) infection is the leading cause of acute viral hepatitis worldwide (Hundesda et al., 2010).

Drinking water, surface water as well as water for recreational purposes in Serbia are controlled from the microbiological aspect, through bacteriological indicators, ie the bacteriological quality of water is determined. The presence of pathogenic viruses of humans and animals in the water reflects fecal contamination and indicates a danger to human and animal health, which is the main reason for establishing monitoring program of the virological quality of surface water.

SURFACE WATER CONTAMINATION

Besides water for bathing and recreation, water used for drinking and crop irrigation is also very often contaminated. This fecal waste may contain pathogenic microorganisms that may pose a risk to humans exposed to contaminated surface water. Studies conducted in both freshwater and marine water have shown that the level of fecal contamination in water increases the frequency of gastrointestinal diseases in swimmers (Dufour et al., 2012). Wastewater after treatment is most often discharged into recipients such as rivers, lakes and seas. Recipients can also be used for other purposes, such as sources of drinking water, water for irrigation and fish farming for human consumption, or for recreational purposes (Myrmel et al., 2015). Many rivers that are used as sources of drinking water after treatment are located downstream of treated wastewater and / or septic tanks, which is a very serious problem for the health of people who are supplied with water from such areas. Fecal contamination of animal origin may pose a risk for human infection with viruses, as many of them are zoonotic agents (Haramoto et al., 2012). Analyzes of untreated wastewater are an effective way to identify enteric viruses circulating in a population. Sewage systems collect pathogens and wastewater is transported to wastewater treatment plants. It was found that the concentration of microorganisms in wastewater is associated with the incidence of disease in the population (Kaas et al., 2015).

TRANSMISSION OF VIRUSES BY WATER

Surface water are used for the production of drinking water, for recreational purposes, for the shellfish and fish farming and for irrigation of crops. Humans can be exposed to pathogens through contaminated surface water in several ways: through (inadequately) treated drinking water, by drinking surface water directly during recreational activities, or by consuming contaminated food or food products (Lodder et al., 2015). Enteric viruses, including NoV, HAV and HEV, are considered very stable in the environment. After the dispersion of the virus into the environment, inactivation depends on the type of virus and the environment in which it is located. Enteric viruses can survive for a very long time (even a year) at temperatures below 5 °C, especially in the absence of UV radiation. Viruses such as HAV, HEV and NoV are resistant to inactivation for a very long time (Lodder et al., 2015). Numerous epidemics caused by viruses are caused by fecal contamination of drinking water and the water used for recreation. Many enteric viruses cause diseases in humans and animals and are then excreted in the feces. Fecal contamination of water used for drinking and food production is a major health problem (Masclaux et al., 2013).

DIRECTIVES AND LAWS IN THE REPUBLIC OF SERBIA

The directive on the protection of bathing water is adopted in order to protect people during recreation in surface water. Indicator organisms that should be controlled as the part of microbiological quality are fecal coliform bacteria and pathogenic viruses in water. The presence of fecal coliform bacteria does not necessarily correlate with the presence of pathogenic viruses in water (Lodder et al., 2015). In Serbia, there are a large number of regulations governing the water management. Besides the Water Law and bylaws, this area is regulated by regulations on the environmental protection system, spatial and urban planning, construction of facilities, local government, utilities, mining and energy, agriculture and forestry, navigation, geological research, waste management, concessions, foreign investments, etc. However, the basis for integrated water management in accordance with the principles of sustainable development and with respect to the principles accepted in the EU has not been provided in the Republic of Serbia.

Problems related to water management and protection of water quality are an issue of great importance to the European Union (EU). This topic becomes of special importance during the process of new EU members accession, because the problems related to water and environmental protection are more noticeable in economically less developed countries. That is why meeting the requirements and meeting EU standards in the field of water is an important condition for European integration. As the accession of the Republic of Serbia to the EU is an ongoing process, the cooperation with the EU is one of the priorities, as well as adjustment to European standards in all areas.

The field of nature protection is normatively regulated by the Nature Protection Law and other laws and bylaws that directly or indirectly relate to nature and natural

resources. The Nature Protection Law ("Official Gazette of the Republic of Serbia" No. 36/09 and 88/2010) which regulates the protection and preservation of nature, biological, geological and landscape diversity is of great importance for the normative regulation of this area, as well as many bylaws. The harmonization of legal regulations in the field of environmental and nature protection with EU regulations is ongoing.

PRESENCE OF VIRUSES IN SURFACE WATER

The first research on the presence of enteric viruses in surface water in Serbia was conducted in 2012. Thirty-three localities of surface water and sewage outflows in Vojvodina were examined. The most common virus detected in this study was human adenovirus. The prevalence of HAdV in the total number of surface water samples was 42.4% and 60.0% in relation to the number of tested localities. In the samples of city sewage water, the prevalence of HAdV was 44.4%. Norovirus GII was detected in 40.4% of surface water samples and in 56.7% of localities, while the presence of NoV GI in the total number of surface water samples was 15.2% and it was detected in 33.3% of examined localities. The prevalence of NoV GII and GI in sewage samples was 66.7% and 22.2% of the samples, respectively. The prevalence of PadV in the total number of tested surface water samples was 11.1% and it was present in 30.0% of the examined localities. However, out of 9 tested samples of urban sewage, PADV was not detected in any of them. The presence of BPyV was found in 7.1% of the examined samples and in 23.3% of the localities. Out of 9 tested samples of urban sewage, BPyV was detected in one of the tested samples. The prevalence of HEV in the examined surface water samples was 3.0%, as well as 10.0% of the examined localities. Out of 9 tested samples of urban sewage, HEV was not detected in any of them. Also, HAV was not detected in any of the analysed surface water, nor was it detected in urban sewage samples (Lazić et al., 2015, Lazić et al., 2018).

The presence of human adenovirus was found in 38.1% of samples originating from city beaches in Vojvodina. The obtained results indicate the potential risk to human health and the need for regular monitoring and reporting the level of contamination of water used for recreational purposes from virological aspect as well. The existence of risks to public health was indicated by another study in Vojvodina, in August and September 2014, in which the presence of human adenovirus was found in 67.0% samples from 5 city beaches in Vojvodina (Jovanović-Galović et al., 2016). Similar researches have been done in the world. Silva et al. (2010) detected HAdV in 44.4% of samples collected from rivers and lakes used for recreation and as a source of drinking water in the city of Goiania in Brazil. In a total of 132 samples of fresh and seawater used for recreation, collected from 24 different locations in nine different European countries, HAdV was detected in 60.6% of the samples (Bofill-Mas et al., 2010). Human adenovirus was detected in water samples with a prevalence of 25.0% to 75.0% in South Africa, Korea, Brazil, Singapore (Silva et al., 2010). In a study conducted in Hungary, noroviruses were detected in 30% of the samples of examined surface water (Kern et al., 2013). Also, the presence of NoV GI and GII in surface and sewage water, but also in sea and groundwater was confirmed in France, Poland,

Kenya, Brazil, USA, Singapore and the prevalence ranged from 9.3% to 71.7% (Lodder and de Roda Husman, 2005). The presence of PAdV in surface water has been confirmed in Hungary, Greece, Poland, Spain, Brazil (Kokkinos et al., 2012). On the territory of the Autonomous Province of Vojvodina there are city sewage outflow systems at 4 localities on Danube river in which the presence of this virus was determined, and it was assumed that the cause of contamination of the city sewage system were wastewater from animal slaughterhouses. These results indicated the need to monitor the presence of this virus, because it was found on the site of the city beach. Lazic et al, 2015. In Spain BPyV was detected in 95% of samples, and in Hungary in 78.29% (101/129), which proved that BPyV is a useful indicator for monitoring fecal contamination (Hundesda et al., 2010). In Greece, Poland and Serbia during 2009 and 2010 the presence of BPyV in water used for irrigation of lettuce was tested by real-time PCR. Virus was detected in 5.1% of samples. Also, in this case, the salad that was irrigated with this water and the land fertilizer on which the salad was grown were examined. Bovine poliomyelovirus was not detected in these samples (Kokkinos et al., 2012). Hepatitis E virus has been detected in surface water used for recreational purposes. The finding of this virus is of great importance, since several studies have confirmed that surface water can be a source of infection. Thus, several cases of HEV infection have been confirmed after bathing in the Ganges River in India after consuming surface water. In support of the fact that the construction of water treatment plants is of great importance are the results obtained in Italy: 16.7% of municipal sewage samples were positive for HEV before treatment, and after purification HEV was not detected in any of tested samples. Hepatitis A virus was not detected in surface or sewage water in Vojvodina, which was confirmed by the fact that the prevalence of HAV in the human population in the study period was extremely low. A similar study was conducted in Bangkok and the presence of HAV by RT-PCR was not determined in 48 samples of urban sewage. It is interesting to mention that in Nokia city contamination of drinking water with treated wastewater occurred, but HAV was not detected in either wastewater or drinking water by real-time RT-PCR (Maunula et al., 2009). In contrast to these studies, in many studies HAV was detected in sewage samples. These results have been published in Greece, South Africa, Cairo, Barcelona, Italy, and France (Kokkinos et al., 2011; Parasidis et al. 2013, Kaas et al., 2015).

PRESENCE OF VIRUS IN FRESH FRUIT AND VEGETABLES

In recent decades, the promotion of public health and healthier lifestyles has led to increased demand for fresh products in many industrialized countries. This has led to increased consumer demand for minimally processed, pre-packaged fruits and vegetables and the availability of these products out of season. Raw and minimally processed fruits and vegetables are usually sold to the consumer in a ready-to-eat form. These products generally do not contain preservatives or antimicrobials and are rarely subjected to any heat treatment before consumption. Consumption of vegetables and

fruits that are fecally contaminated has been recognized as a way of transmitting human enteric viruses.

Contaminated fresh food can lead to infection and viral gastroenteritis or hepatitis if consumed raw. Preventing virus contamination in the production and processing of fresh products can be more effective way than the treatment of food itself, which can often negatively affect food quality (Bouknekt et al, 2015). Several epidemics that have occurred in European countries were associated with the consumption of fresh fruits and vegetables that were contaminated through irrigation water. Water plays a key role in the transmission of fecal-oral pathogens. Freshwater in the environment has excellent conditions for the survival of enteric viruses. (Bouknekt et al, 2015).

In a study by Kokkinos et al. (2012) it was found that the prevalence of HAdV detected by real-time PCR in irrigation water originating from three countries (Greece, Serbia and Poland) was 27.9%, in lettuce as a raw product 26.4% and in fertilizer 60.0%. This study confirmed the possibility of viral contamination of vegetables and the existence of risks to human health, as well as the importance of the indicator virus for the determination of fecal contamination in water and food. In a similar study, using the same method, the presence of BPyV in 1/89 (1.1%) samples of raspberry irrigation water was found. This research demonstrated the potential of the virus to enter the food chain through contaminated food, in this case berries and water used in the fruit production process (Maunula et al., 2013). Water used in primary food production is a critical point for virus contamination of fruit and vegetables. (Maunula 2013).

CONCLUSION

The number and prevalence of detected pathogenic enteric viruses in surface water in the Autonomous Province of Vojvodina have unequivocally confirmed that there is a risk to animal and human health in the area that gravitates to the examined surface water. The risk to public and animal health is particularly significant in areas and localities where the tested surface water are used for agricultural and recreational purposes. Continuous monitoring of virological quality of surface water, as well as wastewater treatment in order to reduce the virus presence in surface water in the Autonomous Province of Vojvodina are of great significance to prevention and control of outbreaks of enteric viruses. It is necessary to establish systems to monitor the quality of water used in the primary production of fresh food because the presence of enteric viruses in the water poses a risk to public health.

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Lazić G.^{1*}, Samojlović M.¹, Lupulović D.¹, Petrović T.¹, Lazić S.¹

¹ Naučni institut za veterinarstvo "Novi Sad"

* autor za kontakt: gospaval@gmail.com, goga@niv.ns.ac.rs

ENTERIČNI VIRUSI U POVRŠINSKIM VODAMA U VOJVODINI KAO RIZIK ZA PROIZVODNJU ZDRAVSTVENO BEZBEDNE HRANE

Sažetak

Kvalitet vode koja se koristi za piće, navodnjavanje, industrijsku preradu hrane ili u rekreativne svrhe, ima veoma važan uticaj na zdravlje ljudi i životinja. Do sada je na području Vojvodine ispitano 33 lokaliteta površinskih voda na prisustvo 7 različitih virusa. Prevalenca enteričnih virusa na ukupnom broju ispitanih lokaliteta je inosila do 60%. Ovakvi rezultati nedvosmisleno potvrđuju da postoji rizik za zdravlje životinja i ljudi na području koje gravitira ispitanim površinskim vodama. Rizik za javno zdravlje i zdravlje životinja je posebno značajan na područjima i lokalitetima gde se ispitivane površinske vode koriste u poljoprivredne svrhe.

Ključne reči: *površinska voda, virusi, q(RT)-PCR, zdravstveno bezbedna hrana, Vojvodina*

**GENETICS, GENETIC RESOURCES,
BREEDING AND GENETIC ENGINEERING
IN THE FUNCTION OF PRODUCING
SAFE FOOD**



**Vera Rajičić^{1*}, Dragan Terzić¹, Vera Popović², Marijana Dugalić¹,
Snežana Branković³, Kristina Luković⁴, Milomirka Madić⁵**

¹ University of Niš, Faculty of Agriculture, Kosančićeva 4, 37000 Kruševac, Serbia

² Institute of Field and Vegetable Crops, Maxim Gorky 30, Novi Sad, Serbia

³ University of Kragujevac, Faculty of Science, Institute of Biology
and Ecology, Kragujevac, Serbia

⁴ Small Grains Research Centre, Save Kovačevića 31, Kragujevac, Serbia

⁵ University of Kragujevac, Faculty of Agronomy, Cara Dušana 34, Čačak, Serbia

E-mail: verarajcic@gmail.com

GENETIC POTENTIAL OF WINTER TRITICALE AS A HEALTHY SAFE FOOD

Abstract

The objectives of this study were to investigate: (1) the effects of cultivar, environment, and their interactions on the grain yield, test weight and 1000 kernel weight of winter triticale, and (2) the correlations between these traits in different environments. Based on the grain results during a three-year investigation with two cultivars, it can be concluded that the grain yield of triticale significantly varied across years, from 4.251 t/ha in 2010/11 to 5.791 t/ha in 2012/13 in the study.

The investigated period clearly indicates that highly significant effect of year was found on grain yield, test weight and 1000 kernel weight. Furthermore, test weight was highly significant regarding the interaction of the year and cultivar and significant for 1000 kernel weight.

Environmental conditions have had a significant effect on grain yield and quality in triticale. Grain yield shows a tendency to increase in the years having a higher total amount and better distribution of rainfall during critical plant development stages.

Key words: *cultivar, yield, quality, productivity, triticale*

INTRODUCTION

Triticale is cereal species gained by cross-breeding of wheat and rye. The yield per unit area is the result of the action of factors of variety fertility in interaction with environmental factors. Therefore, the yield is relative term and is determined by the

variety, environmental conditions and the level of applied technology. Yield is largely dependent on the genetic potential, which could be defined as yield of variety which was grown in conditions on which it had adapted, with adequate amounts of water and nutrients and efficient control of pests, diseases, weeds and other stresses (Đekić et al., 2014). Yields vary considerably primarily as a result of agro-ecological conditions during the growing season (Biberdžić et al., 2012; Bielski et al., 2020; Rajičić et al., 2020).

Triticale presented high tolerance regard the acid soils, as well as good productive results on sandy soils (Đekić et al., 2016). Soil acidity frequently affects agricultural production in Serbia. Triticale was planting where corn did not prosper, as well in the areas with moderate climate (Djekic et al., 2011; Biberdžić et al., 2017). It could be said that it inherited very good up to excellent tolerance regard the most important pathogens and small grains pests. Triticale presented high adaptability on local agro-ecological conditions, and it was influenced on stabile yield reaching.

New perspective triticale lines and varieties has more and better filled grain, higher yield, grain mass and farinaceous content, while proteins and lysine was smaller compared with older varieties (Milovanović et al., 2012; Kendal et al., 2016).

The objective of this study was to evaluate the effect of different fertilization systems on the grain yield and quality of triticale grown on a Pseudogley soil. The study was also aimed at optimizing fertilization for maximum profitability in the future triticale production in Western Serbia.

MATERIALS AND METHODS

Experimental design

During the three growing seasons, two cultivars of winter triticale (Trijumf and Odisej), cultivated at the experimental field in Valjevo were investigated. The experiments were conducted in randomized block systems, with a plot size of 50 m² (5 m x 10 m) in five replications. The sowing was carried out using a machine with row spacing of 12.5 cm. The soil on which the trial was conducted was uniform and well prepared. The amount of seed per square meter amounted to 400-450 viable seeds, depending on the characteristics of varieties. It was sown in the third decade of October, with 400 kg/ha of fertilizer NPK 15:15:15, which was added in the fall, while during the spring fertilization soil was supplemented with 300 kg/ha (KAN 27%N).

The following properties were analyzed: grain yield (t/ha), test weight (kg/hl) and 1000 kernel weight (g). Grain yields were measured for each plot and converted to yield tons per hectare on the basis of 14% grain moisture.

Soil Analysis

The trial was performed on soil that is characterized as pseudogley. According to the analysis, this is a soil of medium acidity, poor in humus, with a substitution and total hydrolytic acidity that were quite high (pH in H₂O=5.59, in KCl=4.50). The soil was moderately provided with total nitrogen, it is poor in easily accessible phosphorus

($P_2O_5 < 15$ mg/100 g of soil), a good provided of easily accessible potassium ($K_2O = 23-35$ mg/100 g of soil) was recorded.

Statistical Analysis

On the basis of achieved research results the usual variational statistical indicators were calculated: average values. Experimental data were analyzed by descriptive and analytical statistics using the statistics module Analyst Program SAS/STAT (SAS Institute, 2000) for Windows. All evaluations of significance were made on the basis of the ANOVA test at 5% and 1% significance levels.

Agroecological conditions

This study was conducted over a three-year period in the Kolubara district, Šumadija region, Western Serbia, on a Pseudogley soil, at Valjevo location, 176 m a. s. l. ($44^{\circ}19'N$ $19^{\circ}55'E$), in a temperate continental climate having an average annual temperature of $11.4^{\circ}C$, typical of Šumadija districts in Western Serbia and a rainfall amount of about 787.7 mm. Valjevo area is characterized by a moderate continental climate, which in general is characterized by uneven distribution of rainfall by month.

Table 1. Middle monthly air temperature and precipitation amount (Valjevo)

Months											
Interval	X	XI	XII	I	II	III	IV	V	VI	VII	Aver.
Mean monthly air temperature ($^{\circ}C$)											
2010/11	9.5	10.1	2.3	0.4	1.0	6.6	12.8	16.1	21.2	22.6	10.26
2011/12	10.7	2.9	4.1	0.8	-3.8	8.7	12.3	16.6	23.2	25.7	10.12
2012/13	13.4	9.4	0.9	3.1	4.2	6.5	13.7	17.6	20.5	22.8	11.21
Average	11.7	6.1	1.9	0.6	2.0	6.6	11.6	16.8	19.9	21.9	9.91
The amount of precipitation (mm)											
2010/11	83.3	39.4	56.7	53.0	75.9	76.1	65.6	117.8	216.8	121.0	905.6
2011/12	32.7	9.3	66.6	28.2	53.7	32.4	33.4	161.4	27.5	101.4	546.6
2012/13	31.0	21.2	105.2	95.4	67.5	14.6	86.6	115.1	28.2	19.4	584.2
Average	62.9	62.7	60.6	49.9	44.6	57.9	59.9	72.1	110.2	71.0	651.8

The data presented in Table 1 for the analyzed triticale growing season (2011-2013) clearly suggest differences in weather conditions between the years of the study and the long-term mean for the region. The average air temperatures were by $0.35^{\circ}C$, $0.21^{\circ}C$ and $1.3^{\circ}C$ higher in 2010/11, 2011/12 and 2012/13, respectively, as compared to the long-term mean, whereas the sums of rainfall were by 253.8 mm higher in 2010/11 years and lower by 105.2 mm and 67.6 mm in 2011/12 and 2012/13 as compared to the long-term mean. Compared to the long-term mean, total rainfall

values, especially in the first year, second and third year, were considerably higher in February, April and May, whereas total rainfall in April 2011/12 decreased by 26.5 mm. Given the high importance of sufficient rainfall amount during the spring months, particularly April and May, for triticale production, the distribution and amount of rainfall over the growing season 2012/13 were considerably more favorable, resulting in increased yields in this year. Apart from the rainfall deficiency during the spring months and the non-uniform distribution of rainfall across months, an increase in average air temperatures was also observed. The warmest month, on average, is July with an average temperature of 21.9°C. The coolest month on average is January, with an average temperature of 0.6°C.

Variations in the temperature, in the amount of precipitation during vegetation as well as in the soil moisture content are the most important factors of the yield instability (Popović et al., 2011; Biberdžić et al., 2012; Đekić et al., 2014; Jelic et al., 2015). It is known that individual or mutual influence of abiotic stress factors (high and low temperatures, drought, acidic and saline soil) in different triticale growth stages limit the expression of the maximum grain yield potential (Djekic et al., 2011; Biberdžić et al., 2017; Terzic et al., 2018; Rajičić et al., 2020).

RESULTS AND DISCUSSION

Grain yield, 1000 kernel weight and test weight

Average values of grain yield, 1000 kernel weight and test weight at investigated winter triticale varieties are presented in the Table 2. The grain yield of triticale significantly varied across years, from 4.251 t/ha in 2010/11 to 5.791 t/ha in 2012/13 (Table 2). During the first year of investigations (2010/11), variety Trujumf achieved the highest yield of grain (4.305 t/ha). During the second year of investigations (2011/12), the grain yield of variety Trujumf was the highest with 4.784 t/ha, while the slightly lower yield was realized by variety Odisej (4.605 t/ha). In 2012/13, yield significantly varied across cultivars, from 5.621 t/ha of variety Odisej to 5.961 t/ha of variety Trujumf (Table 2).

Table 2. Average values of investigated triticale varieties characteristics

Varieties	2010/11		2011/12		2012/13		Average	
	\bar{x}	S	\bar{x}	S	\bar{x}	S	\bar{x}	S
Grain yield, (t/ha)								
Trujumf	4.305	0.490	4.784	0.241	5.961	0.503	5.016	0.822
Odisej	4.198	0.723	4.605	0.486	5.621	0.326	4.808	0.794
Average	4.251	0.585	4.694	0.374	5.791	0.438	4.912	0.801

Test weight (kg/hl)								
Trijumf	67.99	1.244	71.49	1.719	76.49	1.857	71.99	3.913
Odisej	63.44	1.345	73.97	1.635	76.69	2.455	71.37	6.163
Average	65.71	2.691	72.73	2.052	76.59	2.055	71.68	5.082
1000 kernel weight (g)								
Trijumf	38.86	0.727	39.58	1.050	42.60	1.114	40.35	1.906
Odisej	37.92	0.634	40.44	1.228	44.20	1.044	40.85	2.827
Average	38.39	0.812	40.01	1.168	43.40	1.322	40.60	2.383

Achieved statistically significantly higher yields in 2012/13 were, primarily, the result of heavy rainfalls and their good distribution as well as favorable air temperatures during the vegetation period (Table 1). Namely, the total rainfall is reflected on the multiannual average, but the distribution, especially in the critical stages of development, was significantly disrupted (Đekić et al., 2014; Terzic et al., 2018; Rajičić et al., 2020). Đekić et al. (2016) in his research states that the air temperatures and the rainfall amount and distribution during the triticale growing season have the greatest impact on high yields and grain quality. Milovanovic et al. (2012), states that in the domestic production conditions, higher yields are achieved by varieties with shorter growing season because they manage to form the largest part of the yield before the advent of high temperatures. In this study, the triticale was not exposed to extremely high temperatures so early growth did not come into its own.

Table 2 presents average values for grain test weight across years and varieties. The average values for test weight significantly varied across years, from 65.71 kg/hl in 2010/11 to 76.59 kg/hl in 2012/13 (Table 2). During the first year of investigations, variety Trujumf achieved the highest test weight (67.99 kg/hl). During the 2011/12 and 2012/13, variety Odisej achieved the highest test weight (73.97 kg/hl and 76.69 kg/hl). Average test weight observed in the three-years period was the highest at Trijumf variety (71.99 kg/hl), while the lowest yield was obtained by Odisej cultivar (71.37 kg/hl). Generally, the test weight of triticale ranged from 63 to 72 kg/hl, while in dehulled triticale up to 80 kg/hl (Đekić et al., 2014; Kendal et al., 2016; Terzic et al., 2018; Rajičić et al., 2020).

The thousand kernel weight of winter triticale grain was variable, depending on environmental conditions. Thousand kernel weight in the test period was highest in 2012/13 (43.40 g), but significantly decreased in 2010/11 (38.39 g). Average thousand kernel weight observed in the three-years period was the highest at Odisej variety (40.85 g). Previously, many researchers have reported that the 1000-kernel weight values of triticale genotypes have ranged from 23.9 g to 54.9 g (Đekić et al., 2014; Kendal et al., 2016).

Analysis of variance between observed traits of triticale

The analysis of yield variance, test weight and 1000-kernel weight of tested winter triticale varieties grown at investigated Valjevo during three growing seasons, are shown in Table 3.

Table 3. Analysis of variance of the tested parameters (ANOVA)

Effect of year on the traits analyzed				
Traits	Mean sqr Effect	Mean sqr Error	F (2. 27)	p-level
Grain yield (t/ha)	6.2802	0.2245	27.968	0.000
Test weight (kg/hl)	303.9591	5.2248	58.176	0.000
1000-kernel weight (g)	65.3610	1.2570	51.999	0.000
Effect of cultivar on the traits analyzed				
Traits	Mean sqr Effect	Mean sqr Error	F (1. 28)	p-level
Grain yield (t/ha)	0.3261	0.6535	0.499	0.486
Test weight (kg/hl)	2.9141	26.6455	0.109	0.743
1000-kernel weight (g)	1.9253	5.8119	0.331	0.569
Effect of the year x cultivar interaction				
Traits	Mean sqr Effect	Mean sqr Error	F (2. 24)	p-level
Grain yield (t/ha)	0.0356	0.2361	0.151	0.861
Test weight (kg/hl)	32.1591	3.0766	10.453	0.001
1000-kernel weight (g)	4.2663	0.9783	4.361	0.024

Based on the analysis of variance, it can be concluded that there are highly significant differences in grain yield in regard to the year of investigation ($F_{\text{exp}}=27.968^{**}$), while among the investigated triticale varieties the differences were not significant. Analysis of variance was found highly significant effect of year on the test weight ($F_{\text{exp}}=58.176^{**}$) and 1000-kernel weight ($F_{\text{exp}}=51.999^{**}$). The results of significance between years and yield of grain are in accordance with the results of other authors (Đekić et al., 2014; Terzic et al., 2018; Rajičić et al., 2020). Based on the analysis of variance, it can be concluded that there are no significant differences in grain yield, 1000-kernel weight and test weight at investigated triticale varieties were found relative to the cultivar of investigation (Table 3). The interaction of the investigated factors (Y x G) exhibits are no significant affect in grain yield ($p>0.05$), but significant affect in 1000-kernel weight and highly significant in test weight. The present results confirm the opinion of many authors that the traits analyzed are genetically determined but are strongly modified by the environment and weather conditions (Jelic et al., 2015; Đekić et al., 2016; Terzic et al., 2018; Rajičić et al., 2020).

Correlations between the analysed traits

The correlations of yield, test weight and 1000-kernel weight of tested winter triticale varieties during three growing seasons, are shown in Table 4.

Table 4. Correlations between the traits analyzed

Correlations between the traits analyzed in 2010/11			
Traits	Grain yield	Test weight	1000-kernel weight (g)
Grain yield (t/ha)	1.00	0.19	0.01
Test weight (kg/hl)		1.00	0.39
1000-kernel weight (g)			1.00
Correlations between the traits analyzed in 2011/12			
Grain yield (t/ha)	1.00	-0.28	-0.07
Test weight (kg/hl)		1.00	0.25
1000-kernel weight (g)			1.00
Correlations between the traits analyzed in 2012/13			
Grain yield (t/ha)	1.00	-0.21	0.02
Test weight (kg/hl)		1.00	0.35
1000-kernel weight (g)			1.00

Positive correlation coefficients, in 2010/11, were found between yield and test weight (0.19) and 1000-kernel weight (0.01) and were found between test weight and 1000-kernel weight (0.39), (Table 4). During the second year of investigation (2011/12), grain yield was negative but not significantly correlated with and test weight (-0.28) and 1000-kernel weight (-0.07). Test weight was positively correlated with 1000-kernel weight (0.14) in 2011/12. Positive correlation coefficients, in 2012/13, were found between yield and 1000-kernel weight (0.02) and between test weight and 1000-kernel weight (0.35). Insignificant negative dependencies were found between yield and test weight (-0.21), as shown in Table 4. Recorded significant correlations between analysed traits are in agreement with investigations of other authors (Đekić et al., 2014; Terzic et al., 2018; Rajičić et al., 2020).

CONCLUSIONS

Based on obtained results during the three-year investigation on two winter triticale varieties, it can be concluded that the largest three-year average and the best adaptability in the continental climate of Western Serbia at grain yield and test weight expressed the variety Trujumf.

The highly significant influence of the year on grain yields, test weight and 1000-kernel weight was established at investigated winter triticale varieties by variance analysis, while genotype influence on grain yields, test weight and 1000-kernel weight was not statistically significant.

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**Vera Rajčić^{1*}, Dragan Terzić¹, Vera Popović², Marijana Dugalić¹,
Snežana Branković³, Kristina Luković⁴, Milomirka Madić⁵**

¹University of Niš, Faculty of Agriculture, Kosančićeva 4, 37000 Kruševac, Serbia

²Institute of Field and Vegetable Crops, Maxim Gorky 30, Novi Sad, Serbia

³University of Kragujevac, Faculty of Science, Institute of Biology
and Ecology, Kragujevac, Serbia

⁴Small Grains Research Centre, Save Kovačevića 31, Kragujevac, Serbia

⁵University of Kragujevac, Faculty of Agronomy, Cara Dušana 34, Čačak, Serbia

E-mail: verarajcic@gmail.com

GENETSKI POTENCIJAL OZIMOG TRITIKALEA KAO ZDRAVSTVENO BEZBEDNE HRANE

Sažetak

Ciljevi ove studije bili su istražiti: (1) uticaje sorte, životne sredine i njihove interakcije na prinos zrna, hektolitarsku masu i masu 1000 zrna kod ozimog tritikalea i (2) povezanost tih osobina u različitim vegetacionim sezonama. Na osnovu dobijenih rezultata, tokom trogodišnjeg istraživanja dve sorte tritikalea, može se zaključiti da je prinos zrna tokom godina značajno varirao od 4.251 t/ha u 2010/11 do 5.791 t/ha u 2012/13. Analizom varijanse ustanovljen je izuzetno značajan uticaj godine na prinos zrna, masu 1000 zrna i hektolitarsku masu. Štaviše, hektolitarska masa bila je vrlo značajna i značajna za masu 1000 zrna kod interakcije godina x sorta.

Uslovi životne sredine su imali značajan uticaj na prinos zrna i kvalitet tritikalea. Prinos zrna pokazuje tendenciju rasta u godinama koje imaju veću ukupnu količinu i bolju raspodelu padavina tokom kritičnih faza razvoja biljaka.

Ključne riječi: *sorta, prinos, kvalitet, produktivnost, tritikale*



Violeta Mickovski Stefanović¹, Dragana Stanisavljević²,
Sonja Simić³, Predrag Ilić⁴

¹ Institute "Tamiš", Pančevo, Serbia

² Academy of Vocational Studies Southern Serbia – Department of Agricultural
and Food Technology, Prokuplje, Serbia

³ University of Novi Sad, Faculty of Technology, Novi Sad, Serbia

⁴ University of Nis, Faculty of Philosophy, Niš, Serbia

E-mail: vikivms15@gmail.com

THE EFFECT OF GENOTYPE AND LOCATION ON THE HEAVY METAL CONTENT IN WHEAT ROOTS AT HEADING STAGE

Abstract

Heavy metals represent a very significant group of environmental pollutants because they are potential metabolic inhibitors. A study was conducted in order to determine the content of heavy metals (Zn-56.0 mg/kg, Pb-17.9 mg/kg) and their accumulation in the wheat roots of *Triticum sp.* in the heading stage of four wheat varieties, to obtain information on the health safety of cultivated genotypes, and to determine which variety of wheat is the least susceptible to the accumulation of heavy metals. Variations in the content of lead and zinc in wheat roots in the grading phase were expressed at all localities and in all varieties so that the differences were statistically significant (Pb- 1.00-3.17 mg/kg; Zn-3.73-4,67 mg/kg).

Keywords: *heavy metals, Triticum spp., atomic absorption spectrophotometry*

INTRODUCTION

Heavy metals are a significant group of environmental pollutants since they are hardly biodegradable and are characterized by a cumulative effect. The retention period for Cu, Ni, Pb, Se, and Zn is from 1.000 up to 3.000 years.

One of the ways of contaminating food products with heavy metals is the technological process of their production. An example of this is the contamination of the material with metal particles (copper, zinc, and iron) during grinding. Improper storage

and warehousing are also sources of contamination of food products with heavy metals (Jakovljević i dr., 1997). The air in industrial zones is also a significant source of pollution (Škrbić i dr., 2004).

Studying the ash content caused by burning fossil fuels (Bogdanović, 2002), high concentrations of heavy metal ions were found. *Triticum sp. L.* is the most important cultivated plant, and it is the basic strategic product of almost every country in the world (Popović, 2010). The accumulation of lead is more intense in the root than in the aboveground organs.

This research aimed to establish the levels of heavy metals in the soil (Zn, Pb, and Cd) and content in *Triticum sp.* to obtain information on the health safety of the bred genotypes and to establish which wheat type is least prone to accumulating heavy metals.

MATERIAL

The research on how the genotypes and location influence the heavy metals accumulation dynamics in wheat vegetative organs were conducted in four locations:

1. Experimental field in Vojlovica (200m – 500 m from the industrial area)
2. Experimental field in Stari Tamiš (5.000 m from the industrial area)
3. Experimental field of Institute of Tamiš, usual agricultural methods (10.000 m from the industrial area)
4. Experimental field of Institute of Tamiš, agricultural methods without the use of chemicals (10.000 m from the industrial area)

The research subjects were four varieties of wheat: Ljiljana, Pobeda, Renaissance, and Apache.

Standard agricultural methods were applied in the production of wheat. The fore-crop on all the experimental fields was maize. In primary treatment, executed after the maize harvest, the residuals were plowed over. At the same time, presowing preparation was carried out with seedbed cultivators at a depth of 6-8 cm. The mechanical sowing was executed, depending on the weather conditions, during October.

For basic fertilizing of wheat crops, 300 kg ha⁻¹ NPK fertilizer was used in 16:16:16 ratio. Additional fertilizing was done during February 2011 with 100 kg of urea.

PLANT MATERIAL PREPARATION METHODS

The samples of plant material, stems were prepared by finely chopping and drying in the drier at 80 °C. To thus prepared 1g of the sample, 20 ml of 60% HNO₃ was added and put to moderate boiling for 2 hours. After cooling, 3 ml H₂O₂ was added, and then put to boil for another 15 min. The peroxide procedure was repeated. After cooling, 2 ml HClO₄ were added and put to lightly evaporate until thick white perchloride vapor

appeared (Jones i Case, 1990). Then 5 ml of 5M HCl was added, after which the samples were transferred in quantity to normal 50 ml lab dishes and topped to the max volume with distilled water. The solution was then filtered through a quantitative filter paper.

HEAVY METAL CONTENT

The content of heavy metals (zinc, lead, chromium, copper, and cadmium) was determined after the material was treated with concentrated nitric acid and hydrogen peroxide (Krishnamurty i dr., 1976).

The results were obtained through atomic absorption spectrophotometry in acetylene/ air flame (Varian Spectra AA 220 FS).

RESULTS AND DISCUSSION WHEAT ANALYSIS

The content of heavy metals was analyzed in four different wheat varieties (Ljiljana, Pobeda, Renaissance, and Apache), depending on the locality.

Table 1. Zn content in wheat roots, heading stage, mg kg⁻¹

Variant	Pobeda	Ljiljana	Renesansa	Apache	Prosek
Control, Experimental field	2,54 ^b ^a	4,26 ^a	3,89 ^a	3,26 ^b	3,49 ^a
NPK, Stari Tamiš	4,11 ^b	5,94 ^b	4,49 ^b	4,34 ^c	4,72 ^c
NPK, Experimental field	4,26 ^b	4,30 ^a	4,14 ^b	2,78 ^a	3,87 ^b
NPK, Vojlovica	5,92 ^c	4,16 ^a	3,43 ^a	4,54 ^c	4,51 ^c
Average	4,21	4,67	4,00	3,73	4,15
F test – varieties	0,7080081				
F test – locations	1,802535				
LSD 5%	1,4516; 1,3075				
LSD 1%	1,3075; 1,8332				

In wheat roots, in the heading stage, the Apache variety had, on average, the lowest zinc content, while the highest zinc content was recorded in the Ljiljana variety. The tested varieties can be arranged in the following order in terms of zinc content (Table 1): *Ljiljana* > *Pobeda* > *Renesansa* > *Apache*.

Table 2. Pb content in wheat roots, heading stage, mg kg⁻¹

Variant	Pobeda	Ljiljana	Renesansa	Apache	Prosek
Control, Experimental field	0,25 ^a	1,21 ^a	0,91 ^a	0,84 ^a	0,80 ^a
NPK, Stari Tamiš	2,28 ^b	3,19 ^b	2,07 ^c	1,02 ^b	2,14 ^b
NPK, Experimental field	4,03 ^d	4,23 ^d	1,46 ^b	1,27 ^b	2,75 ^b
NPK, Vojlovica	3,25 ^c	4,03 ^d	0,81 ^a	0,88 ^a	2,24 ^b
Average	2,45	3,17	1,31	1,00	1,98
F test – varieties	3,266618				
F test – locations	1,77422				
LSD 5%	1,7131; 1,9217				
LSD 1%	2,4018; 2,6943				

Roots of the *Apache* wheat variety, had on average, the lowest lead content, while the *Ljiljana* variety had the highest. The lead content of the examined variants decreased in the following order (Table 2): *Ljiljana* > *Pobeda* > *Renesansa* > *Apache*.

The lowest content of both taken up heavy metals in relation to other varieties was noticed in the *Apache* variety. The *Ljiljana* variety took up the most Zn -4,67 mg kg⁻¹ in its roots, followed by Pb -3,17 mg kg⁻¹. It was noticed that Zn was the most accumulated heavy metal in other varieties, followed by Pb. This indicates that Zn is more easily taken up by the roots compared to Pb. If we look at the differences in the varieties, we can see that the *Apache* variety is the least susceptible to heavy metals accumulating.

CONCLUSIONS

The results indicate that the heavy metal content is more affected by intensive agricultural practices (use of chemicals) than the proximity of industrial areas. The higher content of lead present in the plant tissue was due to the proximity of the roads and industrial complexes and from improper waste disposal, which often contains salts of different heavy metals. Based on the results from the research of heavy metals uptake by different varieties of wheat, the variety *Apache* can be recommended for growing, considering that it has shown the lowest absorption of all heavy metals.

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**Violeta Mickovski Stefanović¹, Dragana Stanisavljević², Sonja Simić³,
Predrag Ilić⁴**

¹ PSS Institut Tamiš, Pančevo, Srbija

² Akademija Južna Srbija, Odsek za poljoprivredno-prehrambene studije,
Prokuplje, Srbija

³ Tehnološki fakultet, 21000 Novi Sad, Bulevar cara Lazara 1

⁴ Univerzitet u Nišu, Filozofski fakultet, Niš, Srbija

E-mail: vikivms15@gmail.com

UTICAJ GENOTIPA I LOKALITETA NA SADRŽAJ TEŠKIH METALA U KORENOVIMA PŠENICE U FAZI KLASANJA

Izvod

Teški metali predstavljaju vrlo značajnu grupu zagađivača životne sredine jer su potencijalni metabolički inhibitori. Sprovedeno je istraživanje u cilju određivanja sadržaja teških metala (Zn-56,0 mg/kg, Pb-17,9 mg/kg) i njihova akumulacija u korenovima pšenice – *Triticum sp.*, u fazi klasanja kod četiri sorte pšenice, radi dobijanja informacija o zdravstvenoj ispravnosti gajenih genotipova, i da se utvrdi koja je sorta pšenice najmanje podložna akumulaciji teških metala. Variranja sadržaja olova i cinka u korenovima pšenice u fazi klasanja su izražena na svim lokalitetima i kod svih sorti, tako da su razlike bile statistički značajne (Pb- 1,00-3,17 mg/kg; Zn- 3,73-4,67 mg/kg).

Ključne reči: *teški metali, Triticum sp., atomska apsorpciona spektrofotometrija*

**FERTILIZERS AND FERTILIZATION
PRACTICE IN THE FUNCTION
OF PRODUCING SAFE FOOD**



Ana Radulović¹, Marija Bukilica¹

¹ Faculty of Maritime Studies Kotor

E mail: bukilica.marija@gmail.com

FERTILIZERS AND FERTILIZATION IN THE FUNCTION OF HEALTHY SAFE FOOD PRODUCTION

Abstract

In the process of development of the human population and civilization, technical and technological

Numerous types of fertilizers provide plants with growth and development. With regular fertilization, the plants are maintained, and all that affects the vegetables we consume. Organic fertilizer is the best because it provides plants with everything they need and the fruits are much better. Fertilizers are very important for the entire plant world and they definitely need attention.

Key words: *fertilization, plants, food*

INTRODUCTION

In the world, more and more funds are allocated for research in the development of methods for obtaining energy from renewable sources, in order to harmonize the Multivitamins for plants - these are fertilizers. Thanks to fertilizer, a plant that has no chance of surviving in accordance with natural conditions, can succeed thanks to fertilization. Poorly fed plant stands out from the quality in terms of appearance, flowers, fruit, etc.

Plant food is everything that makes a plant unique. Accordingly, we have some fertilizers that are more important and of better quality, and some that help in accordance with their quality. All fertilizers have the following elements:

- Nitrogen,
- Phosphorus,
- Potassium.

Fertilizers have many benefits but also many disadvantages. Each type of fertilizer has its own instructions on how it can be used to make a particular plant succeed. Neither too much nor too little fertilizer is good. Many people make a mistake in that, so putting more fertilizer is already necessary, but they cause a counter-effect. Namely, a large amount of fertilizer often contains much more nutrients than plant needs, but also their ability to absorb (eg in the early pheno-phases while the plants are still small and poorly developed roots, dry, cold, compacted or moist soil, etc.). Some of the excess nutrients (so-called luxury diets) will turn into less available forms, and excess nutrients can prolong or shorten vegetation and cause root and / or leaf damage resulting in lower yields of poor quality (Chand, 2006).

That is why it is necessary to use fertilizers rationally and only in that way can the plant be helped.

TYPES OF FERTILIZERS

In order to devise simple and effective strategies, it is important to know what the organization is particularly good at and what it is not, as well as what resources and assets.

Mineral fertilizers (synthetic or chemical) are divided according to the origin, purpose, composition and method of production, and according to their function they are divided into:

- Immediate or real mineral fertilizers are influenced by the aqueous phases of the soil, so they manage to develop all the necessary ingredients and help the plant to receive them.
- Indirect fertilizers contain biogenic elements and significantly help the plant
- Complete fertilizers give the plant all the essential ingredients and as such help it, so often the use of no other ingredients is necessary.
- Incomplete fertilizers are such a type of fertilizer that they have some good components, but it is always necessary to use some additional means to strengthen the plant.
- Mixed fertilizers, as their name suggests, are created by mixing more fertilizers.
- Pelletized mineral fertilizers or compound fertilizers are actually agglomerated mixed fertilizers (Kaur, 2005).

Most mineral fertilizers are soluble in water, which also allows a high rate of loss. About 1/3 of nitrogen is lost through the movement of water in the soil (mass flow) or diffusion (movement from higher concentrations at the application site to areas outside the root zone or groundwater). Nitrogen mineral fertilizers have a short duration of action because the nitrogen in mineral fertilizers is found in either nitrate or ammonia form. Due to the rapid transformation of nitrogen in the soil, there is an increase in the possibility of its transfer from the rhizosphere and significant losses due to nitrate leaching. In conditions of high humidity and descending water movement, nitrates

move together with water and reach groundwater, which causes environmental pollution on the one hand, and on the other - they are permanently lost to the plant. Ammonia nitrogen is slightly lost by volatilization (like ammonia in the gaseous state). Mineral fertilizers significantly affect ammonia emissions, soil acidity and high nitrate leaching. Mineral fertilizers are not a structural part of the soil, so they increase soil productivity only by increasing the availability of nutrients, but without improving its physical-chemical-biological properties.

CONCLUSION

Crop cultivation is sometimes susceptible, due to various temperature changes, to the risks of failure, so farmers cannot decide which fertilizer to take. The best way to do this is to analyze the soil and find out on what soil they are growing a particular plant.

Fertilizer, although it has some disadvantages, has many more advantages. It is primarily an investment that helps the producer to help himself and his success. Many still wonder why fertilizers are important and some of the answers are:

- Plant production will be more significant and efficient and thus more productive with the help of fertilizers
- Many particularly large plantations use high-quality fertilizers and therefore have great benefits
- Thanks to fertilization, the soil is much better.

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Ана Радуловић¹, Марија Букулица^{1*}

¹ Поморски факултет, Котор

* Одговорни аутор; E-mail: bukulica.marija@gmail.com

ЂУБРИВА И ЂУБРЕЊЕ У ФУНКЦИЈИ ЗДРАВСТВЕНО БЕЗБЕДНЕ ХРАНЕ

Резиме

Многобројне врсте ђубрива омогућавају биљкама раст и развој. Редовном гнојидбом биљке се одржавају и све што утиче на поврће које конзумирамо. Органско ђубриво је најбоље јер биљкама пружа све што им је потребно, а плодови су много бољи. Ђубрива су врло важна за цијели биљни свијет и свакако им треба пажња.

Кључне речи: *оплодња, биљке, храна*



**Dragan Grčak¹, Milosav Grčak¹, Dragana Grčak¹, Miroljub Aksić¹,
Katerina Nikolić¹, Vera Rajičić², Stefan Grčak³**

¹ University of Priština, Faculty of Agriculture, Kosovska Mitrovica-Lešak, Serbia

² University of Niš, Faculty of Agriculture, Kruševac, Serbia

³ University of Niš, Faculty of Civil Engineering and Architecture, Niš, Serbia

E-mail: dragangrcak@gmail.com

BIOSTIMULANTS IN AGRICULTURE

Abstract

Global requirements to reduce the use of pesticides of chemical origin that have been shown to be harmful impose the use of alternative protection systems, such as biostimulants or phytostimulants. The definition and concept of natural biostimulants depends on the variety of components used in production. Plant biostimulants are various non-toxic substances of mostly natural origin that improve and stimulate the processes of plant life other than fertilizers or phytohormones. They have a beneficial effect on the environment by reducing the use of mineral fertilizers. Natural phytostimulants - biostimulants are natural extracts of plant origin (plant amino acids) and / or microorganisms that can stimulate the physiological development of the plant.

Key words: *biostimulants, phytostimulants, efficacy, plants*

BIOSTIMULANTS – PHYTOSTIMULANTS

The definition and concept of natural biostimulants depends on the variety of components used in production. For years, plant biostimulants were considered to be "snake oils—products of mysterious origin that promise to do almost unbelievable miracles" (3). Biostimulant can be defined as "a formulated product of biological origin that improves plant productivity as a consequence of the emergent properties of its constituents" (Yakhin et al. 2017). The term "biostimulant" includes many products such as biogenic stimulants, metabolic enhancers and plant enhancers. Based on the composition, biostimulants are divided into three groups: biostimulants containing humic acid; biostimulants containing hormones and biostimulants containing amino acids (Kauffman et. al., 2007). Historically, biostimulants have been considered as a

subset of growth regulators. They affect metabolism and cell division, affect vegetative development and encourage resistance to climatic factors and diseases. Biostimulants offer a potentially new approach to regulating physiological processes in plants to stimulate growth, alleviate stress-induced limitation, and increase yields. Biostimulants are components with a positive effect on the environment, because they reduce the use of mineral fertilizers by increasing micro and macronutrients, and have a positive effect on plant growth (9) but they also have positive effect on animals (10). Natural phytostimulants – biostimulants are natural extracts of plant origin (plant amino acids) and / or microorganisms that can stimulate the physiological development of the plant. Phytostimulants enable the plant to develop maximum production capacity, increase nutrient intake, nutrient efficiency, encourage resistance to abiotic stress and crop quality. Phytostimulants are alternative solutions that would direct food production towards sustainability (8). Phytostimulants also include rhizobacteria that colonize and promote plant growth (plant growth promoting rhizobacteria (PGPR), which includes biofertilizers and biopesticides) (11; 15) and the ability to trigger induced systemic resistance (ISR) (1). Many biostimulants improve nutrition and they do so regardless of their nutrient contents (7).

Biostimulants affect the yield of plants, only in conditions when there are enough elements in the soil that affect the yield, for example, if there is not enough nitrogen in the soil, the biostimulants has no possibility to increase its amount. The main task of a biostimulants is to encourage the plant to make better use of already available nutrients and to encourage the plant's resistance to physiological stress (21). Biostimulants, unlike bioregulators and hormones, improve metabolic processes in the plant without changing the natural pathway (17).

Defining the biological basis of biostimulants as a class of compounds, is made more complex by the various sources of biostimulants (bacteria, fungi, seaweeds, higher plants, animals and humate-containing raw materials) and the wide diversity of industrial processes used in their preparation. One of the definitions for biostimulants is "a formulated product of biological origin that improves plant productivity as a consequence of the novel or emergent properties of the complex of constituents, and not as a sole consequence of the presence of known essential plant nutrients, plant growth regulators, or plant protective compounds." It is suggested that the focus of biostimulant research and validation should be upon proof of efficacy and safety and the determination of a broad mechanism of action, without a requirement for the determination of a specific mode of action (22).

Agricultural production is inconceivable without mineral fertilizers and chemical plant protection products. However, these funds increase the cost of production, affect the quality and cause negative consequences for the environment, people and animals. One way to avoid the use of chemicals in agriculture is to use plant growth promoting bacteria (PGPB). This group consists of microorganisms in the soil, which have the ability to stimulate plant growth by various mechanisms, and are usually used in forestry, horticulture, remediation and reclamation.

Somers et al. (20) divided bacteria that stimulate plant growth according to their activity into: biofertilizers (increase the availability of nutrients to plants); phytosti-

mulants (stimulate plant growth through hormone production); rhizomediators (decompose organic pollutants) and biopesticides (control plant diseases by producing antibiotics and antifungal metabolites).

In the last three decades, in order to reduce the use of synthetic agrochemicals, the use of natural plant biostimulants (PBs), which improve flowering, plant growth, fruit, crop productivity and nutrient use efficiency (NUE), has been increasingly examined.), and may increase tolerance against a wider range of abiotic stressors (19).

An example of preliminary results reported in a study by Bulgari et al., (5) shows that the application of Retrosal® biostimulants on lettuce provides enhanced tolerance when plants are exposed to NaCl treatments, due to its multiple effects at both biochemical and physiological levels. In particular, we observed a significant effect of biostimulants on several examined variables, including fresh yield, dry biomass, chlorophyll content *in vivo*, nitrate concentration, and some leaf gas exchange parameters. Therefore, this biostimulant is an effective crop management tool to stimulate plant growth and productivity. Additional experiments will be required to investigate in depth the effects of Retrosal® on salinity, subjecting lettuce plants to higher concentrations of salinity, which could result in more stressful conditions for the crop under consideration. (4; 5).

Plant extracts are products that can be a significant source of various elements, and in traces, depending on the type and quality of the soil on which the plant species from which the solution is prepared is grown. The application of extracts of nettle (*Urtica dioica*) and comfrey (*Pulmonaria officinalis*) aims at preventive protection of crops from diseases and pests and the property of foliar fertilization. The aim of the study was to determine the influence of different genotypes and application of plant extract of nettle and comfrey on soybean yield, number and weight of pods, as well as the interaction between the applied test factors. Based on that, it is recommended to use the mentioned organic fertilizer and the prepared preparation in organic production, as well as the variety that responds better to the applied mentioned treatments (6).

Using biostimulants, it was determined that there is an increase in germination energy, germination rate, faster initial growth, longer roots, and the mass of dry matter also increases. Also, a bioregulatory effect on photoperiodism of neutral and short-day plants was observed. Biostimulants affect better seed germination, and they are the drivers of biological activity of plants, at the same time acting on the plant, root and soil microflora. The active substances of biostimulants are of natural origin; such as various plant media (eg algae *Laminaria hyperborea* and *Laminaria nigripes*) which are obtained by enzymatic hydrolysis and are characterized by a high protein content (13).

Maksimović et al. (14) were testing substrates based on black and white peat, in different proportions, with the use of biostimulating nutrients in order to obtain the highest quality seedlings of hyssop (*Hyssopus officinalis* L.). Breeding with different mineral biostimulant nutrients significantly influenced the examined parameters of the quality of hyssop seedlings.

Breeding of peat with various mineral biostimulating nutrients and slow-decomposing fertilizers significantly influenced the examined quality parameters of lavender seedlings (*Lavandula angustifolia* Mill.) (14).

There are also some studies concerning the influence of biostimulants on secondary metabolism. These plant compounds do not participate in primary metabolism (2; 18). Biostimulants positively affect the activity and expression of genes that affect the primary and secondary metabolism of the plant (16).

CONCLUSION

Plant biostimulants are relatively new products in agronomy. The use of biostimulants in agricultural practice is considered a safe way to improve the nutritional composition of the plant, without harmful residues in the soil. Biostimulants are components with a positive effect on the environment, reduce the use of mineral fertilizers and have a positive effect on plant growth. The application of biostimulants on plants leads to a higher content of nutrients in their tissue and to positive metabolic changes. For these reasons, the development of new biostimulants has become the focus of scientific interest. In addition to all this, biostimulants have a positive effect on the resistance of plants to environmental stresses.

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**Драган Грчак¹, Милосав Грчак¹, Драгана Грчак¹, Мирољуб Аксић¹,
Катерина Николић¹, Вера Рајичић², Стефан Грчак³**

¹ Универзитет у Приштини, Пољопривредни Факултет,
Косовска Митровица-Лешак, Србија

² Универзитет у Нишу, Пољопривредни Факултет, Крушевац, Србија

³ Универзитет у Нишу, Грађевинско-архитектонски факултет, Ниш,
Србија – дипломирани инжењер
E-mail: dragangrcak@gmail.com

БИОСТИМУЛАНТИ У ПОЉОПРИВРЕДИ

Сажетак

Глобални захтеви за смањење употребе пестицида хемијског порекла који су се показали штетним намећу употребу алтернативних система заштите, као што су биостимуланси или фитостимуланси. Дефиниција и концепт природних биостимуланата зависи од разноликости компонената које се користе у производњи. Биљни биостимуланси су различите нетоксичне материје углавном природног порекла које побољшавају и стимулишу процесе биљног живота, осим ђубрива или фитохормона. Они благотворно утичу на животну средину смањујући употребу минералних ђубрива. Природни фитостимуланси – биостимуланси су природни екстракти биљног порекла (биљне аминокиселине) и / или микроорганизми који могу подстаћи физиолошки развој биљке.

Кључне речи: *биостимуланси, фитостимуланси, ефикасност, биљке*

**INTEGRATED PEST MANAGEMENT
AND USE OF BIOLOGICAL**



dr Danijela Jašin¹, dr Matilda Lazić²

^{1,2} Technical College of Applied Sciences in Zrenjanin, Zrenjanin, Serbia

E-mail: danijelajasin@gmail.com

ANALYSIS AND APPLICATION OF THE SAFETY DATA SHEET OF ECOCID 5 AS A DISINFECTANT

Abstract

The aim of this work is to analyze the compliance of the SDS of Ekocod 5 with the prescribed elements of the Rulebook on the content of the safety data sheet. Ecocide 5 is a disinfectant for general use in industrial facilities (without direct contact with food) manufactured by Lion Ethyl. It is assumed that the manufacturer produces a SDS according to the regulations, in accordance with the approval for placing the product on the market. The manufacturer complies with the analyzed regulations and validly informs the end user about the harmful of the product in the selected method of use. The data in the SDS and the Instructions for use are consistent. Proper use of disinfectants contributes to a safe way of maintaining workplace hygiene.

Key words: *disinfectant, ecocide 5, biocide, workplace hygiene*

INTRODUCTION

Disinfection of work surfaces, which do not come into contact with food for humans, both in industrial facilities and in households, is extremely important for maintaining a high level of hygiene of the work space e.g. to prevent indirect contamination of unpackaged food and packaging, as well as contamination of food consumers. Disinfection of industrial facilities in the sense that refers to surfaces that do not come into contact with food is mostly done today with biocides of general use. Biocides of general use must meet the relevant regulations regarding the quality of the product itself and regulations related to the registration and sale of biocides, which comes from the application of the concept of integrated and safe management of biocides in our country.

A biocide is an active component or a mixture containing one or more active substances, prepared in a form in which it is distributed to users and whose purpose is to chemically or biologically destroy, deter, render harmless, prevent action or control

undesirable organisms [1]. In the food industry today, especially after the Covid 19 pandemic, it is very important to maintain high level of workplace hygiene to prevent contamination of employees and end users of food products. The use of appropriate disinfectants is of great importance, but in the manner prescribed in the instructions for use. Also, the manufacturer must have the prescribed documentation for safe placing on the market.

The product Ekocid 5 manufactured by Ekosan from Belgrade [2] is very popular on the market of disinfectants and is the subject of study in this work.

The aim of this work is to analyze the compliance of the safety data sheet Ekocod 5 with the prescribed elements of form and content according to the Rulebook on the content of the safety data sheet [3]. It is assumed that the precondition for placing a biocidal product on the market is that the manufacturer develops and makes available a safety data sheet (SDS) that is in line with the Rulebook on the content of the safety data sheet [3]. It is also presumed that Ekosan from Belgrade obtained the required documentation according to the Law on Biocide Products [1] for placing the product on the market; as well as the data from the safety data sheet [4] and the Instructions for use of the product [2] are consistent because it is also legally prescribed. A comparative method of analysis was used to check the compliance of the form and content of the safety data sheet Ekocid 5 [4] with the prescribed elements of the safety data sheet [3]. The work also emphasizes the importance of using the product according to the recommended methods of use in order to minimize the risk and reduce the harm of the product to people handling disinfectants and / or contamination of industrial products in plants where disinfectant is used.

ANALYSIS OF FULFILLMENT OF CONDITIONS FOR MARKETING OF ECOCID 5

According to the Law on Biocide Products [1] a biocide is placed on the market if: the manufacturer has obtained a marketing authorization for it and if the product is classified, marked, packed and has a safety data sheet. Therefore, the manufacturer can place the biocide on the market. After examining the List of biocide products registered in the register of the biocidal products [5] it was found that the product registered under the tradename Ekocid 5. After examining the List of biocide products registered in the Register of the biocide products [5] it was found that the product is registered under the tradename Ekocid 5. The holder of the decision on the entry of biocide in the Provisional List of Biocide products for the submission of the technical dossier is Ekosan DOO from Belgrade with the stated number of the Decision [6] and its validity period until 2023. In that way, the manufacturer completely fulfilled the preconditions for placing the registered product on the market. Approvals for the placing on the market of biocides, according to the Law on Biocide products [1], the manufacturer had to submit a technical file and safety data sheet to the Ministry with charge of environmental protection in advance. By issuing the Authorization, it is considered that the manufacturer has obtained the approval for the use of the prepared safety data sheet in the flow of documents in the biocide supply chain. Ecocide 5 must

be placed on the market as a disinfectant for professional use or disinfectant for general use and is used for disinfection of surfaces, objects and equipment (which is not in direct contact with food for humans) e.g. in households, public and industrial facilities in accordance with use [2,6].

ANALYSIS OF THE COMPLIANCE OF THE SAFETY DATA SHEET WITH THE PRESCRIBED ELEMENTS

Based on a comparative analysis of the form and content of all chapters of the safety data sheet of the biocidal product Ecocide 5 [4] and the prescribed elements of the safety data sheet according to the Rulebook on the content of the safety data sheet [3] (hereinafter: the Rulebook) the results given in this chapter are obtained.

The heading of the considered safety data sheet [4] is fully in accordance to the requirements of the Rulebook [3]. Chapter 1. Identification of the chemical and data on the person placing the chemical on the market [4] provide accurate data, which suits the data from the documentation [2,5,6] on the basis of which the marketing Authorization was issued according to Law on biocide products [1]. Chapter 2. Hazard Identification [4] states that the classification of products is performed according to the Rulebook on Classification, Packaging, Labeling and Advertising of Chemicals and Certain Products in accordance with the Globally Harmonized System for Classification and Labeling UN, which is in accordance with the Law on biocide products [1]. Ecocide 5 causes a corrosive skin damage 1B with hazard statement H314 (causes severe skin burns and eye damage), eye damage or hazard statement H318 (leads to severe eye damage). Ecocide 5 is also, harmful to the aquatic environment, acute 1 and chronic 1, with a warning about the danger of H410 (very toxic to the living world in water with long-lasting consequences). The data complies the stated manner of handling and notifications on precautionary measures from the Instructions for use of the product [2], which is in accordance with the data in the Decision [6]; according to the manufacturer's order exactly stated. The content of Chapter 2. is fully harmonized with the required elements according to the Rulebook [3]. Chapter 3. Composition / information on ingredients [4] states that the product contains the active substance ADBAC (C₁₂-C₁₈) which is listed in the relevant Lists I, Ia, b, in accordance with the provisions of the Law of biocide products [1]. This was also one of the preconditions for issuing the Marketing Authorization for the product Ekocid 5. Chapter 4. of first aid measures [4] clearly describes the first aid measures in terms of symptoms and effects that may occur in exposed / endangered people, which is in accordance with the prescribed elements according to the Rulebook [3]. Chapter 5. Fire-fighting measures [4] lists fire-extinguishing agents and special product hazards, which is in line with the requirements of the Rulebook [3]. Chapter 6. Accident measures [4] provides instructions to people involved in the response to a chemical accident caused by the product Ecocide 5 and measures to prevent the spread of accidents remediation (environmental) which is fully in line with the requirements of the Rulebook [3]. Chapter 7. Handling and storage [4]. Precautions for safe storage are in accordance with the instructions in both the Instructions for Use of the product [2] and with the requirements of the

Rulebook [3] and provide a useful guide to persons who need to properly handle the product in industrial facilities. Conditions for safe storage indicate conditions for proper storage before use. Ecocide 5 is a surface-active disinfectant based on the active substance ADBAC (C₁₂-C₁₈), which causes denaturation of proteins in the cell membrane of certain microorganisms. In ambient conditions, the product destroys all vegetative forms of the listed strains of microorganisms in 5 min. Under the same conditions, it destroys certain fungal spores in 5 minutes. Ecocide 5 is applied in the form of a solution, by diluting the liquid from the original packaging with a certain amount of water at room temperature. The solution is mixed well and then the working solution is used: by dipping, washing or spraying objects and surfaces. In subchapter 7.3. Special ways of use [4] are also defined and instructions for the preparation of the solution. Information in subsection 7.3. Special ways of use are of great importance to people who choose disinfectants because based on the listed organisms they can decide whether the product is efficient for application on target areas. A re-analysis of the contents of the Instructions for Use of the Product [2] established a complete agreement of the data with the statements from subchapter 7.3. of the safety data sheet of the product Ekocid 5 [4], which is in accordance with the assumption used in this work. Information from subsection 7.3. therefore very important for the choice of safe way of application of the product by people who handle the product or come into contact with it in industrial plants. The information is also very useful for the end consumer in the sense of safe use of Ecocid 5 products for disinfection in shops and households where food is served and prepared. Chapter 8 Exposure Control [4] states that there are no mandatory occupational exposure limit values for substances in the product and that personal protection must minimize any possible risk of exposure, which is in line with the requirements of the Rulebook [3]. The data from this chapter indicate what personal protection must be provided to employees by the employer, who uses the product Ekocid 5 for disinfection in industrial facilities. Chapter 9. Physical and chemical properties [4] and Chapter 10. Stability and reactivity, detail the characteristics of the product of interest for use, which is in line with the requirements of the Rulebook [3]. In the chapter Toxicological data [4], data on the acute toxicity of individual components of the product are classified in accordance with the individual harmful effects they may cause, which is in accordance with the requirements of the Rulebook [3]. It is important to note that the product is not carcinogenic and does not cause germ cell mutagenicity. It does not cause acute toxicity to the target organ, which is very important from the aspect of application. Chapter 12. Ecotoxicological data [4] lists aquatic toxicity and M factor for the active substance of the product. ADBAC (C₁₂-C₁₈) is also a biodegradable substance, completely and rapidly degradable, which is an advantage when choosing a preparation for use. ADBAC (C₁₂-C₁₈) is not classified as PBT and vPvB substance or bioaccumulation data are not available. Chapter 13 Disposal [4] states that used packaging and unused product should be treated according to the Law on Waste Management, ie reference is made to related regulations. Chapter 14 [4] provides data on road and rail traffic. Chapter 15 of the Regulatory Data [4] lists the related regulations in the field of safety and health at work and the environment, which must be used, which is in accordance with the required elements of making a safety data sheet according to the Rulebook [3]. Chapter 16. Other data [4] provides an overview of the

data according to the algorithm from the Rulebook [3]. Changes from the previous versions of the product safety data sheet are listed. Chapter 16 provides very important information in the form of a Notice for users of the safety data sheet [4]. The safety data sheet Notice states that it is based on the latest product information. It was emphasized that the data in the safety data sheet are given as a recommendation for the use of the product in an adequate manner and in certain situations, for appropriate purposes and in recommended quantities, as well as recommendations for storage, transport, disposal. Any other uses of the product will be considered unacceptable and inadequate. The indications refer to the interweaving with the data from the Instructions for Use and other, relevant product documentation.

CONCLUSION

It can be concluded that the obtained results of the analyzes performed in the paper are completely in accordance with the used assumptions.

Ekosan DOO from Belgrade, as a producer of biocide for general disinfection of surfaces in industrial conditions and in households, under the trade name Ekocid 5, meets all the prescribed conditions for its placing on the market. Ecocide 5 can be used for disinfection in the food industry on surfaces that do not come into contact with food, according to the recommended methods of use from all analyzed product documentation.

The form and content of the safety data sheet (SDS) of a product with chemical action – Ecocide 5 are completely in accordance with the elements of the safety data sheet, which is prescribed by the Rulebook on the content of the safety data sheet.

According to the toxicological and ecotoxicological data from the safety data sheet, it can be concluded that the biocidal product Ekocid 5 has a specified level of harm and danger, but the emphasized risks to the work and environment but to human health can be significantly minimized by choosing the right way for use.

Consistency of data in the analyzed product documentation and compliance with the applicable Law on biocide products was determined, which indicates that the manufacturer strictly respects the applicable regulations and thus protects end users of the product, while providing them with sound and legitimate information.

The product should be used according to the Instructions for Use, as this is the only safe way to use it. By comparing the data from the Instructions for use of the product and the data from the Notice for users of the product safety data sheet, which is an integral part of the safety data sheet, a complete agreement of the data was determined. Only recommended uses are considered acceptable and adequate. Failure to comply with them poses a risk to the safety of all people handling the product. Handling the product against the recommended ways of use can cause inadequate disinfection of surfaces / spaces and contamination, e.g. food products / packaging if Ecocide 5 is used in any technological operation / stage of production, storage, use, trade in food products.

According to the results of this paper, the importance of applying data from the safety data sheet, their understanding by end users and linking to other, relevant product

documentation Excid 5, can be very important for their safety in the process of providing general hygiene conditions in workplaces and / or disinfection households, especially in situations that require enhanced hygienic and technical supervision.

Further workflow could include risk assessment of the use of the product in specific operating conditions, study of the impact of storage conditions on the stability of the preparation and the choice of packaging type, etc.

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dr Danijela Jašin¹, dr Matilda Lazić²

^{1,2} Visoka tehnička škola strukovnih studija u Zrenjaninu, Zrenjanin

E-mail: danijelajasin@gmail.com

ANALIZA I PRIMENA BEZBEDNOSNOG LISTA EKOCID 5 KAO DEZINFICIJENSA

Sažetak

Cilj rada je analiza usklađenosti SDS Ekocod 5 sa propisanim elementima Pravilnika o sadržaju bezbednosnog lista. Ekocid 5 je dezinficijens za opštu upotrebu u industrijskim objektima (bez direktnog dodira sa hranom) proizvođača Lion Etil. Pretpostavljeno je da proizvođač izrađuje SDS prema propisima, uskladu sa odobrenjem za stavljanje proizvoda na tržište. Proizvođač poštuje analiziranu regulativu i validno informiše krajnje korisnika o štetnosti pri odabranom načinu upotrebe. Podaci iz SDS i Uputstva za upotrebu proizvoda su konzistentni. Pravilna upotreba dezinficijensa doprinosi bezbednom načinu održavanja higijene npr. radnih prostora.

Cljučne reči: *dezinficijens, ekocid 5, biocid, higijena radnog prostora*

**PRODUCTION OF FIELD
AND VEGETABLE CROPS**



**Bsc. Liljana Saltirov^{1*}, Prof. Dr. sc. Klime Beleski¹,
Assist. Prof. Dr. sc. Dushko Nedelkovski¹, Assoc. Prof. Dr. sc. Ile Canev²**

¹ Ss. Cyril and Methodius University in Skopje

Institute of Agriculture – Skopje, Republic of North Macedonia

² Ss. Cyril and Methodius University in Skopje

Faculty of Agricultural Sciences and Food - Skopje, Republic of North Macedonia

* Corresponding author: lsaltirov@yahoo.com

GENERAL CHARACTERISTICS OF TABLE INTERSPECIES VARIETY *VIERUL 59* CULTIVATED IN CONDITIONS IN THE SKOPJE REGION

Abstract

The climatic conditions in the Republic of North Macedonia are ideal for growing both table and wine grapes. The new hybrids provide good quality and quantitative characteristics, and represent the future of modern viticultural production. This paper presents the general characteristics of the table variety Vierul 59, on the experimental vineyard of the Institute of Agriculture – Skopje, location – Butel. The variety is characterized by a large bunch, with a beautiful reddish colour, with excellent organoleptic characteristics and is resistant to some diseases: (*Uncinula necator* and *Plasmopala v.*). This way it saves on the number of treatment against diseases during the growing season and thus reduces the amount of chemicals used.

Key words: *Vierul 59, viticultural production, grapes*

INTRODUCTION

The grape is a culture spread all over the world, it is grown as a table and as a wine grape. The table grape is meant for consumption in its fresh state. Here it's cultivated on smaller areas in relation to the wine varieties of the grape. According to Winkler et al. (1974) a quality table grape needs to possess the following characteristics: average large medium loose cluster, to possess identical, large, fine grains with a characteristic colour for the variety and pleasant taste Cindric et al. (2000).

The aim for the interspecies hybridization is to create varieties that will possess better features, to have higher resistance towards economically harmful diseases, more

attractive look and better taste (Rojchev, 2012). The cultivation of the table grape demands bigger use of agro technical and ampelotechnical measures during its cultivation in comparison with cultivating wine varieties. The climate aspects, temperature, the amount of rain, amount of sunlight, composition of the soil etc. have a big role in cultivating table varieties (Negrulj, 1959; 1946). One of the reasons for this examination is if this variety, with its genetic features, can be cultivated with success in the Skopje region. Because each variety demands specific climate conditions that reciprocate and in which conditions, with the use of good agro technics, will give its maximum.

In the current chase for using as little as possible pesticides, this variety *Vierul 59* is suitable for integrated production.

MATERIAL AND METHODS

Vierul 59 is created with interspecies hybridization from Koarna njagra and SV 20-366 in Chisinau (Moldova) by author N. Guzun. The examined variety is planted in the collectional planting of Institute of Agriculture-Skopje, located in Butel. The planting distance of the vines is 2.8 m x 1.2 m, and the cultivating system is Giov system with two spurs with two buds each and two canes with 10 buds each. In the experimental collection this variety is found amongst other varieties where, in the same conditions and use of the same agro technic, the differences between the varieties are visible.

The agro biological characteristics of the variety are examined descriptively. The examinations with the fruitfulness and yield of the variety were made according to the method by Rojchev (2014).

The method by whom was made the mechanical analysis of the examined clusters is described by Bozhinovikj (1996). The content of total acids was determined titrimetric, the sugars with refractometer, and the pH with a pH-meter.

RESULTS AND DISCUSSION

There was a two-year examination in the Skopje region. The agro biological characteristics of this variety were noticed at the beginning of opening the buds, blossoming, beginning of maturing *i.e.* the beginning of verison and harvest. The phenological observations for this variety are shown in Table 1.

Table 1. Phenophases of variety Vierul 59

Year	Budburst	Blossoming	Verison	Harvest
2010	06 .04	02.06	30.07	01.09
2011	08.04	04.06	03.08	12.09

The phenology of the varieties starts with moving the juices from the underground to the foreground part of the vine plant. As a beginning pheno phase is considered to be mouse ears buds swelling. The budburst is a pheno phase at which the opening of the buds is considered when 50% of the buds are opened is germinated. In 2010 the beginning of opening the buds is 6th April and in 2011 is 8th April. The blossoming is considered to start when half of the caps of the flower are fallen, and that is in the beginning of June in the two years, in 2010 the full blossom was on 2nd June and in 2011 on 4th June. When the grains start to change colour from green to red and become softer than its considered that the verison has started. The beginning of maturing in 2010 is on 30th July and in 2011 is on 3rd August. The technological maturity is when the grains get that distinctive colour. In 2010 the harvest was on 1st September and in 2011 on 12th September. In conditions to Sremski Karlovac, Serbia Cindric and the colleagues (2000) point out that the harvest of this variety is on 4th October. If taken in consideration that the climate conditions in which the variety is examined, we can say that we expected an early technological maturity in these conditions.

Table 2. Fruitfulness of the examined buds for variety Vierul 59

Year	Stock buds (%)	Fruitful buds (%)	Potential coefficient of fertility	Relative coefficient of fertility	Absolute coefficient of fertility
2010	96	76	1.14	1.18	1.5

On Table 2 are shown examinations associated with fruitfulness of variety *Vierul* 59 observed in the conditions of the Skopje vine region. From the results we can see that the percentage of the developed buds is high, 96% in 2010, 94% in 2011. The percentage of fruitful buds in 2010 is 76% and in 2011 is 73%, which indicates the significant difference between the years.

From the received results for fruitfulness of the variety displayed on the Table 2 can be seen that the variety is characterized with high relative coefficient 1.18 and high absolute coefficient of fertility 1.5. The potential coefficient of fruitfulness for this variety is 1.14.

Variety *Vierul* 59 has a nice large and compacted cluster (Fig. 1). As can be seen from the Table 3, the average length of the cluster in 2010 is 18.3 cm. The average width of the cluster in 2010 is 9.5 cm. The average mass of the cluster in 2010 is 284.5 g with the average of 110 grains. Similar results are obtained in 2011, the length of the cluster is somewhat smaller (15.2 cm). The width is 10.4 cm with average mass of 299 g.

The average of the two year examinations of mass of cluster is 291 g, length of cluster is 16.7 cm, width is 9.95 cm and average number of grains in a cluster is 109.5. There is a difference in the mass in Sremski Karlovac, the average mass of the cluster is 423 g (Cindric, et al., 2000). According to the examinations in Sremski Karlovac the average mass of the grain is 4.21 g (Cindric, et al., 2000). This difference in the mass is most likely due to the climate conditions in the two regions (temperature, rain etc.).

Table 3. Mechanical and chemical analysis of variety Vierul 59

Examined parameters	Year of examination	
	2010	2011
Length of cluster (cm)	18.3	15.2
Width of cluster (cm)	9.5	10.4
Mass of cluster (g)	284.5	299
Number of grains on cluster	110	109
Length of grain (mm)	22.8	22.6
Width of grain (mm)	14	14.2
Mass of grain (g)	2.9	2.9
Mass of seeds of 100 grains (g)	9.48	7.18
Sugars (Brix)	14.1	23.1
Total acids (g/L)	9.2	5.6
pH	2.9	3.21

The characteristic shape of the grain is an elongated with a pear-like shape. Flesh (pulp) is with a solid consistency. The length of the grain in 2010 is 22.8 mm and in 2011 its 22.6 mm with the average of 22.7 mm. The width of the grain in 2010 is 14 mm and in 2011 its 14.2 mm. The medium diameter in the two year examinations is 18.4 mm.



Figure 1. A - grape cluster; B - young shoot of variety Vierul 59

The chemical composition of the cluster juice is shown in Table 3. The amount of sugar in 2010 is 14.1 brix and in 2011 it is 23.4 brix. Because of the different technological maturity in which the grape is harvested, it can be seen that the amount of total acids in 2010 (9.2 g/L) in comparison with 2011 (5.6 g/L) is proportional to the amount of sugar in the years the examination was conducted. The pH potential is proportional to the amount of total acids and in 2010 is 2.90, while in 2011 it is 3.21. The average amount of sugar in the examinations Sremski Karlovac is 16.1%, total acids are 6.9 g/L. From here we can conclude that in separate years the variety can possess bigger amounts of sugar and yet to maintain higher amounts of total acids in the cluster. From the received results we can tell that this variety can be maintained in conditions of the Skopje vineyard and thus normally and constantly give high quality table grape.

CONCLUSIONS

From this study we conclude that *Vierul 59* in both examine years has great percentage of developed buds. It has a high potential coefficient of fertility which is 1.14. The cluster is beautiful, large and with an average mass of 291 g. The amount of sugars in the cluster's juice varies depending on the year, but this variety has potential to store big amounts of sugar and still have bigger amounts of acid.

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Дипл. Инж. Љиљана Салтиров^{1*}, проф. др. Климе Белески¹,
доцент Душко Неделковски¹, Ванр. проф. др. Иле Цанев²

¹ Св. Кирил и Методије у Скопљу, Пољопривредни институт – Скопље,
Република Северна Македонија

² Св. Кирил и Методије у Скопљу, Факултет пољопривредних наука и хране
– Скопље, Република Северна Македонија

* Одговорни аутор: lsaltirov@yahoo.com

ОПШТЕ КАРАКТЕРИСТИКЕ СТОЛНИХ ИНТЕРСПЕЦИЈИ СОРТЕ *VIERUL 59* КУЛТИВОВАНЕ У УСЛОВИМА У СКОПСКОМ РЕГИОНУ

Извод

Климатски услови у Републици Северној Македонији идеални су за узгој стоног и винског грожђа. Нови хибриди пружају високи квалитет и изврсни квантитативне карактеристике. Представљају будућност модерне виноградарске производње. У овом раду су представљене опште карактеристике стоне сорте *Vierul 59*, на огледном винограду Пољопривредног института у Скопље, локација – Бутел. Сорту одликује велики плод, прелепе црвенкасте боје, одличних органолептичких карактеристика и отпорна је на неке болести: (*Uncinula necator* and *Plasmopala v.*). На овај начин се штеди на броју третмана против болести током вегетације и на тај начин се смањује количина употребљених хемикалија.

Кључне речи: *Vierul 59*, виноградарска производња, грожђе



Ivan Šimunić¹, Tanja Likso², Palma Orlović-Leko³

¹ University of Zagreb, Faculty of Agriculture, Croatia

² Meteorological and Hydrological Service, Croatia

³ University of Zagreb, Faculty of Mining, Geology
and Petroleum Engineering, Croatia

Corresponding author, E-mail: simunic@agr.hr

ESTIMATION OF DROUGHT IMPACT ON MAIZE AND SOY BEAN YIELDS IN THE DRAVA RIVER BASIN IN CROATIA

Abstract

Maize and soybean are very important crops in human and animal nutrition. Hence, they are cultivated on relatively large agricultural areas in Croatia. The goal of this research was to estimate a decline in maize and soybean yields during drought periods in the specific part of Croatia (the Drava River basin) based on the frequency of precipitation occurrence upon 25% ($F_a=25\%$) probability. In this study, climatological data from three climatological stations was used for the period 1986–2015. Reference evapotranspiration was calculated according to Penman-Monteith method, using the CROPWAT software. Effective precipitation was calculated by the United State Bureau of Reclamation. Soil water balance for each crop was calculated using the Palmer method. The estimation of the decreased yields of the previously mentioned crops was calculated using Doorenbos and Kassam method.

A decline in maize and soybean yields was estimated in the Drava River basin in Croatia due to a drought up to 70% and 44% respectively. The results of numerous studies pointed out a decline in crop yields due to a lack of precipitation, irrespective of the use of standard agricultural technology. Among all the climate extremes, drought has the most significant impact both on agriculture and the society in general. In addition, drought is the most frequent cause of unprofitable crop yields in Croatia.

Key words: *decline in yields, climate extremes, maize, soybean*

INTRODUCTION

The yields of agricultural crops fluctuate over many years and is influenced by many abiotic and biotic factors. A large number of studies indicate that crop yields primarily vary as a result of extreme climate conditions, although other factors, such

as soil fertility, the applied agro-technology and plant species, to name a few, may also affect crop yields. As a consequence of climate change, the rise in frequency and intensity of extreme weather events, such as drought, heavy rain, gales and storms, among others, have a negative impact on yields and their quality (Mađar et al., 1998; Parry et al., 2005; Fischer et al., 2005; Kovačević et al., 2012; Marković et al., 2012; Kovačević et al., 2013; Kovačević and Josipović, 2015; Dokić et al., 2015). Climate characteristics and soil water regime, as well as their variable and complex interrelation define the efficiency of plant production (Šimunić et al., 2013). Agricultural production is very risky in underdeveloped agricultural areas, especially when surplus and/or deficit of precipitation occurs before or during the growing season. Such conditions make production planning very difficult and/or almost impossible, because production and hence yields are dependent on weather conditions, making field crop yields and their quality highly variable (Šimunić, 2016). The highest yields are obtained at the time of the most favourable air to water ratio in the soil, primarily in the critical periods for each crop (Beltrão et al., 1996). Any deficit of water in the soil during the vegetation period causes stress in plants and the consequence of stress is a decline in yields. The problem of decreasing yields could be partially solved by a supply of the required water through irrigation throughout the phases of plant development, but for annual plants, the critical period in terms of a lack of soil water is usually related to the flowering and the formation of generative organs (Šimunić et al., 2007; Marković et al., 2012). In water deficit conditions, an irrigation optimisation plan, corresponding to the exact water needs of the crop in question needs to be developed and applied (Slavov et al., 2006). The goal of this research was to estimate a decrease in maize and soybean yields due to drought in the Drava River basin in the territory of Croatia.

MATERIALS AND METHODS

The Drava River basin is located in the northern part of Croatia, stretching along the Drava River. Three climatological stations were selected for the research, which are located within the Drava River basin, Koprivnica in the western part, Virovitica in the central part and Valpovo in the eastern part of the basin (Table 1). Climate data from all the three stations for the period 1986–2015 was used in the study. The data based upon 25% probability ($F_a=25\%$) of the precipitation occurrence frequency was used for the estimation of the decrease in maize and soybean yields. Reference evapotranspiration (ET_o) was calculated according to the Penman–Monteith method, using CROPWAT computer program, Version 8. The effective precipitation was calculated by the United States Bureau of Reclamation. The soil water balance for each crop was calculated using the Palmer method, using Hidrokalk computer program. The soil studied had the following characteristics: silt and clay texture. Field water capacity was 38.5 vol%, while wilting point was 15.4 vol%. The root depth for the calculation of soil water balance was 25 cm. The available water was calculated to a given total depth, which is on a par with the possible soil water storage to the given total depth. For both crops, the vegetation period from April to September was considered and phenological phases of both crops and their duration were determined. Each phono-

logical phase was corrected by the crop coefficient. The reaction of the crops to water deficit and the decline in yields was calculated according to the Doorenbos and Kassam method expressed by the relation:

The results of this study have been presented in the following tables.

$$\left(1 - \frac{Y_a}{Y_m}\right) = k_y \left(1 - \frac{ET_a}{ET_c}\right) \quad (1)$$

Ya – Actual yield

Ym – Maximum possible yield

ky – Yield response factor

ETa – Actual evapotranspiration

ETc – Crop (maximum) evapotranspiration

Table 1. Climatological stations (CS) used and the details in connection with their geographical position.

Climatological station (CS)	Latitude	Longitude	Altitude (m)
Koprivnica	46°18' N	16°07' E	141
Virovitica	45°49' N	17°23' E	118
Valpovo	45°40' N	18°20' E	92

RESULTS AND DISCUSSION

Reference evapotranspiration, effective precipitation and the difference between their values

The values of reference evapotranspiration based on the frequency of the occurrence of climate elements upon 25% (Fa=25%) probability for the three climatological stations have been presented in Tables 2a, 2b and 2c.

Table 2a. Reference evapotranspiration based on the frequency of the occurrence of climate elements upon 25% probability, CS Koprivnica

Month	Tmin (°C)	Tmax (°C)	Humidity (%)	Wind (km.day ⁻¹)	Sun (h.day ⁻¹)	Radiation MJ.m ⁻² .day ⁻¹	ETo (mm.day ⁻¹)
Jan	0.1	5.4	93	130	1.3	3.7	0.3
Feb	0.6	9.4	86	121	3.9	7.4	0.7
Mar	5.3	14.8	83	146	4.6	11.0	1.5
Apr	5.2	15.9	87	104	6.8	16.6	2.1
May	11.8	24.3	81	104	9.3	22.0	3.7
June	12.3	23.9	83	146	8.7	22.1	3.8

July	15.8	26.9	73	104	8.4	21.2	4.1
Aug	15.3	28.7	81	121	10.3	21.7	4.2
Sep	10.0	19.2	89	146	4.0	11.2	1.9
Oct	9.7	18.9	87	95	5.9	10.0	1.4
Nov	0.4	7.6	88	130	3.0	5.2	0.7
Dec	-6.4	0.4	93	250	2.7	4.1	0.3
Average	6.7	16.3	85	133	5.7	13.0	2.1

The relationship between reference evapotranspiration and effective precipitation based on the frequency of the occurrence of climate elements upon 25% (Fa=25%) probability both for the whole year and the vegetation period have been presented in Tables 3a and 3b.

Table 2b. Reference evapotranspiration based on the frequency of the occurrence of climate elements upon 25% probability, CS Virovitica

Month	Tmin (°C)	Tmax (°C)	Humidity (%)	Wind (km.day ⁻¹)	Sun (h.day ⁻¹)	Radiation MJ.m ⁻² .day ⁻¹	ETo (mm.day ⁻¹)
Jan	-4.4	1.4	87	190	1.0	3.6	0.4
Feb	-0.7	6.4	78	354	1.7	5.7	1.0
Mar	3.0	12.2	70	320	3.8	10.3	1.9
Apr	8.2	21.7	65	216	7.6	17.7	3.4
May	11.6	24.5	69	216	8.8	21.5	4.2
June	13.4	25.7	73	233	7.4	20.4	4.2
July	15.5	29.0	71	190	11.2	25.0	5.1
Aug	15.5	29.7	71	173	9.4	20.7	4.5
Sep	12.3	25.9	76	147	7.9	15.7	3.1
Oct	6.4	17.5	78	216	4.3	8.7	1.8
Nov	1.9	13.2	83	216	3.0	5.3	1.0
Dec	-0.5	7.0	84	216	1.8	3.7	0.7
Average	6.9	17.8	75	225	5.7	13.2	2.6

Table 2c. Reference evapotranspiration based on the frequency of the occurrence of climate elements upon 25% probability, CS Valpovo

Month	Tmin (°C)	Tmax (°C)	Humidity (%)	Wind (km.day ⁻¹)	Sun (h.day ⁻¹)	Radiation MJ.m ⁻² .day ⁻¹	ETo (mm.day ⁻¹)
Jan	-0.1	6.6	85	232	2.1	4.4	0.6
Feb	-0.9	6.6	84	232	3.0	6.8	0.8
Mar	2.3	13.4	68	302	5.4	12.0	2.1

Apr	4.7	19.1	58	284	7.9	18.1	3.6
May	11.2	23.9	72	268	7.7	20.0	4.0
June	13.8	27.5	68	250	9.7	23.6	5.0
July	16.6	31.3	66	216	10.7	24.4	5.6
Aug	16.3	31.4	71	216	9.0	20.2	4.9
Sep	12.4	24.2	76	250	6.0	13.6	3.1
Oct	6.4	16.3	86	250	3.8	8.3	1.4
Nov	2.1	14.5	80	206	4.4	6.4	1.1
Dec	0.5	6.4	92	189	2.1	3.9	0.4
Average	7.1	18.4	76	241	6.0	13.5	2.7

As shown in the previously mentioned Tables, the lowest value of the average annual evapotranspiration was registered in the western part of the basin (2.1 mm.day⁻¹) and the highest in the eastern part of the basin (2.7 mm.day⁻¹), while the value of the average annual evapotranspiration in the central part of the basin was between the previously mentioned values (2.6 mm.day⁻¹). The values of the reference evapotranspiration are consistent with the values of the climate elements observed at the previously mentioned climatological stations. Similar research studies have been carried out on a wider area both of the central and the eastern part of Croatia and the obtained findings are in accordance with the findings presented in this paper (Šimnić et al., 2007; Kovačević et al., 2012; Dokić et al., 2015).

Table 3a. The difference between reference evapotranspiration and effective precipitation based on the frequency of the occurrence of climate elements upon 25% probability for the whole year, CS Koprivnica, Virovitica and Valpovo

Month	Koprivnica			Virovitica			Valpovo		
	ETo (mm)	Precip. (mm)	Eff. Precip. (mm)	ETo (mm)	Precip. (mm)	Eff. Precip. (mm)	ETo (mm)	Precip. (mm)	Eff. Precip. (mm)
	A	B	C	A	B	C	A	B	C
Jan	9.3	77.8	68.1	12.4	87.4	75.2	18.6	71.4	63.2
Feb	19.6	3.0	3.0	28.0	39.4	36.9	22.4	56.1	50.2
Mar	46.5	96.8	81.8	58.9	33.1	31.3	65.1	41.3	38.6
Apr	63.0	51.5	47.3	102.0	36.2	34.1	108.0	19.1	18.5
May	114.7	54.2	49.5	130.2	38.8	36.4	124.0	128.4	102.0
June	114.0	98.0	82.6	126.0	85.1	73.5	150.0	19.4	18.8
July	127.1	61.9	55.8	158.1	66.1	59.1	173.4	32.5	30.8
Aug	130.2	16.0	15.6	139.5	28.5	27.2	151.9	39.8	37.3
Sep	57.0	178.3	127.4	93.0	28.4	27.1	93.0	38.8	36.4

Oct	43.4	17.0	16.5	55.8	92.5	78.8	43.4	131.9	104.1
Nov	19.6	61.8	55.7	30.0	85.2	73.6	33.0	43.1	40.1
Dec	9.3	44.0	40.9	21.7	115.6	94.2	12.4	4.2	4.2
Total	753.7	760.3	644.2	955.6	736.3	647.4	995.2	625.0	544.2
	A-C=109.5			A-C=308.2			A-C=451.0		

Tables 3a and 3b show that the western part of the Drava River basin had the lowest amount of evapotranspiration, but the highest amount of precipitation both over the whole annual period and the vegetation period, while the eastern part of the basin saw the opposite situation.

The central part of the basin recorded the values between the previously mentioned values. The difference between reference evapotranspiration and effective precipitation based on the frequency of the occurrence of climate elements upon 25% ($F_a=25\%$) probability was both for the whole year and the vegetation period the lowest in the western part of the basin (109.5 mm and 227.8 mm, respectively) and the highest in the eastern part of the basin (451.0 mm and 556.5 mm, respectively), while the central part of the basin recorded the value between the above mentioned values (308.2 mm and 491.4 mm, respectively). According to the presented data, it is evident that reference evapotranspiration is higher than effective precipitation throughout the Drava River basin and it indicates a water deficit during the growing of crops. The real water deficit for each crop will be determined at soil water balance.

Table 3b. The difference between reference evapotranspiration and effective precipitation based on the frequency of the occurrence of climate elements upon 25% probability for the vegetation period, CS Koprivnica, Virovitica and Valpovo

Month	Koprivnica			Virovitica			Valpovo		
	ETo (mm)	Precip. (mm)	Eff. Precip. (mm)	ETo (mm)	Precip. (mm)	Eff. Precip. (mm)	ETo (mm)	Precip. (mm)	Eff. Precip. (mm)
	A	B	C	A	B	C	A	B	C
Apr	63.0	51.5	47.3	102.0	36.2	34.1	108.0	19.1	18.5
May	114.7	54.2	49.5	130.2	38.8	36.4	124.0	128.4	102.0
June	114.0	98.0	82.6	126.0	85.1	73.5	150.0	19.4	18.8
July	127.1	61.9	55.8	158.1	66.1	59.1	173.4	32.5	30.8
Aug	130.2	16.0	15.6	139.5	28.5	27.2	151.9	39.8	37.3
Sep	57.0	178.3	127.4	93.0	28.4	27.1	93.0	38.8	36.4
Total	606	459.9	378.2	748.8	283.1	257.4	800.3	278	243.8
	A-C=227.8			A-C=491.4			A-C=556.5		

Tables 3a and 3b show that the western part of the Drava River basin had the lowest.

Soil water balance for maize and soybean

Table 4a. Soil water balance for maize in the vegetation period

Month	Western part of the basin			Central part of the basin			Eastern part of the basin		
	ETc (mm)	ETa (mm)	ETc-ETa (mm)	ETc (mm)	ETa (mm)	ETc-ETa (mm)	ETc (mm)	ETa (mm)	ETc-ETa (mm)
Apr	19	19	0	31	31	0	32	24	8
May	80	74	6	91	59	32	87	87	0
June	120	96	24	132	84	48	158	65	93
July	133	73	60	166	66	100	182	31	151
Aug	104	19	85	112	27	85	122	37	85
Sep	31	31	0	51	27	24	51	36	15
Total	487	312	175	583	294	289	632	280	352

Table 4b. Soil water balance for soybean during the vegetation period

Month	Western part of the basin			Central part of the basin			Eastern part of the basin		
	ETc (mm)	ETa (mm)	ETc-ETa (mm)	ETc (mm)	ETa (mm)	ETc-ETa (mm)	ETc (mm)	ETa (mm)	ETc-ETa (mm)
Apr	19	19	0	31	31	0	32	24	8
May	80	74	6	91	59	32	87	87	0
June	114	94	20	126	83	43	150	65	85
July	127	73	54	158	67	91	174	31	143
Aug	91	20	71	98	27	71	106	37	69
Sep	23	23	0	37	27	10	37	36	1
Total	454	303	151	541	294	247	586	280	306

Soil water balance is a quantitative measure of soil water regime and it is an indicator of change of soil water supply in a given area during a certain period of time. It includes elements of water intake and elements of water loss (Šimunić, 2016). Tables 4a and 4b show the water deficit in the soil during the vegetation period both for maize and soybean. In the entire area of the Drava River basin a higher soil water deficit was determined for maize, while a lower soil water deficit was determined for soybean. The western part of the Drava River basin had the lowest soil water deficit both for maize and soybean, yet the highest soil water deficit was in the eastern part of the basin. The central part of the basin recorded values between the previously mentioned values. Similar results were obtained in the former studies in connection with soil water deficit in the continental part of Croatia (Šimunić et al., 2007; Kovačević et al., 2013).

Soil water deficit affects the growth and development of field crops, which in turn affect their yields and quality. Water deficit is especially harmful if it occurs in the "plant's critical period of water need". This period may have shorter or longer duration and it can occur in different phenological phases of a particular plant.

The reaction of maize and soybean to water deficit and estimation of a decline in yields of the crops in question

Any deficit of soil water causes some decrease in yields, depending on the lack of precipitation and the phase of crop development.

Table 5. Estimation of decreased yields (%)

Crop	Western part of the basin	Central part of the basin	Eastern part of the basin
Maize	45	62	70
Soybean	28	39	44

The values of reference evapotranspiration based on the frequency of the occurrence of climate elements upon 25% (Fa=25%) probability for the three climatological stations have been presented in Tables 2a, 2b and 2c.

According to Table 5, it is obvious that there was a decline in yields of both crops. The estimation of the decline in maize yields were in the range from 45% to 70% and in soybean from 28% to 44%. Similar results, in terms of declining maize and soybean yields in this region, were confirmed by Šimunić et al. (2007 and 2013) and Kovačević et al. (2012). The lowest decrease in yields for both crops was in the western part of the basin with the lowest soil water deficit during the vegetation period (Tables 4a and 4b). The highest reduction of yields was in the eastern part of the basin with the highest soil water deficit during the vegetation period. The central part of the basin recorded values between the previously mentioned values. Considering the issue of the effect of precipitation amount on agricultural production, the focus exclusively on annual precipitation amount is not sufficient. The distribution of precipitation throughout the year is also one of the most important parameters, especially during the critical phenological phases such as germination, flowering and fruit development (Šimunić, et al., 2013).

CONCLUSIONS

Against the backdrop of the estimation of a decline in maize and soybean yields during drought periods/years in the Drava River basin in the territory of Croatia, the following conclusion can be reached:

1. A decline in yields of both crops.
2. The estimation of a reduction of maize and soybean yields varied from 45% to 70% and from 28% to 44%, respectively.

3. The lowest decrease in yields for both crops was in the western part of the basin with the lowest soil water deficit during the vegetation period.
4. The highest reduction of yields was in the eastern part of the basin with the highest soil water deficit during the vegetation period.

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Ivan Šimunić¹, Tanja Likso², Palma Orlović-Leko³

¹ University of Zagreb, Faculty of Agriculture, Croatia

² Meteorological and Hydrological Service, Croatia

³ University of Zagreb, Faculty of Mining, Geology
and Petroleum Engineering, Croatia

Corresponding author, E-mail: simunic@agr.hr

ПРОЦЕНА УТИЦАЈА СУШЕ НА ПРИНОС КУКУРУЗА И СОЈЕ У БАЗЕНУ РЕКЕ ДРАВА У ХРВАТСКОЈ

Сажетак

Кукуруз и соја су веома важни усеви у исхрани људи и животиња. Зато се гаје на релативно великим пољопривредним површинама у Хрватској. Циљ овог истраживања био је да се процени пад приноса кукуруза и соје током сушних периода у специфичном делу Хрватске (слив реке Драве) на основу учесталости падавина на вероватноћи 25% ($F_a = 25\%$). У овом истраживању коришћени су климатолошки подаци са три климатолошке станице за период 1986–2015. Референтна евапотранспирација израчуната је по методи Penman-Monteith користећи софтвер CROPWAT. Ефикасне падавине израчунате су по US бироу за рекултивацију. Биланс воде у земљишту за сваки усеv је израчунат помоћу Палмер методе. Процена смањених приноса претходно поменутих култура израчуната је методом Doogenbos и Kassam.

Пад приноса кукуруза и соје процењен је у сливу Драве у Хрватској због суше и до 70%, односно 44%. Резултати бројних студија указали су на пад приноса услед недостатка падавина, без обзира на употребу стандардне пољопривредне технологије. Међу свим климатским екстремима, суша има најзначајнији утицај и на пољопривреду и на друштво уопште. Поред тога, суша је најчешћи узрок нерентабилних приноса у Хрватској.

Кључне речи: пад приноса, климатски екстрем, кукуруз, соја



Červenski J., Medić-Pap S., Danojević D., Bugarski D.
Institute of Field and Vegetable Crops, Maksima Gorkog 30, Novi Sad, Serbia
E-mail: janko.cervenski@nsseme.com

SIGNIFICANCE OF VEGETABLE CROPS ROTATION IN GARDEN PLOTS FROM THE PERSPECTIVE OF PRODUCING HEALTH-SAFE FOOD

Abstract

Vegetable crops production should represent the source of healthy and safe food, which is the basis for human development and health. It allows intensive use of soil and earns a high income per unit area, certainly with greater investment and a lot of human labour. Production of health-safe and biologically valuable vegetables with known composition and quality in controlled conditions is becoming increasingly interesting to consumers. Therefore, land resources should be used as rationally as possible and with proper vegetable crop rotation, reducing the possible occurrence of harmful organisms and obtaining health-safe products. In vegetable production, crop rotation is the most often neglected basic preventive measure.

Key words: *vegetable species, crop rotation, food, quality*

INTRODUCTION

Vegetable production is a significant and traditional economic activity in the Republic of Serbia. Vegetable crops production allows intensive use of soil and irrigation systems through rotation of two to three crops during a year on the fields, greenhouses and gardens. The specificity of a large number of vegetable species also enables the production of food in climatically and edaphically unfavourable conditions, using different production methods and systems (Vlahović et al., 2010).

Over 95% of vegetable production in Serbia takes place in the open field, and only a small part, up to 5%, is conducted in a protected area. The production of vegetables in gardens and backyards is also important. It occupies about 20% of vegetable production in the Republic of Serbia (Červenski et al., 2015; Gvozdanović-Varga et al., 2016).

Červenski et al., (2019) pointed out that gardens and backyards for vegetable production in the Republic of Serbia occupy small, but globally important areas.

According to the data of the Republic Statistical Office in the Republic of Serbia, in the last four years (2016-2019) the following vegetable species are mostly grown: potatoes, peppers, beans, tomatoes, cabbage and kale, peas, melons and watermelons, cucumbers, carrots and garlic (www.stat.gov.rs) (Tab. 1).

Vegetable production is one of the most intensive branches of plant production, which is expressed by yield per unit area, income, net income and human labour participation. The total production of vegetables is closely related to the development of processing capacities (Vlahović et al., 2016).

For these reasons, the aim of this paper is to point out the importance of vegetable crop rotation in garden plots, as a basic preventive measure in the production of health-safe food.

Table 1. Areas under certain vegetable species in the Republic of Serbia in the period 2016-2019

Family	Vegetable species	Year			
		2016	2017	2018	2019
		Area (ha)			
Nightshades (Solanaceae)	potato	40,105	38,472	28,232	34,110
	pepper	16,977	17,386	12,016	10,097
	tomato	10,065	10,917	8,629	7,888
Leguminosae (Fabaceae)	beans	12,404	13,181	9,112	9,091
	peas	7,502	8,097	6,736	6,282
Mustards (Brassicaceae)	Cabbage and kale	10,804	10,213	8,251	7,957
Gourds (Cucurbitaceae)	melons and watermelons	6,314	8,372	6,814	5,709
	cucumber	3,843	4,271	3,220	3,020
Onions (Alliaceae)	onion	4,772	4,145	3,618	3,349
	garlic	1,581	1,820	1,441	1,145
Umbellifers (Apiaceae)	carrot	2,465	1,932	1,385	1,915
Total	(with potato)	116,832	118,806	89,454	90,563
	(without potato)	76,727	80,334	61,222	56,453

(www.stat.gov.rs)

Organization of crop rotation in intensive vegetable production on garden plots

Vegetable production is a source of quality and health-safe food that is the basis for human development and health. Besides that, it allows intensive use of soil and earns

a high income per unit area, certainly with greater investment and a lot of human labour. One of the conditions for successful vegetable production in gardens is intensive crop rotation or crop rotation in time and space. Crop rotation requires rotation of crops during year, as well as the simultaneous cultivation of different species, i.e. diverse vegetable production during the year, maximum use of available resources (land and labour), and high profitability.

Studies of Medić-Pap et al., (2019) concluded that the producers usually want to produce fresh and health-safe food. Of course, with well-organized and precisely timed (adjusted) vegetable production, we create the condition for continuous production throughout the year. By using a larger number of vegetable species in production as well as crop rotation, we provide a certain security of production. At the same time, in intensive vegetable production, it is necessary to conduct a systematic control of soil fertility and the use of fertilizers, which is monitoring the soil quality on each production plot and protected area.

In the last 50 years, crop rotation has been greatly simplified due to the reduction of the number of species in the crop rotation and the increase in the share of land under monoculture. The reason is the appearance and widespread use of synthetic fertilizers, pesticides and separation of crop and livestock production. Agricultural producers use different crop rotations to control the balance of nutrients, water, weed, pests, diseases, and the needs of people and livestock for food. Modern farms have simplified the "ways" of land use (Barbieri et al., 2017).

Often the same vegetable species are grown in gardens, such as peppers, tomato, cucumbers, cabbage, etc. Intensive cultivation practices are applied in the production of these vegetable species. Cultivation of one vegetable species at the same spot during several years creates conditions for intensive appearance of harmful organisms (diseases, pests and weeds). Therefore, the open garden can be divided into several smaller units to include larger number of vegetable species into the production, which will contribute the high yields in the shortest possible time. Mandatory rotation of two to three vegetable species is of utmost importance. This organization also increases the economy of intensive vegetable production. Intensive vegetable crop rotation can be based on the principle of three-field vegetable crop rotation. During one season or year, several types of vegetables are grown on the same land consecutively or simultaneously. This means that immediately after removing one species, another is sown or planted. This is possible due to the different length of vegetable seasons, differences in heat requirements, resistance of some species to low temperatures and different space requirements. The crop rotation plan is made on the basis of the main crop, i.e. the crop that has the longest vegetative season or the highest yield. In intensive crop rotation, there are: preceding crop (usually some early spring or winter varieties such as: lettuce, spinach, kohlrabi, radishes, peas, chard, early potatoes, spring onions); main crop (pepper, tomato, green beans, cabbage, onion, zucchini) and stubble crop – grown after the main crop (autumn garlic, silverskin onion, lettuce, spinach) (Lazić et al., 2013).

An example of a four-year vegetable crop rotation was studied by Medić-Pap et al., (2017). In the first year, they suggested planting young potatoes as a preceding crop for cabbage. After removing the potatoes, late cabbage should be planted on the same

plot in the same year. With this kind of arrangement, we make maximum use of the production area, and we also get two harvests a year. In the second year, they recommended producing pepper or tomato, and in the third year, onions or autumn garlic. Peas or beans are a good crop for the fourth year of vegetable cultivation. After harvesting peas or beans, 50-60 t of manure per hectare should be applied by deep autumn ploughing. The mentioned four-year crop rotation represents one of the possibilities for the organization of vegetable production in the crop rotation. With this formation, we also reduce the possibility of the appearance of a potential inoculum causing plant diseases.

It is not easy to compile a good vegetable crop rotation with all the elements, such as land rotation, crop rotation and shifting cultivation, because one needs to choose the species, cultivar, tillage, sowing and planting deadlines, fertilization, protection from harmful organisms and ripening time. Crop rotation should provide optimal development to plants in terms of soil structure and availability of nutrients and water. When planning crop rotation, it is important to take into account the change of species with different root depths, and to rotate the species with different needs for water and nutrients. For example, species that consume a lot of water, such as peppers, tomatoes, cucumbers and cabbages, should be replaced with species that have moderate water needs (root vegetables, onions and legumes).

The team of authors of Červenski et al., (2016) included in their research the well-organised and timed production of fourteen vegetable species in the optimal time: kohlrabi, radishes, lettuce, spinach, peas, peppers, cabbage, tomatoes, kale, beets, garlic, cucumber, onion, chard. Among first preceding crops sown on the open field were: peas, radishes, kohlrabi, spinach and lettuce. After the harvest, the main crops were transplanted: cabbage, tomato, peppers, beets, and kale. After harvesting the main crops, stubble crops were planted: silverskin onion, garlic, lettuce, spinach. Appropriate crop rotation should enable continuous cultivation of plant species that are economically important for a given region, without compromising soil fertility (Curl, 1963).

Medić-Pap et al., (2017) emphasized the role of crop rotation in preventing the appearance of harmful organisms due to the possible presence of pathogens, but insects and weeds as well. Growing vegetable crops in monoculture on the same area creates opportunities for the accumulation of plant pathogens in the soil, as well as increasing the number of pests and weeds, while nutrients from the soil are consumed unilaterally and irregularly. The same authors further pointed out that the system of crop rotation organization is often affected by the needs of the farm itself, their total land area and the fragmentation of plots. It is also important how much manpower a particular market-oriented farm has at its disposal in a critical period (e.g. requirements in planting, harvesting, sorting, packaging, etc.). Therefore, land resources should be used as rationally as possible, and with the correct crop rotation the possibility of the harmful organisms' appearance should be reduced, aiming to obtain health-safe products. More intensive occurrence of diseases caused by phytopathogenic microorganisms, which are maintained in the soil, are often a consequence of a poor crop rotation. Proper crop rotation can be a significant preventive measure that reduces weed number and controls the population of phytopathogenic organisms, improves soil fertility and increases yields (Sumner 1982; Brust & Stinner 1991, Medić-Pap et al., 2017).

An important condition for successful intensive vegetable production is the introduction of crop rotation, i.e. crop rotation in time and space, primarily due to the possible occurrence of common diseases, weeds and pests in species from the same family. This also refers to the different requirements of certain vegetable species for nutrients, with regular chemical analyses of the soil in order to monitor and improve the qualitative indicators of soil fertility (Lazić et al., 2003; Shafique et al., 2016; Popsimonova, et al., 2017).

Bokan et al., (2016) and Červenski et al., (2017), emphasized the importance of legumes in the vegetable crop rotation as one of the most desirable preceding crops, which leaves the soil in a favourable biophysical condition with a high content of accumulated nitrogen in a natural way. Today, vegetable production is becoming more and more market-oriented. It is associated with the cultivation of only a few significant vegetable species (peppers, tomatoes, cucumbers, potatoes, cabbage, onions), and often through a system of monoculture (Červenski et al., 2016).

One of the reasons for the underutilization of crop diversity lies in the close connection of cultivation practices and the environment with the economic and social issues, such as employment, work organization and the provision of markets for the placement and sale of these products. Most vegetables are sold on the market in the fresh form. The variety and availability of vegetables for the market directly depends on the degree of diversification and the way of production on the farm. Crop diversification even calls into question the organization of the farmhouse work (Castilla et al., 2004; Navarrete et al., 2015).

The importance of rotating two to three types of vegetables during one year is also stated by Ilin et al., (2009). The rotation of vegetable species conditions successful production in a longer period of time, with respect to intensive cultivation practices, whether it is a production in the protected spaces or in the open field.

The choice of a certain production method in the open field with mandatory irrigation, well-chosen and organized time of works and the necessary investments creates the conditions for intensive vegetable production, which Červenski et al., (2013) also stated.

Each vegetable production in garden plots has its own specifics depending on the species, region and cultivation method (indoor or outdoor space). Therefore, in the production of vegetables, there are number of preventive measures that need to be applied in order for the final product to be what vegetables are supposed to be, and that is the source of health-safe food.

CONCLUSIONS

The monoculture way of growing vegetable species in gardens and backyards leads to the accumulation of plant pathogens in the soil, as well as to an increase in the number of pests and weeds. When planning crop rotation, it is important to rotate vegetable species with different root depths, different water needs and nutrients, along the vegetation season. It is not easy to compile a good crop rotation with all the elements such as land rotation, crop rotation and shifting cultivation, because one needs

to choose the species, cultivar, tillage, sowing and planting deadlines, fertilization, protection measures, as well as ripening time. Agricultural producers should monitor, supplement and enrich their knowledge of vegetable production through regular education and training, so that this production can be realized according to health and safety principles.

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Červenski J., Medić-Pap S., Danojević D., Bugarski. D.
Institut za ratarstvo i povrtarstvo, Maksima Gorkog 30, Novi Sad, Srbija
janko.cervenski@nsseme.com

ZNAČAJ SMENE POVRTARSKIH USEVA U BAŠTAMA SA STANOVIŠTA PROIZVODNJE ZDRAVSTVENO BEZBEDNE HRANE

Sažetak

Povrtarska proizvodnja treba da predstavlja izvor zdravstveno bezbedne hrane, koja je osnov za razvoj i zdravlje čoveka. Ona omogućava intenzivno korišćenje zemljišta i ostvaruje visok dohodak po jedinici površine, svakako uz veća ulaganja i dosta ljudskog rada. Proizvodnja zdravstveno bezbednog i biološki vrednog povrća sa poznatim sastavom i kvalitetom u kontrolisanim uslovima postaje sve interesantnija potrošačima. Zbog toga treba što racionalnije koristiti zemljišne resurse i pravilnom smenom povrtarskih biljaka, smanjiti moguću pojavu štetnih organizama te dobijanja zdravstveno bezbednih proizvoda. U proizvodnji povrća plodored predstavlja najčešće zapostavljenu osnovnu preventivnu meru.

Ključne reči: *povrtarske vrste, plodored, hrana, kvalitet*



Ivana Janković¹, Vesna Vujasinović¹, Miloš Ćirić¹, Sanja Dimić²

¹ University of Novi Sad, Faculty of Sciences, Novi Sad, Serbia

² BIMAL SUNCE d.o.o., Edible oil factory, Sombor, Serbia

E-mail: jankovic.ivanaaa@gmail.com

ACRYLAMIDE – POTENTIAL CONTAMINANT IN FRIED POTATO PRODUCTS IN CATERING

Abstract

Acrylamide is an unsaturated amide that occurs in thermally processed foods, such as potato chips, biscuits, nuts, cereals, coffee, etc., and it occurs in larger quantities in foods that are processed at high temperatures. Recently, legal regulations related to acrylamide in food have been introduced in the Republic of Serbia, and the subject of this paper was to examine the awareness of employees in the hospitality industry regarding this contaminant in fried potato products. The results of the research indicated that employees were poorly informed about the presence of acrylamide, as well as adequate preparation phases of potatoes before frying or baking, in order to reduce the content of this toxic contaminant.

Key words: *acrylamide, contaminants, potato, hospitality, food*

INTRODUCTION

Acrylamide is defined as a low molecular weight organic compound. From the aspect of chemical composition, acrylamide is a type of amide, which contains an electrophilic double bond and an amine group with weakly acidic properties (Vujasinović et al, 2020). Acrylamide is metabolized very quickly in the body, after which glycidamide is obtained, which is also toxic and is one of the main genotoxic and carcinogenic substances (Pundir et al., 2019; Bignardi et al., 2019; Raffan and Halford, 2019). After consuming certain foods in which it is found, acrylamide is distributed to vital organs: heart, brain, liver and kidneys (Hu et al., 2014). According to Borisavljević and Dragičević (2017), acrylamide belongs to a special group of toxic chemical substances, since it is formed in the process of food processing.

The formation of acrylamide in food is influenced by several factors. The water content, the time and temperature of heat treatment, i.e. the mechanism for heat trans-

fer, the speed of heating and cooling, the shape and thickness of food, as well as others are a particularly great influencing factors on food preparation before heat treatment (Bignardi et al., 2019).

A very important segment in food preparation is, of course, the use of fat. Oils and fats are an important part of the human diet, as a component of various food formulations. Therefore, they are widely used in households, catering, as well as in the industrial production of various food products. Oils also play a significant role in the preparation of traditional home-made food, which can also cause a problem with acrylamide. Namely, this food is rich in carbohydrates, including baked and fried potatoes, as well as various types of bakery products, which are prepared by heat treatment, i.e. exposure to high temperatures, due to which the risk of exposure to acrylamide is significantly increased and leads to the danger of human organism (Delević et al., 2016).

In the Republic of Serbia, based on the Law on Food Safety (Official Gazette of RS, No. 41/09 and 17/19) in the Rulebook on maximum concentrations of certain contaminants in food from 2019 (Official Gazette of RS, No. 81/2019), *the levels of reference values for the presence of acrylamide in certain foods are given*. The Ordinance also prescribes some of the measures to reduce the effects in order to reduce the presence of acrylamide in food. The ordinance lists foods that have an increased risk of acrylamide, and measures to mitigate the effects of acrylamide are divided into a couple of groups: raw potato products; potato chips cut into leaves, sticks and similar shapes; french fries and other deep-fried sliced potatoes; chips and products, based on pellets, flips, expanded products, crackers and other potato dough products; measures for fine bakery products; measures for breakfast cereals; coffee measures; coffee substitute measures containing more than 50% cereals; coffee substitute measures containing more than 50% chicory; measures for bread. (Rules, 2019 – Annex 3).

Given the fact that the presence of acrylamide in food is a very significant risk factor for the health of the population of all ages, and the legislation of its restrictive level is only recently in force, the subject of this paper was to conduct a survey in a number of restaurants to gain insight into the employees' knowledge regarding acrylamide in fried potato products.

MATERIAL AND METHODS

The research was conducted in the period from 01.02.2020 to 15.05.2020. on the territory of Belgrade in 20 catering facilities, which deal with food and beverage services. The focus of the respondents was on catering workers, and the total number of respondents was 55.

Research within this paper was conducted by:

- the method of surveying catering workers through questionnaires and
- descriptive analysis of survey questionnaire data.

The positions held by the respondents were: chef, manager, waiter and receptionist, however, most of them were food preparation workers.

RESULTS

ANALYSIS OF SOCIO-DEMOGRAPHIC CHARACTERISTICS OF RESPONDENTS

Table 1 shows socio-demographic characteristics of respondents in the hospitality industry.

Table 1. Socio-demographic characteristics of respondents in the hospitality industry

Gender (participation %)	Men	Women
		63,6
Age	Year of age	Participation (%)
	18–30	83,6
	31–40	10,9
	41–50	3,6
	51–60	1,9

As it can be seen from Table 1, the majority of respondents were younger people, aged 18 to 30 years (83.6%), with 63.6% of respondents being male.

The total number of meals, produced daily in the examined facilities, was in the following range: from 151 to 200 meals (share 25.5% – the most) and preparation of up to 30 meals a day (7.3% – the least).

ANALYSIS OF EMPLOYEES' INTELLIGENCE ON THE IMPORTANCE OF ACRYLAMIDE, AS WELL AS PREPARATORY PHASES IN THE POTATO FRYING PROCESS

Table 2 shows most important results of the survey of catering employees regarding the preparatory phases and process of frying potatoes from the aspect of acrylamide.

Table 2. Results of the survey of respondents in the hospitality industry related to acrylamide

Question	Answer	Percentage (%)	Answer	Percentage (%)	Answer	Percentage (%)
Have you heard of acrylamide?	yes	21,8	–	–	no	78,2
Do you know at what temperature are potatoes stored?	yes <6 °C	60	yes >6 °C	33	no	7

Do you blanch potatoes?	yes	50,9	sometimes	27,3	no	21,8
Do you use immersion method?*	yes	49,1	sometimes	21,8	no	29,1
Potato frying temperature	160–175 °C	31	175–210°C	60	>210 °C	9
Do you know the connection between color and acrylamide**	yes	10,9	–	–	no	89,1

* method of immersion potato in cold water before baking;

** dependence between color and amount of acrylamide in fried/baked product

Based on the analysis of the data from Table 2, it can be concluded that the vast majority of respondents, as many as 78.2%, have never encountered the term acrylamide. However, to the question from the survey questionnaire: In which foods does acrylamide most often appear?, the answer was mainly that they are: chips, potatoes, toast and coffee. The results on the occurrence of acrylamide according to Bethke and Bussan (2013) show significant concentrations in foods rich in carbohydrates, especially starch, such as potato chips and french fries, which indicates that these foods may have an adverse effect on the consumer.

Temperature is one of the key factors for storage of raw materials, semi-finished products, finished products, as well as for heat treatment of food. Therefore, there is a need to investigate the temperature at which potatoes are stored (as raw material) in catering facilities. Based on the analysis of the answers to this question, it was found out that there are catering workers who do not know at all how and in what way potatoes are stored before use. Judging by the answers, only in 60% of catering facilities, potatoes were stored under appropriate conditions, ie. at temperatures below 6 °C.

According to the literature (Shibamoto & Bjeldanes, 2009), in order to reduce the concentration of acrylamide in fried potato products, it means a good choice of potato variety, i.e. the choice of varieties with low sugar content, which are stored in the right place and the right temperature, on which additional germination is suppressed and varieties that can be blanched. Measures to further reduce acrylamide in food - food products, imply that food should not be exposed to heat treatment or high temperatures for a long time. Medeiros Vinci et al. (2011) also reported that higher sugar content in potatoes, as in other foods, involves the production of higher amounts of acrylamide, which exceeds the reference value.

Due to the large volume of work in the hospitality industry, as well as the large quantities of food used in one day, the question of the preparatory phase of certain raw materials arises. In the case of baked potatoes, this refers to the process of blanching the potatoes. It can be stated that in about 50% of the surveyed facilities, the technique of blanching potatoes is applied before further use. Blanching reduces the time of frying potatoes in deep oil, which can significantly affect and reduce the presence of acrylamide.

It is a known fact that the concentration of starch in potatoes is high, so it was logical to ask the question: If you do not blanch, do you use the method of immersing potatoes in cold water? Unfortunately, more than half of the respondents answered that they never (29.1%) or sometimes (21.8%) immerse potatoes in cold water in order to reduce the amount of starch. This is very important information, because in this case, the frying process guarantees that the amount of acrylamide will also be reduced, because by dipping, a certain amount of starch will be washed out of the potato and thus reduce the length of heat treatment.

Frying in deep fat or frying is one of the oldest and most common methods of heat treatment of food. When frying, food is immersed in fat that is heated to high temperatures (Farkas, Singh, & Rumsey, 1996). Frying creates crunchiness and dehydration in foods. The core region of fried foods is considered to be oil-free after all (Pedreschi, 2009). Eat ie. Dill side dish is mainly prepared in large quantities in food preparation establishments. The EU regulation stated that acrylamide levels can be lowered by certain mitigation approaches, such as the application of good manufacturing / manipulation-practices and the application of procedures based on hazard analysis and the principles of critical control points, storage, preparation and mechanical processing (European Commission, 2017).

Research by Matoso et al. (2019) showed that the formation of acrylamide in food was confirmed after frying at a temperature of 220°C. Having in mind the obtained results, the authors concluded that fried and baked food are in the forefront when it comes to the creation of acrylamide, which is made possible by the chemical reaction that takes place between the individual ingredients of heat-treated food. Messiah et al. (2019) recommended reducing the presence of acrylamide, which includes the frying process at a temperature not exceeding 175°C. According to the results of research within this paper, it can be concluded that in only 31% of the facilities the frying temperature was up to 175°C, in 60% up to 210°C, and in 9% of the facilities the fried food was prepared at a temperature above 210°C.

The sensory properties of fried potatoes are something that the consumer first notices in catering facilities and based on that it can be determined whether the product is well, badly baked, fried or over fried. That is why the connection between the color of fried potatoes and the amount of acrylamide is of special importance. It is a devastating fact that only about 10% of respondents gave a positive answer about knowing this correlation. This is a very important fact, which shows that the workers in the catering industry are not sufficiently informed about the importance of food preparation, hence they do not know and do not distinguish between good or bad fried food. The color and sensory properties of a food can be a significant indicator of a food, if you notice a brown or black color on a food after heat treatment, it can be stated that the food has a higher percentage of acrylamide in its composition than a lighter or golden yellow color.

Extensive research has been conducted at the European Union level and it has been announced that lowering acrylamide levels in food can be achieved by modifying the process and / or reducing potential causes in the food production process itself (Food-DrinkEurope, 2019).

CONCLUSION

In the Republic of Serbia, regulations on restrictions and measures related to the amounts of acrylamide present in food have been in force since 2019. Based on that, there is a need to examine catering workers who have contact with food preparation, about their knowledge of this contaminant. It is very important to raise awareness among people that the intake of acrylamide in food can significantly increase the risk of cancer.

In accordance with the fact that acrylamide causes a harmful effect in the body, a survey was conducted in order to find out how familiar employees in the hospitality industry are with this topic. Based on the research, it can be concluded that a very small number of respondents are familiar with the concept of acrylamide, the way it is formed during the food preparation process, and thus its effect in the body. It can also be concluded that very high temperatures are used in restaurants for most food preparation. A much larger part of employers should be familiar with the legal regulations related to acrylamide, in order to influence the staff and the application of various measures in order to reduce its quantity in meals prepared in catering facilities.

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Ivana Janković¹, Vesna Vujasinović¹, Miloš Ćirić¹, Sanja Dimić²

¹Univerzitet u Novom Sadu, Prirodno-matematički fakultet, Novi Sad, Srbija

²BIMAL SUNCE d.o.o., Fabrika biljnih ulja, Sombor, Srbija

E-mail: jankovic.ivanaaa@gmail.com

AKRILAMID – POTENCIJALNI KONTAMINENT U PRŽENIM PROIZVODIMA OD KROMPIRA U UGOSTITELJSTVU

Sažetak

Akrilamid je nezasićeni amid koji se javlja u termički obrađenoj hrani, kao što su čips od krompira, keks, orašasti plodovi, žitarice, kafa i dr., a u većim količinama se javlja u namirnicama koje se obrađuju na visokim temperaturama. Od nedavno su u Republici Srbiji uvedene zakonske regulative vezane za akrilamid u hrani, te predmet ovog rada je bio da se ispita upućenost zaposlenih u ugostiteljstvu vezano za ovaj kontaminent u prženim proizvodima od krompira. Rezultati istraživanja su ukazali na slabu upućenost zaposlenih o prisustvu akrilamida, kao i adekvatnim pripremnim fazama krompira pre samog prženja ili pečenja, radi smanjenja sadržaja ovog toksičnog kontaminanta.

Ključne reči: *akrilamid, kontaminanti, krompir, ugostiteljstvo, hrana*



Vesna Perišić¹, Vladimir Perišić², Kristina Luković², Vera Rajjičić¹,
Dragana Predojević³, Snežana Pešić³, Filip Vukajlović³

¹ Faculty of Agronomy, University of Niš, Kruševac, Serbia

² Center for Small Grains, Kragujevac, Serbia

³ Faculty of Science, Institute for Biology and Ecology,
University of Kragujevac, Serbia
E-mail address: vperisic@kg.ac.rs

PERSISTENCE AND EFFICACY OF DIATOMACEOUS EARTH FROM SERBIA AGAINST *RHYZOPERTHA* *DOMINICA* F. ON WHEAT

Abstract

The persistence and efficacy of diatomaceous earth from Serbia (DE S-1 and DE S-2) on *Rhyzopertha dominica* F. in stored wheat was examined. Commercial DE formulation, Protect-It, was used as a standard. Three months after treatment with DEs at rates of 1 mg kg⁻¹, grains were infested with adults of *R. dominica* F. Insect mortality was determined after 7, 14 and 21 days. The results show that the efficacy of DEs increased with the duration of exposure. After the 21st day the higher mortality was detected in grains treated with Protect-It (99.5%), while there were no differences between DE S-1 and DE S-2 (96.5% and 95.5%, respectively). The progeny/progeny reduction then weak after exposure were 6/99.2% Protect-It, 54.8/93.1% DE S-1 and 193/75.84% DE S-2.

Keywords: *Rhyzopertha dominica*, diatomaceous earth, insecticidal activity, persistence, wheat

INTRODUCTION

The lesser grain borer, *Rhyzopertha dominica* (Fabricius, 1792) (Coleoptera: Bostrichidae) is a primary pest of stored grain, with the great economic importance in the Republic of Serbia and many regions of the world. *R. dominica* spends most of its life inside kernels, feeding on its endosperm, which causes damage and changes in grain physicochemical properties. Modern methods of protection of stored grains and

other plant products from insect pests strive towards optimizing the use of different techniques and methods within integrated pest management (IPM) programs. Diatomaceous earths (DEs) have been identified as natural materials and promising alternatives to stored-grain protectants, such as residual insecticides (Athanasassiou et al., 2014; Andrić et al., 2012; Kavallieratos et al., 2005, 2010; Korunić, 2013). They leave no toxic residues on the product and according to the US EPA (Environmental Protection Agency) they are classified in the category of GRAS (Generally Recognized As Safe) since they are used as food or feed additives (FDA, 1995). Moreover, they are non-toxic to mammals (rat oral LD50 > 5000 mg/kg of body weight) and as inert materials, no interaction with the environment occurs.

Available data show that stored-product insects are variably susceptible to inert dust, resulting from their different morphological, physiological and ecological characteristics. The DEs mined currently vary remarkably in their insecticidal activity, depending upon the geological and geographical origin as well as certain characteristics, such as SiO₂ content, pH, tapped density and adherence to kernels (Korunić, 2013). Several DEs, based on natural deposits, are now commercially available. However, the search for newer, naturally occurring DEs that are more effective for insect control is still in progress. Korunić (2013) and Athanasassiou et al. (2011) found that local DEs from the former Yugoslavia were very effective, and could be used with success against stored-grain pests.

Also, as inert materials, DE particles remain unaffected and can persist on the product, providing long-term protection (Athanasassiou et al., 2005; Vayias et al., 2006). DEs persist in the treated substrate, providing long-term protection against stored products insect pests that are not possible with the use of residual insecticides.

In the present study, we evaluated the potential of long-term protection of wheat against *R. dominica* through the use of DEs from Serbia and compared with a commercialized DE product, Protect-It. In addition to parental mortality, we also evaluated progeny production on the treated grains.

MATERIAL AND METHODS

The trial was carried out on laboratory populations of *R. dominica*. Insects were reared in 2.5 L glass jars containing soft wheat grain with moisture degree below 12%. The temperature in the insectary was 26±1 °C, and relative humidity – r.h. 60±5%. Unsexed 2-4 week old adults were used in all trial variants.

Two DE samples from Serbia, DE-S1 and DE-S2, were tested, and a commercial DE formulation, Protect-It (Hedley Technologies Inc., Canada), was used as a standard for comparing the effectiveness of the Serbian DEs.

Table 1. Chemical composition of diatomaceous earth

DE samples	Chemical composition							
	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	K ₂ O	Na ₂ O	MgO	CaO	TiO ₂
<i>DEs from Serbia</i>								
DE S-1	79,7	9,41	1,11	0,79	0,08	0,14	0,63	0,21
DE S-2	63,15	10,31	1,67	0,91	0,08	0,31	1,01	0,31
<i>Standard</i>								
DZ Protect-It™	83,7%*	3%	1%	<1	<1	<1	<1	–

* +10% silica aerogel

The wheat cultivar Vizija, grain variety originating from the Center for Small Grains Kragujevac, Serbia, was used. The tested grain was infestation-, pesticide-, and dockage-free.

Three 0.5 kg lots of grain were prepared. The application rates were 1.0 g kg⁻¹ (1000 ppm) for all three DEs. The lots were placed in glass jars of 1000 mL volume. In order to secure equal distribution of the DEs, the grain was shaken manually for 2-3 min and then mixed on a rotary mixer for 10 min. Treated and untreated grain was stored under ambient conditions (21.0 ± 1.0°C, 40-60% r.h.) in 2 L plastic containers with vented bottoms and lids. After three months, four samples of 50 g were taken from each DE and placed into a 200 mL plastic vessel. The quantity of 50 g was weighed on an analytical balance. Subsequently, 25 adults of *R. dominica* were released into each vessel and the vessel was topped with cotton cloth and fixed with a rubber band. The same procedure was applied to untreated grain samples which served as a Control. So, Control is infested with 25 adults of *R. dominica*, but pesticide-, and dockage-free. All vessels were placed in an incubator set to 26±1°C temperature and 60±5% r.h. Insect mortality was determined after 7, 14 and 21 days of contact with treated or untreated grain types. After the last mortality count, both dead and living adults were removed and all vessels were returned to the incubator for 7 additional weeks under the same (described) conditions. Progeny emergence/suppression was determined by counting insects in treated and control grains.

The whole procedure was repeated twice.

Data analysis

Before analysis, the percentage of mortality was transformed using *arcsine*, progeny number was transformed by *log(x+1)*. Untransformed means for mortality and progeny emergence with standard errors are shown in the tables. All data were submitted to a one-way ANOVA and the means were separated by Fisher (LSD) test at *P*=0.05. Insect progeny reduction in wheat was determined by using the formula $PR (\%) = (K-T) \times 100/K$ where K – number of progeny in the untreated control group, and T – number of progeny in treatment groups. All data were processed on StatSoft version 7.1 (StatSoft Inc., Tulsa, Oklahoma).

RESULTS

Results obtained for *R. dominica* mortality after 7, 14 and 21 days of exposure in wheat treated with DEs are presented in Table 2. After 7 days of exposure, the highest insect's mortality of 87.25% was recorded for Protect-It, while DEs from Serbia caused the mortality from 53.25% (DE S-2) to 62.0% (DE S-1).

After 14 days of exposure, all three tested DEs caused significantly higher mortality of *R. dominica* than after the initial 7-day exposure period. High adult mortality, 98.5%, was found in wheat treated with Protect-It. After 14 days of exposure, the lowest *R. dominica* mortality was found in grains treated with DE S-2 (89.0%), but there were no statistical differences between DEs from Serbia.

Over the interval of 21 day, high mortality, 95.5%-99.5%, was observed. Generally, the higher mortality were detected in grains treated with Protect-It (99.5%), while there were no differences between DE S-1 and DE S-2 (96.5% and 95.5%, respectively).

Table 2. Mean percentage mortality (\pm SE) of *Rhyzopertha dominica* adults exposed in wheat treated with DEs from Serbia three months before exposure

Formulation	Mortality (% \pm SE) after exposure in grains		
	After 7 days of exposure	After 14 days of exposure	After 21 days of exposure
DE S-1	62.00 \pm 3.15 ^b	92.00 \pm 1.19 ^b	96.50 \pm 1.19 ^b
DE S-2	53.25 \pm 4.6 ^c	89.00 \pm 1.6 ^b	95.50 \pm 1.61 ^b
Protect-It	87.25 \pm 2.6 ^a	98.50 \pm 1.06 ^a	99.50 \pm 0.5 ^a
Control	1.00 \pm 0.66 ^d	2.50 \pm 0.74 ^c	6.50 \pm 1.51 ^c
F	50.40	84.73	170.34

* For each exposure period separately, means within columns followed by the same letter are not significantly different. Fisher (LSD) test at $P>0.05$; in all cases $df=7,32$; $P<0.05$.

High levels of progeny reduction of 99.2% were found in wheat treated with Protect-It as well as in grains treated with DE S-1 (93.2%). The least progeny reduction of 75.84% was found in samples treated with DE S-2 (Table 3.).

Table 3. Progeny emergence (adults/val) and reduction of *R. dominica* in wheat treated with DEs from Serbia at dose of 1000 ppm three months before exposure

Formulation	Mean number of progeny (adults/val \pm SE)	Progeny reduction (%)
DE S-1	54.8 \pm 3.17 ^b	93.10 \pm
DE S-2	193.0 \pm 4.98 ^c	75.84 \pm
Protect-It	6.37 \pm 0.75 ^a	99.20 \pm
Control	799.0 \pm 20,02 ^d	/
F	20.78	/

* Means within columns followed by the same letter are not significantly different. Fisher (LSD) test at $P>0.05$; in all cases $df=7,32$; $P<0.05$.

DISCUSSION

Available data show that stored-product insects are variably susceptible to inert dust, resulting from their different morphological, physiological and ecological characteristics. The dust DE S-1 and DE S-2, originating from Serbia, are less effective against *R. dominica* than against rice weevil *Sitophilus oryzae* (L.) or red flour beetle *Tribolium castaneum* (Herbst) (Andrić et al., 2012). Despite this, Perišić et al. (2018), after 21 days of exposure of Protect-It, DE S-1 and DE S-2 reported high mortality of *R. dominica* in wheat (93.0-96.5 %). The high mortality of *R. dominica* after application of different commercially available DEs has been reported by many authors (Athanasassiou et al., 2005, 20011, 2014; Korunić, 2013; Kavallieratos et al., 2005, 2010).

Previous studies indicated the high efficacy of DEs, but these studies do not indicate the possibility of long-term protection of stored wheat. Protection of wheat for extended time periods of storage is a basic purpose of any grain management program. Although, Athanassiou et al. (2005) reported residual efficacy of DEs – Insecto, SilicoSec, and PyriSec against *S. oryzae* L. on wheat and barley for up to 450 days, Vayias et al. (2006) conducted the first study of the residual effect of three DEs on wheat and maize against *T. confusum* and indicate good protection over 360 days. Similar results have also been reported by Stathers et al. (2008) for the DE Protect-It on farm-stored maize in the field in Tanzania. The authors showed that Protect-It maintained its insecticidal efficacy for 20 months.

The present study provides clear evidence that the tested DEs were effective and could offer long-term protection to the treated wheat against *R. dominica*. DEs from Serbia achieved efficacy of 95.5-96.5% against *R. dominica* exposed for 21 days. The results are similar as results of studies where adults of *R. dominica* were exposed immediately after treatment of different DEs (Kavallieratos et al., 2005; 2010; Athanassiou et al., 2011; Perišić et al., 2018).

The results show that the efficacy of DEs from Serbia against *R. dominica* increased with the duration of exposure. This is consistent with findings reported by many other studies (Athanassiou et al., 2005, 2011, 2014; Kavallieratos et al., 2010; Andrić et al., 2012; Korunić, 2013; Perišić et al., 2018). In the cited studies, insects were also exposed immediately after wheat treatment with diatomaceous earth. Vayias et al. (2006) treated the wheat and maize with DEs – Insecto, PyriSec and SilicoSec. Samples were taken on the day of storage and every 30 days until completion of a 360 day period of storage and bioassayed with *T. confusum* adults. Thus a DE treatment of 1 g kg⁻¹ was shown to provide long-term protection of wheat against *T. confusum*.

Although DE S-1 and DE S-2 were not formulated or silica gel was added to them, as is the case with Protect-It (+10% of silica gel), these DEs showed good efficacy even after three months of wheat treatment.

The effect of inert dust on progeny emergence of stored-product insect pests is a very important parameter, which reveals the potential for long-term protection of stored grains. Athanassiou et al. (2014) recorded that even when parents' mortality was 100%, progeny emergence was inevitable with *R. dominica*. In the present study, Protect-It achieved 99.5% mortality after 21 days of exposure but a small number of offspring did emerge in some of the examined grain varieties, i.e. 6.37 insects. Significant dif-

ferences in progeny reduction of DE S-1 and DE S-2 were found. In DEs treated grains, offspring counts were the highest in wheat treated with DE S-2 (193.0). This finding is consistent with the finding of Perišić et al. (2018) who examined the efficacy of DE from Serbia immediately after treatment.

These results imply that DE S-1 has better efficiency than DE S-2. Vayias et al. (2006) and Korunić (2013) have identified SiO₂ content and particle size as the characteristics of DEs that primarily determine the efficacy of DEs. Similar conclusions could be inferred from present findings as DE S-1 contains 79.8% SiO₂, while DE S-2 contains 63.2% SiO₂. The particle fraction < 13 µm is the prevailing fraction in the DE S-1, 95.3% somewhat lower in DE S-2, 81.0% (Andrić et al., 2012). Based on the above mentioned, in this study, the differences in the content of SiO₂ and particle size between DE S-1 and DE S-2 were recorded.

Athanassiou et al. (2011) and Korunić (2013) in an extensive screening of DEs from several parts of the world found that local DEs from the former Yugoslavia were very effective, and could be used with success against stored-grain pests. Andrić et al. (2012) and Perišić et al. (2018) showed the good insecticidal potential of DEs from Serbia in stored insects control in grains such as wheat, barley, rye, oats and triticale. The presented results confirm the high persistence of DEs as the good insecticidal potential of DEs from Serbia. The use of a natural, non-toxic insecticide that persists in the grain could be a very promising alternative to the residual pesticides that currently dominate stored grain protection.

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Vesna Perišić¹, Vladimir Perišić², Kristina Luković², Vera Rajičić¹, Dragana Predojević³, Snežana Pešić³, Filip Vukajlović³

¹ Poljoprivredni fakultet, Kruševac, Univerzitet u Nišu, Srbija

² Centar za strna žita, Kragujevac, Srbija

³ Prirodno-matematički fakultet, Institut za biologiju i ekologiju,

Univerzitet u Kragujevcu, Kragujevac, Srbija

E-mail: vperisic@kg.ac.rs

PERZISTENTNOST I EFIKASNOST DIATOMEJSKE ZEMLJE POREKLOM IZ SRBIJE U SUZBIJANJU *RHYZOPERTHA DOMINICA F.* U PŠENICI

Abstract

Ispitivana je perzistentnost i efikasnost diatomejske zemlje poreklom iz Srbije (DZ S-1 i DZ S-2) u suzbijanju *Rhyzopertha dominica* F. Kao standard korišćen je preparat na bazi DZ Protect-It. Uskladištena pšenica tretirana je DZ u količini od 1000 ppm (1 g DZ kg⁻¹ žita). Tri meseca nakon tretiranja pšenica je infestirana adultima *R. dominica*. Smrtnost izlaganih jedinki utvrđivana je posle 7, 14 i 21. dana izlaganja. Na procenat smrtnosti značajno je uticao period izlaganja. Najveću smrtnost posle 21. dana izlaganja prouzrokovao je Protect-It (99,5%). Nije ustanovljena razlika u efikasnosti DZ S-1(96,5%) i DZ S-2 (95,5%). Prosečan broj potomaka (±SG) / redukcija potomstva (%) deset nedelja posle izlaganja bio je 6/99.2% Protect-It, 54.8/93.1% DZ S-1 i 193/75.84% DZ S-2.

Ključne reči: *Rhyzopertha dominica*, diatomejska zemlja, insekticidna efikasnost, perzistentnost, pšenica

FRUITS AND GRAPES PRODUCTIONS



Ana Selamovska¹, Elizabeta Miskoska-Milevska²

¹ Department of Fruit Growing, Institute of Agriculture, Ss. Cyril and Methodius University in Skopje, R. of North Macedonia

² Faculty of Agricultural Sciences and Food, Ss. Cyril and Methodius University in Skopje, R. of North Macedonia
E-mail: miskoska@yahoo.com

THE HIGHEST QUALITY TRADITIONAL PEAR VARIETIES IN MACEDONIA

Abstract

Twenty-six traditional pear varieties exist on the territory of Macedonia. According to the phonological, fruit and chemical characteristics, the varieties 'Karamanka', 'Erebasma', 'Shaldanka', 'Tatlikuti', 'Tiranka' and 'Ekshikuti' are characterized with the best features. The aim of the present study was comparison of the phonological, fruit and chemical characteristics of these traditional pear varieties. According to the ripening time, the variety 'Karamanka' is characterized as late-summer variety. The pears 'Tatlikuti', 'Erebasma' and 'Shaldanka' are autumn varieties, while the varieties 'Tiranka' and 'Ekshikuti' are winter varieties. The researched varieties are characterized as long-lasting, middle-vigorous trees ('Shaldanka', 'Tiranka', 'Ekshikuti') to vigorous varieties ('Tatlikuti', 'Erebasma' and 'Karamanka'). The researched varieties formed medium-large fruits, with exception of the variety 'Ekshikuti' which had smaller fruits. The short fruit stalk had the varieties 'Tatlikuti' and 'Ekshikuti', the pear 'Erebasma' had medium-long stalk, while the rest of the varieties had long stalk. The fruits contain low quantity of healthy seeds in fruits, except the pears 'Shaldanka' and 'Ekshikuti'. All varieties, with the exception of the varieties 'Ekshikuti' and 'Erebasma' had firm fruit exocarp. The fruits contained highest value of soluble dry matter and total sugar, and middle to excellent taste. Statistically significant differences among the researched pear varieties for all fruit characteristics were found. The varieties 'Tiranka', 'Erebasma' and 'Karamanka' were characterized as pear varieties with the best flavor.

Key words: *pear, traditional, variety, quality*

INTRODUCTION

According to the previous researches, 26 traditional pear varieties exist in the Macedonia, 13 of them are summer varieties, 5 are autumn varieties and 8 are winter

varieties (Selamovska & Nikolic, 2012; Selamovska *et al.*, 2012; Selamovska, 2013; Selamovska *et al.*, 2013a; Selamovska *et al.*, 2013b; Selamovska *et al.*, 2014a; Selamovska *et al.*, 2015; Miskoska-Milevska *et al.*, 2016; Miskoska-Milevska *et al.*, 2018; Selamovska *et al.*, 2019). In the past, implementation of new industrial varieties, by substitution of local varieties with those from abroad, puts the negative effects on genetic variations. With intensive agricultural production and implementation of new pear varieties, new diseases also came along, that destroyed the local gene fond as well as the gene fond brought from abroad. The presence of fire blight bacteria (*Erwinia amylovora* Burr.) and pest (*Psylla pyri* L.) in 90's years of 20th Century, was reason for huge damaging the pear production in Republic of Macedonia, and worldwide. Today, there are almost no pear orchards in Macedonia. Also, traditional pear varieties are very rare in our country and can be found in abandoned regions or sporadically in some yards.

According many scientists, the pear has a long history on the Balkan Peninsula (Milutinovic *et al.*, 1998; Milutinovic *et al.*, 2005; Mratinic, 2000; Niketic, 1951), as well as in Macedonia (Avramovski *et al.*, 2005; Dimitrovski, 1974, Selamovska *et al.*, 2013a). In Macedonia, the orcharding achieved a great success in the time of St. Kliment Ohridski and St. Naum, in the 9th and 10th centuries. In the period of the Ottoman Empire, the Turkish dignitaries were involved in dissemination of pear. At that time, many traditional orchards were erected. Many old traditional pear varieties still exist in the Ohrid region (Avramovski *et al.*, 2005). The traditional pear varieties are characterized with vitality, long lasting, very well adaptation to the local conditions and naturally resistant to some diseases. In that sense, these traditional pear varieties represent healthy organic food.

The present study provides information on 6 the highest traditional pear varieties in Macedonia and in same time is a contribution in the process of revitalization and preserving of the traditional pear gene-fond in Macedonia.

MATERIALS AND METHODS

In this study, the characteristics of 6 the highest quality traditional pear varieties on the territory of Macedonia ('Shaldanka', 'Tatlikuti', 'Erebasma', 'Karamanka', 'Tiranka' and 'Ekshikuti') are presented (Selamovska *et al.*, 2013a; Selamovska *et al.*, 2013a; Selamovska *et al.*, 2014a; Selamovska *et al.*, 2015; Selamovska *et al.*, 2016).

The outreach researches were realized in all regions in Macedonia (Selamovska & Nikolic, 2012; Selamovska *et al.*, 2012; Selamovska, 2013; Selamovska *et al.*, 2013a; Selamovska *et al.*, 2013b; Selamovska *et al.*, 2014a; Selamovska *et al.*, 2015; Miskoska-Milevska *et al.*, 2016; Miskoska-Milevska *et al.*, 2018; Selamovska *et al.*, 2019). The region of Gevgelija belongs to sub-mediterranean, or modified mediterranean climate-vegetation-soil area. The regions of Skopje, Veles and Kumanovo belong to continental-submediterranean, climate-vegetation-soil area. The regions of Kriva Palanka, Bitola, Ohrid, Kratovo, Tetovo, Gostivar, Debar and Kichevo belong to hot continental climate-vegetation-soil area, while the regions of Berovo and Resen belong to cold continental climate-vegetation-soil area (Filipovski *et al.*, 1996).

The varieties 'Shaldanka', 'Tatlikuti', 'Ekshikuti' only exist in Prespa region (Selamovska *et al.*, 2015). The pears 'Erebasma', 'Karamanka' and 'Tiranka' exist in almost all regions in Macedonia (West, East and Povardarie) (Selamovska *et al.*, 2013a; Selamovska *et al.*, 2014a; Selamovska *et al.*, 2014b; Selamovska *et al.*, 2019). In some regions, these pear varieties have different synonyms.

During this research, we analyzed the phenological characteristics (ripening time), fruit characteristics (fruit mass, fruit firmness, length of fruit stalk and number of seeds in a fruit); characteristics of fruit mesocarp (color, taste, presence of stone cells); and chemical characteristics of fruits (total sugar, total acids and soluble dry matter). The descriptor, developed by the International Board of Plant Genetic Resources (IBPGR) was used for determination of morphological characteristics. According to the fruit mass, the pear varieties are classified as: very small fruit (to 25 g), small fruit (26-50 g), medium-small fruit (51-100 g), medium fruit (101-150 g), medium-large fruit (151-200 g), large fruit (201-300 g) and very large fruit (over 300 g) (Mratinic, 2000). According to the number of seeds in the fruit, pear varieties have very low quantity (0.1-1), low (1.1-3), medium (3.1-5) to high quantity of seeds (5.1-10). According to the length of the fruit stalk, pear varieties have short stalk (to 2 cm), medium-long (2.1-3.5 cm) and long stalk (more than 3.5 cm). The fruit firmness was measured with a FT02 penetrometer, while the fruit mass was weighed on the Mettler analytical laboratory scale. The extraction of seeds was done manually and then the number of filled (healthy) seeds per fruit was counted. The total sugar and the soluble dry matter were measured with Carl Zeiss Jena-DDR/713457 refractometer. The total acids were determined by a standard method of titration (NaOH). In order to compare researched pear varieties, the data were statistically processed using analysis of variance (ANOVA).

All outreach analyses were realized in cooperation with professionals from the Agency for individual Agriculture Development. This research was a part of the scientific-research projects "Study of Autochthonous Pear Varieties in the Republic of Macedonia" (2009) and "Autochthonous Pear Varieties in Republic of Macedonia" (2011), financed by the Ministry of Agriculture, Forestry and Water Economy of Macedonia.

RESULTS AND DISCUSSION

In this study, phenological, fruit and chemical characteristics of 6 the highest traditional pear varieties ('Shaldanka', 'Tatlikuti', 'Erebasma', 'Karamanka', 'Tiranka' and 'Ekshikuti') were compared. All analyzed pear trees are very old and solitary. Also, these pear trees are not treated with chemicals in pest and disease control and exist without watering. Their fruits are harvested by the local residents for their needs or for local markets.

According to the ripening time, the variety 'Karamanka' is late-summer variety and it is in agreement with conclusions of Avramovski *et al.* (2005) and Selamovska & Nikolic (2012). The pears 'Tatlikuti', 'Erebasma' and 'Shaldanka' are autumn varieties, while varieties 'Tiranka' and 'Ekshikuti' are winter pear varieties. Also, the pear 'Ereba-

sma' is classified as autumn variety by Avramovski *et al.* (2005) as well as Selamovska and Nikolic (2012). According to Stancevic (1983), the pear 'Shaldanka' is a late-autumn to winter variety depending on climatic conditions. The varieties 'Shaldanka', 'Tatlikuti', 'Ekshikuti' only exist in Prespa region, while, the pears 'Erebasma', 'Karamanka' and 'Tiranka' exist in almost all regions in Republic of North Macedonia, so it was possible to done comparative analysis related to the ripening time in different regions.

The fruits of pear 'Karamanka' ripen in the third decade of August, in the time of the orthodox holiday Golema Bogorodica. On the other hand, the average ripening time of the variety 'Erebasma' is the middle of September. Depending of the climatic conditions, the pears 'Karamanka' and 'Erebasma' have different ripening time and this is due to the influence of the ecological conditions. Namely, the fruits of pear 'Erebasma' from the regions of Skopje and Kumanovo ripen in the first half of September, in the Debar region in the end of September, while in the regions of Berovo, Resen and Pehchevo in beginning of October. The fruits of the pear 'Karamanka' ripen from the second half of August until the end of August in the Skopje and Kumanovo regions, while in the other regions in the beginning, or in the first half of September. According to Selamovska *et al.* (2013) the reasons for the earliest time of fruit ripening in the Skopje and Kumanovo regions are the higher air temperatures, lower altitude and smaller quantity of rain fall during the year, compared with the other ecological regions.

The researched varieties produced medium-large fruits, whit the exception of the variety 'Ekshikuti' which produced smaller fruits. The detected differences in the fruit mass among the researched pear varieties were statistically significant (Table 1).

Table 1. Analysis of variance (ANOVA) for fruit mass

ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	110580,6	5	22116,11	26178256	0	2,266062
Within Groups	0,147	174	0,000845			
Total	110580,7	179				

SS – sum of squares, df – degrees of freedom, MS – mean square, F – F-test, P – value – probability, F – critic – critical value of F

According to Selamovska *et al.* (2014a) the variety 'Karamanka' forms the biggest fruits in the region of Kumanovo and Resen, although the biggest fruits were expected in the region Resen because of the excellent climate and soil conditions for growing pears. The smallest fruits with the worst taste and biggest amount of stone cells were produced in the Kratovo and Skopje regions.

According to Selamovska *et al.* (2013) the variety 'Erebasma' produces the largest fruits in Pehchevo region (191.5 g), while the smallest are found in Skopje region (90.3 g). Large fruits (under 150 g) are detected in the region of Kriva Palanka, Debar, Pehchevo and Berovo.

According to Mratinic (2000), the variety 'Karamanka' produces medium-small fruits (with average mass of 87.55 g), while according to Niketic (1951), Milutinovich *et al.* (1998), Milutinovich *et al.* (2005) and Avramovski *et al.* (2005) this variety has medium-large fruits. Depending of climatic factors, fruits of pear 'Erebasma' is found to be medium-small size (Mratinic, 2000) to medium large (Niketic, 1951; Avramovski *et al.*, 2005; Milutinovich *et al.*, 2005; Selamovska *et al.*, 2013a). Under dry conditions, its yield is altering, giving smaller fruits with low quality, poor taste and higher amount of stone cells (Dimitrovski, 1974).

Long fruit stalk was characterized for all researched pear varieties, with the exception of the varieties 'Tatlikuti' and 'Ekshikuti' which had short fruit stalk, and the pear 'Erebasma' which had medium-long stalk. The differences in the length of the fruit stalks among the researched pear varieties were statistically significant (Table 2). Namely, the long fruit stalk gives a good connection between the branches and the fruit, and it is very important for hilly-mountainous regions. The longest fruit stalk in the pear 'Karamanka' was found in the Skopje and Kumanovo regions (Selamovska *et al.*, 2014a). According to Dimitrovski (1974), this characteristic of pear 'Karamanka' is important for its growing in windy regions. According to Selamovska *et al.* (2013a), a fruit stalk of the variety 'Erebasma' is long in all regions, with the exception of region of Debar and Resen).

Table 2. Analysis of variance (ANOVA) for length of fruit stalk

ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	26084,25	5	5216,85	90592,01	4,3E-295	2,266062
Within Groups	10,02	174	0,057586			
Total	26094,27	179				

SS – sum of squares, df-degrees of freedom, MS – mean square, F – F-test, P – value – probability, F – critic – critical value of F

These varieties contained a low quantity of seeds in the fruits, with the exception of the pears 'Shaldanka' and 'Ekshikuti'. The pear 'Shaldanka' had very low, while the variety 'Ekshikuti' had high quantity of seeds in the fruits. The differences in the number of seeds in fruit were statistically significant (Table 3). According to Dimitrovski (1974), Mratinic (2000), Avramovski *et al.* (2005) and Nyeki *et al.* (1998), low quantity of seeds indicates triploidy of the varieties and a tendency of parthenocarpy.

Table 3. Analysis of variance (ANOVA) for number of seeds in fruit

ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	665,85	5	133,17	11034,09	1,2E-215	2,266062
Within Groups	2,1	174	0,012069			
Total	667,95	179				

SS – sum of squares, df – degrees of freedom, MS – mean square, F – F-test, P – value – probability, F – critic – critical value of F

The biggest number of seeds in the fruits of the variety 'Erebasma' was counted in fruits from the Skopje region (Selamovska *et al.*, 2013a). The lower number of seeds in a fruit of the 'Karamanka' is due to the triploidy of the variety and was confirmed by Mratinic (2000) and Avramovski *et al.* (2005). According to the Selamovska *et al.* (2014a) the biggest seed number was found in fruits from the Kratovo region.

Table 4. Analysis of variance (ANOVA) for fruit firmness

ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	5779020	5	1155804	16759158	0	2,266062
Within Groups	12	174	0,068966			
Total	5779032	179				

SS – sum of squares, df – degrees of freedom, MS – mean square, F – F-test, P – value – probability, F – critic – critical value of F

For transport and storage of fruits, the fruit firmness is one of the more important characteristic. Of course, the firmer fruits are easier to be transport and store. The highest values for fruit firmness were measured in the fruits of the varieties 'Karamanka' and 'Tiranka', while the lowest values were detected in the fruits of the pears 'Ekshikuti' and 'Erebasma'. Significant differences were also found in the fruit firmness, among the researches varieties (Table 4). The fruits of the pear 'Erebasma' are characterized by very thin exocarp and can crack and juice leaks out when the fruit is mature enough. This characteristic is reason, the pear 'Erebasma' to be named *erebasma* that in Turkish language means "do not touch me" (Avramovski *et al.*, 2005).

Table 5. Analysis of variance (ANOVA) for soluble dry matter

ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1778,2	5	355,64	29467,31	1,1E-252	2,266062
Within Groups	2,1	174	0,012069			
Total	1780,3	179				

SS – sum of squares, df – degrees of freedom, MS – mean square, F – F-test, P – value – probability, F – critic – critical value of F

The taste and the color of the fruit mesocarp are very important characteristics.

The pear 'Shaldanka' forms fruits with whitish color of the fruit mesocarp, with medium fine to fine taste, high value of stone cells. The mesocarp became overripe when the fruits ripened. (Selamovska *et al.*, 2015).

The color of the fruit mesocarp in the variety 'Tatlikuti' is whitish, with fine to excellent taste and juicy mesocarp. The mesocarp became overripe when the fruits ripened (Selamovska *et al.*, 2015).

The color of fruit exocarp of the variety 'Erebasma' is green-yellow with red blush on the sunny side as well as with presence of green or rusty spots. In maturity stage, fruit exocarp becomes yellow. The fruit exocarp is tiny and softy. A fruit mesocarp is very juicy, light green, softy, with pleasant sweet-sour flavor and specific aroma. This variety is named 'Sonlija' in region of Berovo and Pehchevo, that means nice like dream. Matured fruit becomes rotten (Selamovska *et al.*, 2013a).

Table 6. Analysis of variance (ANOVA) for total acids

ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0,3885	5	0,0777	11266,5	1,9E-216	2,266062
Within Groups	0,0012	174	6,9E-06			
Total	0,3897	179				

SS – sum of squares, df – degrees of freedom, MS – mean square, F – F-test, P – value – probability, F – critic – critical value of F

The fruit of 'Erebasma' is characterized with medium texture and small quantity of stone cells. The stone cells usually are not tasted in maturity fruits. In dry conditions,

fruits contain more stones cells and tannins (Mratinic, 2000; Avramovski *et al.*, 2005; Selamovska *et al.*, 2013a). In different regions of Macedonia, this pear varieties can be found under different names as: 'Erebasma', 'Erebaska', 'Eribasma', 'Esenska vodenka', 'Vodnjanka', 'Vodenjak', 'Vodnjak', 'Sulija', 'Sumlija', 'Sonlija', 'Dardha langi' (Selamovska *et al.* 2013).

The fruits of the pear 'Karamanka' have asymmetrical pear shape. The fruit peel is smooth, green-yellow with red blush on the sunny side and it rarely has small spots. At the time of full maturity the fruit gets yellow color like straw, with green small spots all over the fruit surface. The fruit mesocarp is very juicy, white-yellow, and semisolid, with sweet-sour flavor and excellent taste and aroma. The fruit has middle fine to fine texture and small to middle amount of stone cells. A mature fruit has rotten mesocarp. The season of their consummation lasts up to 30 days, which is not characteristic to the other summer pear varieties (Selamovska *et al.*, 2014b). This pear variety is present in all regions of Macedonia and can be found under several synonyms: blagun, begram, bozdunka, bozdogan, bozdoganka, kashija, beljak, medenica, mlechnica.

Table 7. Analysis of variance (ANOVA) for total sugar

ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	114,8648	5	22,97296	655,8288	2E-110	2,266366
Within Groups	6,06	173	0,035029			
Total	120,9248	178				

SS – sum of squares, df – degrees of freedom, MS – mean square, F – F-test, P – value – probability, F – critic – critical value of F

The color of fruit exocarp of the variety 'Tiranka' is yellow with red blush. The mesocarp is very juicy, solid, and crispy, with good to excellent taste. The fruit mesocarp has middle fine texture and small amount of stone sells. A mature fruit has rotten mesocarp (Selamovska *et al.*, 2012). The pear 'Ekshikuti' forms fruits with yellowish color of the mesocarp and medium fine to fine taste (Selamovska *et al.*, 2015).

The average value of soluble dry matters in researched varieties was 16.5 %. The average value of total acids was 0.20 %, while average total sugar was 13.8 %. The differences in the soluble dry matter, total sugar and total acids among the pear varieties were statistically significant (Table 5, 6 and 7). The variety 'Tiranka' contained the highest values of dry matter and total sugar.

Depending of the region, the quantity of the chemical components of the fruit alters. The fruits of the variety 'Karamanka' content about 14.2 % of soluble dry matter, 13.5% total sugar and 0.13% total acids. The highest amount of soluble dry matter and total

sugar was measured in fruits of the variety 'Karamanka' from the Kriva Palanka region, while the fruits from the Kratovo region had the smallest amounts (Selamovska et al., 2013a). According to Mratinic (2000), the fruits of the variety 'Karamanka' contain 19.5 % of soluble dry matter, 17.9 % of total sugar and 0.17 % of total acids.

Fruits of the pear 'Erebasma' contained 14.0% total sugar, 15.4% soluble dry matter and 0.23% total acids. The highest values of dry matter and total sugar were detected in fruits from Debar region, while the lowest value of soluble dry matter and total sugar were found in fruits from the region of Kriva Palanka, Skopje and Resen. The lowest value of total acids was detected in fruits from Berovo region, while highest value in Resen region (Selamovska et al., 2013a). According to Mratinic (2000) the fruits of the pear 'Erebasma' contain 19.5 % dry matter, 0.17 % total acids and 17.9 % total sugar.

CONCLUSION

From 26 traditional pear varieties that exist in Macedonia, the varieties 'Karamanka', 'Erebasma', 'Shaldanka', 'Tatlikuti', 'Tiranka' and 'Ekshikuti' are characterized with the best features. According to the ripening time,

the variety 'Karamanka' is characterized as late-summer variety. The pears 'Tatlikuti', 'Erebasma' and 'Shaldanka' are autumn varieties, while the varieties 'Tiranka' and 'Ekshikuti' are winter varieties. The differences among six the highest traditional pear varieties in Macedonia, for analyzed characteristics were statistically significant. Three varieties, 'Tiranka', 'Erebasma' and 'Karamanka' were characterized as pear with the best flavor.

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Ана Селамовска¹, Елизабета Мискоска-Милевска²

¹ Одељење за воћарство, Пољопривредни институт, Institute of Agriculture, Универзитет Св. Кирил и Методије, Скопље, Македонија

² Факултет пољопривредних наука и хране, Универзитет Св. Кирил и Методије, Скопље, Македонија
E-mail: miskoska@yahoo.com

НАЈКВАЛИТЕТНИЈЕ ТРАДИЦИОНАЛНЕ СОРТЕ КРУШАКА У МАКЕДОНИЈИ

Резиме

На територији Македоније постоје 26 традиционалних сорти крушке. Према фонолошким, воћним и хемијским карактеристикама, сорте "Караманка", "Еребасма", "Шалданка", "Татликути", "Тиранка" и "Екшикути" имају најбоље карактеристике. Циљ ове студије је поређење фонолошких, воћних и хемијских карактеристика ових традицио-

налних сорти крушке. Према времену зрења сорта "Караманка" се карактерише као касно лета сорта. Крушке "Татликути", "Еребасма" и "Шалданка" су јесење сорте, док су сорте "Тиранка" и "Екшикути" зимске сорте. Истраживане сорте су окарактерисане као дуговечне, средње бујно развијене ("Шалданка", "Тиранка", "Екшикути") до развијене, вигорозне сорте ("Татликути", "Еребасма" и "Караманка"). Истраживане сорте формирале су средње крупне плодове, са изузетком сорте "Екшикути" која је имала мање плодове. Кратка плодна дршка имале су сорте "Татликути" и "Екшикути", сорта "Еребасма" је имала средње дугу дршку, док су остале сорте имале дугу дршку. Плодови садрже малу количину здравих семенки у плодовима, осим сорте "Шалданка" и "Екшикути". Све сорте, осим сорте "Екшикути" и "Еребасма", имале су чврст воћни егзокарп. Плодови су садржали највећу вредност растворљиве суве материје и укупног шећера, а средњег до одличног укуса. Статистичке значајне разлике између испитиваних сорти крушке за све карактеристике плода су пронађене. СORTE "Тиранка", "Еребасма" и "Караманка" окарактерисане су као сорте крушке са најбољим укусом.

Кључне речи: *крушка, традиционална, сорта, квалитет*

**LIVESTOCK HUSBANDRY
FROM THE ASPECT OF SAFE FOOD
PRODUCTION**



Vesna Gantner¹, Mirna Gavran¹, Maja Gregić¹, Dragan Dokić²,
Franjo Poljak³, Zvonimir Steiner¹

¹ Faculty of Agrobiotechnology Osijek, University of J.J. Strossmayer
in Osijek, Croatia

² Erdut Municipality, Bana Josipa Jelačića 4, Dalj, Croatia

³ Croatian Agency for Agriculture and Food, Vinkovačka cesta 63c, Osijek,
Croatia

E-mail: vgantner@fazos.hr

ESTIMATION OF AMMONIUM POLLUTION FROM DAIRY SIMMENTAL COWS USING PRECISION FARMING TECHNOLOGIES IN ORDER TO PRODUCE HEALTH SAFE FOOD

Abstract

In order to determine the effect of parity (I, II, III, and IV) and season (spring, summer, autumn and winter) on the variability of daily milk yield, milk urea nitrogen and ammonium emission 1,719,033 test-day records of dairy Simmental cows were used. The results indicate significant variability in daily milk yield, milk urea nitrogen and ammonium emission due to the animal characteristics (stage and number of lactation) as well as due to season. Furthermore, test day records as a way of precision dairy farming could be used not only for determination of cows' productivity and detection of feeding disbalance but also for assessing the ammonium pollution from dairy cattle farms.

Key words: *Simmental cattle, milk recording, estimation, ammonium pollution, precision farming*

INTRODUCTION

The application of precision technologies in agriculture is one of the main topics affecting the development of agriculture worldwide. Precision dairy farming implies the usage of different technologies in order to determine production, physiological,

and behavioural indicators of individual animals. Modern dairy cattle production implies higher milk production as well as the production of large quantities of manure. Accordingly to Hristov et al. (2011) an important part of cattle manure nitrogen, particularly from urinary urea, is transformed into ammonium and finally lost to the atmosphere as ammonia. Ammonia endangers the health of farmworkers and animals as well as the environment. The effect of animal production systems on the environment – particularly on climate and ecosystems – is one of the major issues in the term of intensification and consolidation of animal production. Accordingly to FAO (2009), overall production of milk, meat, and eggs has grown fast through the last decades, in particular in developing countries. The important drivers of animal production sector growth are economic growth, rising incomes, urbanization, and population growth. Dairy production represents a significant part of the animal production sector, producing globally approximately 553 million tonnes of milk in year 2007 (FAOSTAT, 2010) and 34 million tonnes of meat from the dairy-related herd (FAO, 2010). Furthermore, this production is quickly increasing, for instance crude milk production raised by 44% between year 1980 and 2007. Furthermore, accordingly to FAO (2006), animal production sector will remain to be the most dynamic agricultural sub-sector since global milk production is projected to increase from 580 to 1043 million tonnes in year 2050. Forecasted significant production growth must be accompanied with the adequate measures in order to enable protection of the environment. Bijgaart (2003) reported that in Netherlands farms are controlled accordingly to the milk urea content that enables defining potential pollution sources and informing farms concerning precautionary activities. Furthermore, accordingly to Ruska et al. (2017), in Europe the optimum amount of urea in the milk is set to 15–30 mg/dL. Studies point out that milk urea identifies the content of urea in blood and urine. Also, it has been confirmed that there is a notable correlation between milk urea content and nitrogen content in animal urine and manure (Burgos et al., 2010; Eckersall & Bell, 2010; Klein et al., 2011; Spek et al., 2013). Furthermore, Broderick and Huhtanen (2013) and Jonker et al. (2002) reported that in order to calculate the amount of nitrogen in feed, the milk urea content is mainly used. Furthermore, milk urea content can be used for determination of digestive efficiency since it indicates lacks of raw protein for a dairy cow, particularly excess in the digestive tract as well as for evaluation of environmental pollution (Broderick and Clayton, 1997; Hof et al., 1997; Burgos et al., 2010).

Burgos et al. (2010) stated that evaporation of ammonia is a process in which the nitrogen in animal manure (urine and feces) is released in the environment through biochemical and mass transfer reactions. Furthermore, urea estimates for 50 to 90% of total nitrogen in cattle urine (Bristow et al., 1992). Various nature of the factors controlling ammonia volatilization, like manure management, ambient temperature, wind speed, and manure composition and pH, complicate defining ammonia emissions from cattle. The reduction of ammonia emissions from dairy cattle production represents one of the major factors in enabling the environmentally sustainable animal farming. Therefore, the objective of this paper was to determine the ammonium pollution from dairy Simmentals accordingly to parity and season using the methodology of precision farming (test-day records).

MATERIAL AND METHODS

Test-day records of Simmental dairy cows collected in the period from January 2004 to December 2013 provided by the Croatian Agricultural Agency were used for the statistical analysis. Test-day records were collected during the regular milk recording performed monthly in accordance to the alternative milk recording method (AT4 / BT4) on dairy cattle farms in Croatia. At each recording, measuring and sampling of milk were performed during the evening or morning milkings.

Test-day records with lactation stage in (< 5 days and > 500 days), age at first calving in (< 21 and > 36 months), missing parity, missing breed, and missing or nonsense daily milk traits (ICAR standards, 2017) were deleted from the dataset. After logical control dataset consisted of 1,719,033 test-day records from 90,159 dairy Simmental cows reared on 6,701 farms.

The milk urea nitrogen (MUN) content was calculated using milk urea content (UREA) accordingly to the following equation:

$$\text{MUN (mg/dL)} = \text{UREA} * 0.46 \text{ (Spiekers \& Obermaier, 2012)}$$

The ammonium emission (AM-EMISS) was calculated using milk urea nitrogen (MUN) accordingly to the following equation:

$$\text{AM-EMISS (g/cow daily)} = 25.0 + 5.03 * \text{MUN} \text{ (Burgos et al., 2010)}$$

Furthermore, in regard to the parity cows were divided into four classes: I., II., III., and IV. (animals in fourth and higher lactations). Also, in regard to the recording date, test day records were divided into four seasons: spring (March, April, and May), summer (June, July, and August), autumn (September, October, and November), winter (December, January, and February).

Basic statistical parameters of analysed traits (daily milk traits, milk urea nitrogen and ammonium emission) is presented in Table 1.

Table 1. Basic statistical parameters of analysed traits (daily milk traits, milk urea nitrogen and ammonium emission)

Variable	N	Mean	SD	CV	Minimum	Maximum
DMY	1719033	15.47	5.93	38.32	3.00	94.0
DFC	1655847	4.17	0.90	21.46	1.50	9.00
DPC	1670025	3.46	0.46	13.32	1.12	6.98
UREA	1465628	19.90	10.66	53.56	0.50	60.00
MUN	1465628	9.15	4.90	53.56	0.23	27.60
AM-EMISS	1465628	71.05	24.66	34.71	26.15	163.82

* DMY – daily milk yield (kg); DFC – daily fat content (%); DPC – daily protein content (%); MUN – milk urea nitrogen (mg/dL); AM-EMISS – ammonium emission (g/cow daily)

For the evaluation of the effect of parity and season on the variability of analysed traits (daily milk traits; milk urea nitrogen and ammonium emission) in dairy Simmental cows following statistical model was used:

$$y_{ijklm} = \mu + b_1(d_i/305) + b_2(d_i/305)^2 + b_3 \ln(305/d_i) + b_4 \ln^2(305/d_i) + S_j + A_k + P_l + e_{ijklm}$$

Where:

y_{ijklm} = estimated trait;

μ = intercept;

b_1, b_2, b_3, b_4 = regression coefficients;

d_i = days in milk ($i = 5$ to 500 day);

S_j = fixed effect of recording season class j ($j =$ spring, summer, autumn, winter);

A_k = fixed effect of age at first calving class k ($k = 21$ to 36 month);

P_l = fixed effect of parity l ($l = I, II, III,$ and IV);

e_{ijklm} = residual.

The significance of the differences between the parity and season classes was tested by Scheffe's method of multiple comparisons (using the PROC GLM procedure in SAS (SAS Institute Inc., 2000)).

RESULTS AND DISCUSSION

The analysis of variance showed statistically highly significant effect ($p < 0.001$) of all effects included in the used statistical model (age at first calving, stage of lactation, parity and season) on of daily milk yield; milk urea nitrogen and ammonium emission. Lsmeans values of analysed traits of dairy Simmentals in regard to parity (I, II, III and IV) are presented in Table 2. Daily milk yield differed statistically highly significant ($p < 0.001$) regarding the parity. Daily milk yield was the lowest in primiparous cows (14.29 kg), while the highest yield was determined in cows in third parity (16.13 kg).

Statistically highly significant ($p < 0.001$) lowest value of milk urea nitrogen and ammonium emission was determined in cows in fourth and higher parity. Furthermore, the highest content of milk urea nitrogen as well as ammonium emission was determined in cows in second parity.

Table 2. Lsmeans of daily milk yield, milk urea nitrogen and ammonium emission regarding the parity

Parity	DMY	MUN	AM_EMISS
I	14.29 ^A	9.26 ^A	71.56 ^A
II	15.43 ^B	9.29 ^A	71.75 ^A
III	16.13 ^C	9.27 ^A	71.60 ^A
IV	16.05 ^B	9.03 ^B	70.42 ^B

* DMY – daily milk yield (kg); MUN – milk urea nitrogen (mg dL⁻¹); AM_EMISS – ammonium emission (g/cow daily); Lsmeans marked with different letters (A, B, C, D) differ statistically significant ($p < 0.001$)

The results of analyses of variance of daily milk yield, milk urea nitrogen and ammonium emission of dairy Simmental cows regarding the season (spring, summer, autumn and winter) are presented in Table 3. All analysed traits differed statistically highly significant ($p < 0.001$) regarding the seasons. The highest recorded daily milk yield was in spring (15.98 kg); while on the other hand, milk produced in summer had the highest MUN (mg/dL) as well as highest ammonium emission (g/cow daily). The lowest daily yield (14.94 kg) was determined in autumn, while the lowest milk urea nitrogen and ammonium emission per animal was determined during the winter season.

Table 3 LSmeans of daily milk yield, milk urea nitrogen and ammonium emission regarding the season

Season	DMY	MUN	AM-EMISS
Spring	15.98 ^A	8.82 ^A	69.34 ^A
Summer	15.79 ^B	11.16 ^B	81.15 ^B
Autumn	14.94 ^C	9.16 ^C	71.08 ^C
Winter	15.18 ^D	7.71 ^D	63.76 ^D

* DMY – daily milk yield (kg); MUN – milk urea nitrogen (mg dL⁻¹); AM-EMISS – ammonium emission (g/cow daily); LSmeans marked with different letters (A, B, C, D) differ statistically significant ($p < 0.001$)

Significantly higher urea content in milk produced during the summer period was also found by Ruska et al. (2017). In accordance to Spohr and Wiesner (1991) and Spann (1993), increased urea in milk reveals a complication related to providing highly productive dairy cows with fodder dosage having sufficient amounts of energy and protein. According to Kohn et al. (2002) and Bucholtz et al. (2007), many studies carried out in Europe have used urea content in milk; on the other side, studies conducting in the USA mainly used milk urea nitrogen (MUN) content. Furthermore, MUN is used for control of feeding efficiency control with the desirable MUN content in interval 8.0–12.0 mg/dL. In a case when MUN threshold is exceeded, farms have to pay attention to the usage of proteins in fodder and their balancing with energy in single feed dose. Aguilar et al. (2012) based on data collected in the USA concerning fodder protein and MUN content reported that for reaching MUN threshold of 12 mg/dL it is essential to decrease protein amount in food to 12.8% in dry matter.

In the countries assessing nitrogen use and efficiency the milk urea content is suggested as indicator for evaluating and planning the farming model (Godden et al., 2001, Haig et al., 2002). Furthermore, daily milk traits could be used not only for assessing animal productivity but also for characterizing metabolism processes in the cow's organism, and consequently predicting potential disorders (ketosis, acidosis) and fed disbalance on time and managing farming efficiency.

CONCLUSION

The objective of this study was to determine the effect of parity (I, II, III, and IV) and season (spring, summer, autumn and winter) on the variability of daily milk yield, milk urea nitrogen and ammonium emission from dairy Simmental cows using precision farming methodology. Statistically highly significant ($p < 0,001$) effect of age at first calving, stage of lactation, parity and season on all analysed traits (daily milk yield, milk urea nitrogen and ammonium emission) was determined. Daily milk yield was the lowest in primiparous cows, while the highest was in cows in third parity. The highest content of milk urea nitrogen as well as ammonium emission was determined in cows in second parity. Regarding the season, the highest recorded daily milk yield was in spring, while the milk produced in summer had the highest milk urea nitrogen as well as highest ammonium emission. The results indicate significant variability in ammonium emission due to the animal characteristics (stage and number of lactation) as well as due to season. Furthermore, test day records as a way of precision dairy farming could be used not only for determination of cows' productivity and detection of feeding disbalance but also for assessing the ammonium pollution from dairy cattle farms.

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Весна Гантнер¹, Мирна Гавран¹, Маја Грегић¹, Драган Докић², Фрањо Пољак³, Звонимир Стеинер¹

¹ Агробиотехнолошки факултет Осиек, Универзитет Ј.Ј. Strossmayer у Осиеку, Хрватска

² Ердут Општина, Бана Јосипа Јелачића 4, Даљ, Хрватска

³ Хрватска агенција за пољопривреду и храну, Винковачка цеста 63ц, Осиек, Хрватска

E-mail: vgantner@fazos.hr

ПРОЦЈЕНА ЗАГАЂЕЊА АМОНИЈАКОМ МЛИЈЕЧНИХ ГОВЕДА СИМЕНТАЛСКЕ ПАСМИНЕ КОРИШТЕЊЕМ ТЕХНОЛОГИЈА ПРЕЦИЗНЕ ПОЉОПРИВРЕДЕ У ЦИЉУ ПРОИЗВОДЊЕ ЗДРАВСТВЕНО СИГУРНЕ ХРАНЕ

Сажетак

За утврђивање утјецаја паритета (I, II, III и IV) и сезоне (прољеће, лето, јесен и зима) на варијабилност дневне количине млијека, уреје у млијеку и емисије амонијака, кориштено је 1.719.033 записа на контролни дан млијечних говеда сименталске пасмине. Резултати показују значајну варијабилност у дневној количини млијека, уреји у млијеку и емисији амонијака услијед карактеристика животиње (стадиј и број лактације) као и због сезоне. Осим тога, записи на контролни дан као методологија прецизног млијечног говедарства могу се користити не само за утврђивање производности крава и откривање дисбаланса хранидбе, него и за процјену загађења амонијаком са фарми млијечних говеда.

Кључне ријечи: *сименталска говеда, контрола млијечности, процјена, онеччишење амонијаком, прецизна пољопривреда*



Mirna Gavran¹, Goran Kušec¹, Vesna Gantner¹

¹ Faculty of Agrobiotechnical Sciences Osijek, University of Josip Juraj
Strossmayer in Osijek, Osijek, Croatia
E-mail: vgantner@fazos.hr

USE OF ANABOLICS IN LIVESTOCK PRODUCTION AND THEIR PERCEPTION FOR FOOD SAFETY IN DIFFERENT REGIONS OF THE WORLD

Abstract

Livestock has undergone a significant transformation in the last few decades. Improvements in animal husbandry, mechanical innovations and the introduction of specially formulated animal feed and pharmaceutical products have increased the efficiency and productivity of domestic animals. The use of anabolics results in the same final effect, respectively higher growth of breeding animals and better organoleptic properties of meat. Since 1988, the European Union has banned the use of all substances that have a hormonal effect in order to anabolic effects in domestic animals.

Key words: *anabolics, growth hormone, food safety, ban*

INTRODUCTION

Livestock has undergone a significant transformation in the last few decades. Production has shifted from smaller farms to large farms that often have corporate contracts. Most meat and dairy products are now produced on large farms with single-species buildings or open-air stables. Modern farms have also become much more efficient. Since 1960, milk production has doubled, meat production has tripled, and egg production has quadrupled. Improvements in animal husbandry, mechanical innovations and the introduction of specially formulated animal feed and pharmaceutical products have increased the efficiency and productivity of domestic animals. It also takes a much less time to breed a fully grown animal (Hribar, 2010). Due to the economic profitability of meat production in the livestock industry, various substances with anabolic effect were misused. The use of anabolics results in the same final effect,

respectively higher growth of breeding animals and better organoleptic properties of meat (Table 1). Toxicological studies have shown that the use of anabolics in animals results in a number of toxic effects on the health of consumers, since they accumulate in the tissues of animals that are further used in human nutrition. Several cases of anabolic abuse in the world have led to significant detrimental consequences for consumer health. Therefore, the use of substances with an anabolic effect in livestock production is prohibited (Pleadin et al., 2011). Since 1988, the European Union has banned the use of all substances that have a hormonal effect in order to anabolic effects in domestic animals (Heitzman, 1993).

Table 1. Substances with anabolic effect (Heitzman, 1993.)

A group of substances with an anabolic effect	Name of substance with anabolic effect
Stilbenes, stilbene derivatives, their salts and esters	diethylstilbestrol dienestrol hexestrol
Antithyroid substances	tapazole 2-thiouracil
Natural steroid sex hormones	17 β -estradiol progesterone testosterone
Synthetic steroid sex hormones	trenbolone 19-nortestosterone methyltestosterone stanozolol boldenone
Resorcylic acid lactones	zeranol taleranol zearalenol
Beta-agonists	clenbuterol salbutamol cimaterol ractopamine

NATURAL HORMONES

Hormones are chemical substances produced by animals to coordinate their physiological activities. Hormones play the role of messengers, they are produced and released from one type of tissue to constantly stimulate or inhibit a process in other tissue for the long term. A significant part at various stages of mammalian development

including prenatal development, growth, reproduction, and sexual and social behavior have steroid hormones (Passantino, 2001). Of vital importance for the normal development, maturation and physiological functioning of many vital organs and processes in the body are hormones. But, like all other chemicals of natural or synthetic origin, under specified conditions, hormones can be toxic to living organisms. The toxicity might be a consequence of an excess of its normal physiological action (Bolt et al., 2001). Some of the approved drugs are naturally produced throughout life in people and animals, such as estradiol (estrogen), progesterone, and testosterone. These natural hormones are necessary for normal development, growth, and reproduction. People are not at risk from eating food from animals treated with these drugs because the amount of additional hormone following drug treatment is very small compared with the amount of natural hormones that are normally found in the meat of untreated animals and that are naturally produced in the human body (FDA, 2020). The disturbing discovery in 1977 of breast enlargement in girls and boys attending a school in Milan (Italy) led to a ban across Europe (Scaglioni et al., 1978). When school meal samples were tested, no estrogen contamination was detected. The cause of this epidemic is considered to be an uncontrolled supply of poultry and beef. (Fara et al., 1979).

SYNTHETIC HORMONES

Some of the approved drugs are synthetic versions of the natural hormones, such as trenbolone acetate, melengestrol acetate and zeranol (Table 2). Just like the natural hormone implants, before FDA approved these drugs, FDA required information and/or toxicological testing in laboratory animals to determine safe levels in the animal products that we eat (edible tissues). Furthermore, FDA required that the manufacturers demonstrate that the amount of hormone left in each edible tissue after treatment is below the appropriate safe level. As described above, a safe level is a level which would be expected to have no harmful effect in humans (FDA, 2020). Melengestrol acetate stimulates growth in heifers but not in steers, and which can also be used for the suppression of oestrus. Numerous other gestagens also exist, but at present few other than progesterone and melengestrol acetate are used to stimulate growth. (Velle, 1982).

*Table 2. Natural hormones and their synthetic alternatives
(CAHI, 2000)*

Natural Hormones	Synthetic Hormones
Estradiol (estrogen)	Zeranol
Progesterone	Melengestrol acetate
Testosterone	Trenbolone acetate

GROWTH HORMONE

Porcine (pST) growth hormone is protein of 190 amino acids and bovine (bST) growth hormone is protein of 191 amino acids, both are products of the adenohypophysis. The action of growth hormone (somatotropin) is shown through several metabolic effects in organisms, with the main target liver tissue, skeleton, adipose tissue, and muscle. Many factors, such as gender, age, breed, and environmental conditions influence the effectiveness of the effects of somatotropin on farm animals. Research results show that significant growth stimulation can be a consequence of the use of pST in pigs, as well as bST in calves. (Kirchgessner et al., 1987; Van der Wal et al., 1989). Treatment of animals leads to reduced synthesis fatty acids, due to reduced enzyme activity systems involved in the pentose phosphate and synthase cycle fatty acids (Elherton, 1989). This results in elevated blood glucose and insulin levels. More glucose is available to the muscles and skeleton, and in addition the growth of these tissues is directly stimulated by somatotropin and IGF-I which originates from the liver after somatotropin stimulation. Further data suggest that the synthesis of amino acids in muscle increased, while the breakdown of amino acids in the liver is reduced. By detecting somatotropin mRNA in skeletal muscle, Baumbach et al. (1989), confirmed that somatotropin can directly stimulate muscle growth but also that hepatic IGF-I may be very important for this growth. Guler et al. (1989), suggest that somatotropin stimulates bone growth directly but also indirectly through IGF-I.

USE OF ANABOLICS

Hormonal substances and antibiotics are used legally and illegally as growth promoters in food producing animals for the growth promotion of livestock animals. Estradiol-17 β , progesterone, testosterone, zeranol, trenbolone, and melengestrol acetate are hormonal substances that are still under debate in terms of their human health impacts. From the 1950s, the Food and Drug Administration (FDA) has approved several steroid hormone drugs for use in beef cattle and sheep, including natural estrogen, progesterone, testosterone as well as synthetic versions. These drugs enhance the animals' growth rate and the efficiency by which they convert the feed they eat into the meat. The FDA approves these drugs only after information and studies have confirmed that the food from the treated animals is safe for people to eat and that the drugs do not harm the treated animal or the environment. The drugs also have to be effective, meaning that they work as intended. The labeling for each product provides all instructions for safe and effective use and is approved by the FDA. These steroid hormone drugs are typically formulated as pellets or "implants" that are placed under the skin on the back side of the animal's ear. The implants dissolve slowly under the skin and do not require removal. The ears of the treated animals are discarded at slaughter and are not used for human food. Using scientific data, FDA establishes the acceptable safe limits for hormones in meat. A safe level for human consumption is a level of drug in the meat that would be expected to have no harmful effect in humans based on extensive scientific study and review. No steroid hormone implants are approved for

growth purposes in dairy cows, veal calves, pigs, or poultry. All of the steroid hormone implants are available for over-the-counter purchase in the U.S. and are generally given by the livestock producer at specific stages of the animals' growth. Unless otherwise approved and labeled for reimplantation, only one ear implant may be given to an animal during a specific stage of growth (FDA, 2020). Growth rate and FCE (feed conversion efficiency) are higher in intact males than in castrates. Starting in the mid-1950s, DES (diethylstilboestrol) and hexoestrol were increasingly given to cattle in the US and the UK, either as implants or as feed additives, also additional types of substances progressively became available. Principally, that treatment has contributed to 10–15% increases in daily gains, related improvements in FCE, and advancement of carcass quality (increased lean/fat ratio). Hence, there was a considerable decrease in the amount of energy required per unit weight of protein produced and there were great economic consequences. With the increase in the use of hormonally active substances in livestock production, resistance to their use also increased, because of the theoretical probability that residues in edible tissues may threaten consumers. Few statements prove that DES jeopardizes the health of animals and people while frequently used in large doses, consequently, it was banned for the first time in 1973. Nevertheless, as regards hazards due to the presence of residues in meat produced according to regulations, no documented deleterious effects have ever been reported in man, either from DES or any other substance with hormonal activity (Velle, 1982). A sensitive topic of debate in the EU and elsewhere for many decades was the use of hormonal growth promotants in food-producing animals. The EC had no universal policy on the use of growth-promoting hormones in meat animals before 1981. Greece and Belgium had never allowed the use of hormones for fattening goals. The use of hormones had been banned in Italy since 1961, in Denmark since 1963, and in Germany since 1977. Nevertheless, France, Spain, the Netherlands, and the United Kingdom allowed the application of most hormones for speeding growth in beef cattle. (FAO, 2020.)



Picture 1. Implantation site of growth hormones on the ear (PS, 2020)

CONCLUSION

Growth hormones need to be applied correctly regarding their dose, place of administration and implanted by suitable experts. Natural hormones are testosterone, oestradiol and progesterone while their synthetic alternatives are melengestrol acetate, trenbolone acetate and zeranole which are widely used in different countries of the world. The use of anabolics in food production results in increased growth of farm animals and better organoleptic qualities of meat. Researches showed that the use of anabolics in livestock production causes numerous toxic effects on animals and consequences on the health of consumers as they accumulate in the tissues of animals that are further used in human nutrition. The use of substances with an anabolic effect should be monitored at all stages of the production of food of animal origin.

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Мирна Гавран¹, Горан Кушец¹, Весна Гантнер¹

¹ Факултет агробиотехничких наука Осиек, Универзитет Јосип Јурај
Strossmayer, Осиек, Хрватска
E-mail: vgantner@fazos.hr

УПОТРЕБА АНАБОЛИКА У СТОЧАРСКОЈ ПРОИЗВОДЊИ И ЊИХОВА ПЕРЦЕПЦИЈА ЗА СИГУРНОСТ ХРАНЕ У РАЗЛИЧИТИМ РЕГИЈАМА СВЕТА

Извод

Стоچارство је претрпело значајну трансформацију у последњих неколико деценија. Побољшања у узгоју животиња, механичке иновације и увођење посебно формулисане хране за животиње и фармацеутске производе повећали су ефикасност и продуктивност домаћих животиња. Употреба анаболика резултира истим коначним ефектом, односно већим растом гајених животиња и бољим органолептичким својствима меса. Од 1988. године, Европска унија је забранила употребу свих супстанци које имају хормонални ефекат у циљу анаболичких ефеката код домаћих животиња.

Кључне речи: *анаболици, хормон раста, безбедност хране, забрана*



Stipo Benak¹, Zvonimir Steiner², Tina Bobić², Vesna Gantner²

¹BELJE plus d.o.o., Sv. Ivana Krstitelja 1, Darda, Croatia

²Faculty of Agrobiotechnology Osijek, University of J.J. Strossmayer in Osijek,
Vladimira Preloga 1, Osijek, Croatia

Email: vgantner@fazos.hr

THE EVALUATION OF THE EFFECT OF THE DIFFERENT STARTERS ON BODY MEASUREMENTS OF DAIRY CALVES

Abstract

The objective of this study was to determine the effect of different starters for calves (including dried whey and protein sources whit low ANFs) on the variability of the birth weight, body weight and body measurements (birth weight, body weight, withers height, hip height, body length, chest depth, chest width, heart girth, cannon bone circumference and hip width). Accordingly, to feeding, calves were divided into four groups; control (control starter), E1 (starter whit added dry whey), E2 (starter whit added protein sources whit low ANFs), and E3 (concentrate whit added dry whey and protein sources whit low ANFs). Calves were individually housed in a boxes with feeders and drinkers. Average birth weight of calves were 41.21 ± 3.22 kg. Based on obtained results it could be concluded that different starters significantly influenced following traits: body weight, withers height, body length and hip width while the variability of other analysed due to different feeding groups were not statistically significant.

Key words: *calves, starter, body measurements, performance*

INTRODUCTION

Using adequate feeding technology for rearing dairy calves improve the efficiency and economy of dairy cattle farm. Initial phase of rearing on liquid feed is the most expensive phase and because of that it is one of the limiting factors in dairy business. Early growth phase of dairy calves is the most critical and most important since it request fast development of digestive system whit good immunological status, because that influences the long-term animal performance ((Davis-Rincker et al., 2011; Hill et al., 2013). For stimulation of transition of the new-born calf to the real ruminants, it is

necessary that calf have offered solid feed from first week of live. Consumption of solid feed increase butyrate production in the rumen and this volatile fatty acid is responsible for the development of epithelial tissue in reticulorumen (Hill et al., 2006; Hodgson, 1971; Jenny et al., 1982). Gibbonson and Brown (2012) used microbial enhanced soy protein (MSP) in their trial and they reported that MSP has greater protein content and less anti-nutritional factors (ANF) compared to soya bean meal (SBM). Chamberlain et al. (1993) fed lactose, primary nutrient in whey, to the sheep and concluded that feeding with lactose increase ruminal pH in comparison whit diet which contains other sugars and starch. Dried whey is used primarily for feeding young calves and the introduction of whey at the rate till 10% of the concentrate feeds can increase feed intake (Morrill and Dayton, 1974). Schingoethe (1976) in his research has shown that it could supply most of the lactose in calf feeds from 6 to 8 weeks before weaning. Gelsinger et al. (2016) in their research find that although preweaning average daily gain (ADG) is positively related to first-lactation milk yield, factors other than preweaning feed intake and growth rate are very important in determining first-lactation performance. Furthermore, body measurements could be used for monitor the growth of female dairy cattle, primarily for estimation of body weight (Heinrichs and Hargrove, 1987; Heinrichs et al., 1992.) and for determination of nutritional requirements (NRC, 2001). The different growing program for special-fed dairy calves could cause differential growth rates and body dimension changes compared with dairy animals managed in more conventional growing program. Furthermore, the relationship between body weight and body measurements depends of dairy cattle breed (Heinrichs and Hargrove, 1987; Heinrichs et al., 1992). The objective of this study was to evaluate the effect of the different feeding groups (including dried whey and protein sources whit low ANFs in the diet) on body measurements of dairy calves.

MATERIAL AND METHODS

The experiment was conducted on a commercial dairy cattle farm located in East Croatia. Forty Holstein calves with birth weight 41.21 ± 3.22 kg were selected and randomly allocated to 4 groups of 10 calves per group. Basic statistical parameters of analysed body traits are shown in Table 1.

Table 1. Basic statistical parameters of analysed traits (body measurements, n = 140, birth weight n = 40) for Holstein breed calves

Trait	mean	SD	CV	Min	Max
Birth weight, kg	41.21	3.22	7.82	35.00	50.00
Body weight, kg	58.23	17.37	29.83	35.50	105.00
Withers height, cm	82.30	4.40	5.34	73.00	95.00
Hip height, cm	85.79	5.67	6.60	76.00	100.00
Body length, cm	75.88	6.85	9.02	61.00	95.00

Chest depth, cm	31.88	3.90	12.22	24.50	41.50
Chest width, cm	15.98	2.17	13.58	11.50	21.50
Heart girth, cm	90.37	9.69	10.73	74.00	116.00
Cannon bone circumference, cm	11.28	0.70	9.66	10.00	13.00
Hip width, cm	23.72	2.38	10.03	18.00	30.50

During the experiment all calves had a same feeding plan. All selected calves were fed with 4 L of colostrum within 2h after birth. After administration of colostrum by drench, first three days calves were fed whit non-pasteurized whole milk from transition cows (two times per 3 litres) and after that they were fed whit solution of milk replacer (143 g per litre of water, two times per day). During the 35 days calves had 6 litre of milk replacer, then 7 days 4 litre of milk replacer and finally 7 days 2 litre of milk replacer only in the morning. From fourth day of life calves had *ad libidum* water and solid feed. Calves was allocated in 4 different groups which was fed with four different starters: C group (control group) had control starter, E1 (experimental group 1) had starter whit added dry whey, E2 (experimental group 2) had starter whit added protein sources whit low ANFs, and E3 (experimental group 3) had starter whit added dry whey and protein sources whit low ANFs. Ingredients and nutrient composition of starters are shown in Table 2.

*Table 2. Ingredients and nutrient composition of the starters
(air dry matter basis)*

Ingredients, %	C	E1	E2	E3
Wheat bran	25	25	25	25
Toasted full fat soy	10	10	10	10
Limestone	1	1	1	1
Mono-calcium phosphate	1.1	1.1	1.1	1.1
Mannan oligosaccharide (commercial Bio-Mos)	0.2	0.2	0.2	0.2
Aroma vanilla	0.05	0.05	0.05	0.05
Pellet binder	0.1	0.1	0.1	0.1
Calf premix ¹	0.25	0.25	0.25	0.25
Dry sugar beet pulp	3	3	3	3
Molasses	3	3	3	3
Dextrose	1	1	1	1
Salt	0.5	0.4	0.5	0.4
Corn	37.7	32	42.4	36.5
Soya meal	14.1	12.9	–	–
Rapeseed meal	3	3	–	–
Nucleotide (commercial NuPro)	–	–	3	1

Soya protein concentrate	–	–	7.3	7.9
DL-methionine	–	–	0.5	0.5
L-lysine HCl	–	–	1.6	1.6
Whey powder	–	7	–	7.4
Nutrient composition				
Dry matter (%)	88.15	88.64	88.91	89.34
Crude protein (%)	18.03	18.01	18.01	18.03
Crude fats (%)	4.00	3.85	3.84	3.74
Starch (%)	31.18	27.32	34.24	31.04
Lactose (%)	–	5.55	–	5.87
Carbohydrates total (%)	5.80	11.22	5.27	10.08
Lysine (%)	0.91	0.93	2.11	2.13
Methionine (%)	0.28	0.28	0.74	0.74
Ash (%)	6.16	6.65	6.00	6.34
ME (MJ/kg)	11.60	11.58	11.77	11.78

Calf premix provided per kg of starter: Vitamin A 10.000 IU, Vitamin D 2.000 IU, Vitamin E 40 mg, Vitamin B₁ 1 mg, Vitamin B₂ 2 mg, Vitamin B₅ 10 mg, Vitamin B₆ 10 mg, Vitamin B₁₂ 0,013 mg, nicotinic acid 30 mg, Fe 50 mg, Cu 12,5 mg, Mn 40 mg, Zn 41 mg, Se 0,3 mg, I 0,75 mg, choline chloride 150 mg.

Follow-up of body measures was performed four times during the experiment, the first time at 6 days of age, the second time at 24 days of age, the third time at 50 days of age and the fourth time only female calves at 90 days of age. All measurement devices were in metric graduations.

Measurements was performed as follows:

- Withers height was measured by Lydtin's rod placed vertically along the front leg, from the floor to the top of the withers, directly above the centre of the shoulder.
- Hip height was measured by Lydtin's rod placed perpendicular to the back leg, from the floor to the top of the front edge of the hip at the point where the central line of the spine and the line that connects the front edges of the side tubercle (*tuber coxae*) are intersected.
- Body length was measured by Lydtin's rod placed from the vertebral column from scapula to the tubercle of the ischium (*tuber ischiadicum*).
- Hip width was measured by measuring tape between the left and right side tubercle (*tuber coxae*).
- Chest depth – measured by Lydtin's rod placed in the place where the ridge passes into the backline, to the point where the sternum begins.
- Chest width – measured by Lydtin's rod placed just behind the shoulder blades.
- Heart girth was measured by a measuring tape placed around the chest as the minimal circumference immediately behind the front shoulder.
- Cannon bone circumference was measured by a measuring tape in the middle of the shin of the front leg (*metacarpus*).

For the evaluation of the effect of the different feeding groups on the variability of analysed body measurements (birth weight, body weight, withers height, hip height, body length, chest depth, chest width, heart girth, cannon bone circumference and hip width) following statistical model was used:

$$y_{ijkl} = \mu + S_i + M_j + T_k + e_{ijkl}$$

where y_{ijklm} = estimated trait;

μ = intercept;

S_i = fixed effect of sex i (i = male, female);

M_j = fixed effect of measurement j (j = I, II, III, IV);

T_k = fixed effect of treatment l (k = C, E1, E2, E3);

e_{ijkl} = residual.

The significance of the differences between the analysed body measurements due to different feeding groups was tested by Scheffe's method of multiple comparisons (using the PROC GLM procedure in SAS (SAS Institute Inc., 2000)).

RESULTS AND DISCUSSION

The last square means of body weights and all body measurement for each feeding group during the entire experiment are presented in Table 3. Birth weight, hip height, body length, chest depth, chest width, heart girth, cannon bone circumference and hip width wasn't significantly influenced by different starters ($P > 0.05$) while body weight and withers height was significantly affected by feeding whit different starters ($P < 0.05$). Furthermore, the highest determined value of body weight and withers height was in calves in E1 group.

Table 3. Lsmeans of birth weight, body weight and body measurements

Trait	C group	E1 group	E2 group	E3 group
Birth weight, kg	41.02 ^A	42.23 ^A	40.31 ^A	41.29 ^A
Body weight, kg	58.82 ^A	61.29 ^A	57.74 ^B	59.88 ^A
Withers height, cm	80.69 ^A	82.47 ^B	81.32 ^A	81.73 ^A
Hip height, cm	84.90 ^A	85.82 ^A	84.54 ^A	85.66 ^A
Body length, cm	76.58 ^A	77.36 ^A	75.67 ^A	76.09 ^A
Chest depth, cm	31.72 ^A	32.31 ^A	31.63 ^A	32.19 ^A
Chest width, cm	15.51 ^A	15.95 ^A	16.09 ^A	15.81 ^A
Heart girth, cm	89.15 ^A	90.07 ^A	88.61 ^A	89.70 ^A
Cannon bone circumference, cm	11.12 ^A	11.33 ^A	11.22 ^A	11.06 ^A
Hip width, cm	23.77 ^A	23.69 ^A	23.45 ^A	23.53 ^A

During the experiment, body measures were taken four times. First measuring was at 6 days of age (table 4.), the second time at 24 days of age (table 5.), the third time at 50 days of age (table 6.) and the fourth time when only female calves at 90 days of age were measured (table 7.).

Table 4. Lsmeans of first measuring for body weight and body measurements

Trait	C group	E1 group	E2 group	E3 group
Body weight, kg	42.52 ^A	43.55 ^A	41.70 ^A	42.52 ^A
Withers height, cm	77.17 ^A	80.03 ^B	79.11 ^B	77.79 ^A
Hip height, cm	80.43 ^A	81.03 ^A	79.81 ^A	80.04 ^A
Body length, cm	67.82 ^A	71.31 ^A	69.67 ^A	69.15 ^A
Chest depth, cm	28.23 ^A	29.17 ^A	28.71 ^A	27.57 ^A
Chest width, cm	13.71 ^A	13.47 ^A	14.34 ^A	13.85 ^A
Heart girth, cm	80.88 ^A	81.42 ^A	80.07 ^A	80.17 ^A
Cannon bone circumference, cm	10.90 ^A	10.75 ^A	10.72 ^A	10.58 ^A
Hip width, cm	21.47 ^A	21.66 ^A	21.06 ^A	22.31 ^A

On the first measurement, the significant difference ($P < 0.05$) in withers height due to different starters was found. The highest withers height was determined in E1 group, while the lowest value was determined in control group. Khan et al. (2007) in their trial had lighter calves at birth than calves in this trial (by group they had birth weight between 38.79 and 39.88), heart girth where between 74.75 and 76.16 cm and wither height where between 74.98 and 76.16 cm. Other body measures were similar like in this trial (body length between 68.47-69.05 cm, and hip height between 78.75-79.29 cm).

Table 5. Lsmeans of 2nd measuring for body weight and body measurements

Trait	C group	E1 group	E2 group	E3 group
Body weight, kg	50.11 ^A	53.33 ^A	49.70 ^A	50.41 ^A
Withers height, cm	80.03 ^A	81.34 ^A	80.14 ^A	80.14 ^A
Hip height, cm	82.32 ^A	85.05 ^A	82.68 ^A	84.20 ^A
Body length, cm	72.08 ^A	75.25 ^A	74.20 ^A	73.02 ^A
Chest depth, cm	29.05 ^A	31.43 ^A	29.50 ^A	31.12 ^A
Chest width, cm	15.16 ^A	15.82 ^A	16.13 ^A	15.50 ^A
Heart girth, cm	85.68 ^A	87.50 ^A	86.24 ^A	86.73 ^A
Cannon bone circumference, cm	11.16 ^A	11.35 ^A	11.10 ^A	10.94 ^A
Hip width, cm	23.37 ^A	22.96 ^A	22.87 ^A	21.82 ^B

On the second measurement, the significantly lowest ($P < 0.05$) hip width were determined in group E3 with the highest value determined in control group of calves. In this trial, the measured value of hip width was higher than in research by Tahmasbi et al (2014). They determined had hip width at 3 weeks of age between 18.7 and 19.4 cm. Also, they observed body length, withers height and hip height at 3 weeks of age (70.70-72.80 cm. 78.10-80.80 cm. 83.10-84.90 cm) which are similar data like in this experiment.

Table 6. Lsmeans of 3th measuring for body weight and body measurements

Trait	C group	E1 group	E2 group	E3 group
Body weight, kg	62.87 ^A	64.67 ^A	61.48 ^A	63.83 ^A
Withers height, cm	84.37 ^A	83.58 ^A	83.24 ^A	84.91 ^A
Hip height, cm	88.63 ^A	87.03 ^A	88.91 ^A	89.53 ^A
Body length, cm	80.50 ^A	76.93 ^A	76.92 ^A	78.20 ^A
Chest depth, cm	33.75 ^A	32.48 ^A	33.30 ^A	33.52 ^A
Chest width, cm	16.42 ^A	16.85 ^A	16.40 ^A	16.38 ^A
Heart girth, cm	94.43 ^A	95.47 ^A	93.39 ^A	95.76 ^A
Cannon bone circumference, cm	11.74 ^A	11.65 ^A	11.50 ^A	11.43 ^A
Hip width, cm	24.77 ^A	24.45 ^A	24.66 ^A	24.80 ^A

On the third measurement, there were not significant difference ($P > 0.05$) between measured traits due to different starters. Similar body measures at age of 49 days were also observed by Khan et al. (2007). They performed a feeding trial with different starch sources (barley, corn, oat, and wheat).

In their trial, at 49 days of age, regarding the feeding group, body weight where between 64.13 and 68.71 kg, withers height where between 84.25 and 88.29 cm, hip height where between 88.38 and 90.43 cm, body length between 80.75 and 84.29 cm and heart girth between 89.63 and 93 cm.

Table 7. Lsmeans of 4th measuring for body weight and body measurements

Trait	C group	E1 group	E2 group	E3 group
Body weight, kg	93.33 ^A	97.19 ^A	87.26 ^A	99.32 ^A
Withers height, cm	86.70 ^A	92.25 ^B	90.90 ^C	90.94 ^C
Hip height, cm	94.82 ^A	97.72 ^A	93.68 ^A	96.59 ^A
Body length, cm	90.42 ^A	90.40 ^A	83.51 ^B	90.07 ^A
Chest depth, cm	39.54 ^A	38.97 ^A	38.58 ^A	39.80 ^A

Chest width, cm	19.37 ^A	20.48 ^A	20.03 ^A	19.42 ^A
Heart girth, cm	108.87 ^A	108.73 ^A	107.92 ^A	109.28 ^A
Cannon bone circumference, cm	12.43 ^A	12.04 ^A	12.13 ^A	12.00 ^A
Hip width, cm	28.29 ^A	28.27 ^A	27.21 ^A	28.02 ^A

Finally, on the forth measurement, the significant difference ($P < 0.05$) due to different starters was determined in withers height and in body length, with the highest value of withers height determined in E1 group, and highest value of body length in control group. In this trial values for wither heights, heart girth, hip width and hip height was higher than values in study of Omidi-Mirzaei et al. (2015), who measured those traits at 70 days of life in milking feeding systems by step-up/step-down method (89.3 cm, 103.5 cm, 21.7 cm and 94.3 cm).

CONCLUSION

The objective of this study was to determine the effect of different starters for calves on the variability of the birth weight, body weight and body measurements (birth weight, body weight, withers height, hip height, body length, chest depth, chest width, heart girth, cannon bone circumference and hip width). Based on the determined results it could be concluded that different starters significantly influenced following traits: body weight, withers height, body length and hip width while the variability of other analysed due to different feeding groups were not statistically significant.

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Стипо Бенак¹, Звонимир Стеннер², Тина Бобић², Весна Гантнер²

¹ БЕЛЈЕ плус д.о.о., Св. Ивана Крститеља 1, Дарда, Хрватска

² Факултет за Агробиотехнологију Осијек, Универзитет Ј.Ј. Строссмаер у

Осијеку, Владимира Прелога 1, Осијек, Хрватска

E-mail: vgantner@fazos.hr

ОЦЕНА УТИЦАЈА РАЗЛИЧИТИХ СТАРТЕРА НА МЕРЕ ТЕЛА МЛЕЧНЕ ТЕЛАДИ

Извод

Циљ ове студије био је да се утврди утицај различитих стартера на телад (укључујући сушену сурутку и изворе протеина са ниским АНФ-има) на променљивост од масе по рођењу, телесне тежине и телесних мерења (тежина по рођењу, телесна тежина, висина

гребена, кук висина, дужина тела, дубина груди, ширина груди, обим срца, опсег кости и ширина кука). У складу са прихраном телади, подељена у четири групе; контрола (контролни стартер), Е1 (стартер са додатком суве сурутке), Е2 (стартер са додатком извора протеина са ниским АНФ-ом) и Е3 (концентрат са додавањем суве сурутке и извора протеина са ниским АНФ-ом). Телади су индивидуално смештене у боксове са хранилицима и појилицима. Просечна тежина рођених телади је била $41,21 \pm 3,22$ кг. На основу добијених резултата могло се закључити да су различити стартери значајно утицали на следеће особине: телесну тежину, висину гребена, дужину тела и ширину кукова, док променљивост осталих анализа због различитих група храњења није била статистички значајна.

Кључне речи: *телади, стартер, мерења тела, перформансе*



Aleksandar Milovanović^{1*}, Jelena Apić¹, Tomislav Barna¹,
Milica Živkov-Baloš¹, Jasna Prodanov-Radulović¹, Sandra Jakšić¹,
Nevena Maksimović²

¹ Scientific Veterinary Institute "Novi Sad", Serbia

² Institute for Animal Husbandry, Belgrade, Serbia

Contact person e-mail: aca@niv.ns.ac.rs

EFFECT OF MYCOTOXINS ON PORCINE SEMEN QUALITY IN ARTIFICIAL INSEMINATION CENTERS

Abstract

This paper describes escalation of sudden drop in semen quality in two boars' farm centers affected by high mycotoxin level in forage (primarily by deoxynivalenol-DON). Barley and wheat harvested in 2019 was generally indicated as most risky grains for animal health and production and main source of DON. DON dominantly affected sperm total and progressive motility (agglutination and astenospermia) as well as sperm chromatin structure, while acrosome status and semen morphology were less sensitive to these changes. Bacterial control indicated increase of bacterial presence. After forage replacement a period of 1-2 months is essential for recovery of semen production, supported with prolonged vitamins and antibiotic treatment.

Routine control of forage for high producing animals is essential. Sperm production is affected with DON level when is even below recommended standards for sows feed (cumulative effect), and no clinical signs may appear. Commercial mycotoxin absorbers are not efficient for such production.

Key words: *mycotoxins, DON, boar, semen quality*

INTRODUCTION

Mycotoxins are toxic secondary metabolites produced by certain fungi belonging predominantly to the *Aspergillus*, *Penicillium* and *Fusarium* genera, which can cause a variety of adverse effects on both humans and animals (Prodanov Radulović et al., 2012). It is estimated that 25% of the world's crop production is contaminated by mycotoxins during the pre-harvest period, transport, processing or storage (Greinier et al., 2013; Weaver et al., 2013). *Fusarium spp.* is frequently found in the Serbian

climatic area which is suitable for cereal production (Jakšić et al., 2012). Among mycotoxins produced by *Fusarium spp.*, fumonisins are usually present in maize and maize products, while deoxynivalenol (DON) is a common contaminant of wheat. All farm animals can experience a negative impact from a dietary intake of mycotoxins but pigs are one of the species which are highly sensitive (Prodanov Radulović et al., 2012).

A major problem associated with animal feed contaminated with mycotoxins is not acute disease, but rather the ingestion of low levels of toxins, which may cause an array of metabolic, physiologic and immunologic disturbances (Stojanov et al., 2013; Waškiewicz et al., 2014). The manifestation of acute DON toxicity in animals is reflected in feed rejection, vomiting, diarrhea and finally, loss of weight. Pigs are particularly sensitive animals, they reject food already at DON concentrations of 1-2 mg/kg of food, while it is minimal emetic dose in these animals 0.05-0.2 mg/kg body weight, if administered orally (Scientific Committee on Food, 1999). There is evidence that DON is an immunosuppressant and immunostimulant depending on the dose and time of exposure (Rotter et al., 1996).

Pigs are considered to be the farm animals which are the most affected by mycotoxins in general (Burel et al., 2013; Wache et al., 2009). Reproductive failure in swine is often a difficult diagnostic problem. Many times, when diagnosis of infectious disease or management problems is not obtained, feed quality and safety may be questioned. Mycotoxins are often present in swine feed in amount that can have detrimental impact on production and reproduction in Serbia.

This paper describes escalation of inadequate semen quality in two boars' farm centers affected by high mycotoxin level in forage (primarily by DON) in a similar period (spring-summer 2020).

MATERIAL AND METHODS

Animals: Boars were located at two boars' farm centers with 16 (Farm A) and 65 boars in exploitation (Farm B). Semen was produced just for own farm needs. Centers had high sanitary and epizootic standards, experienced workers and standard equipment for intensive semen production. Boars were imported from SPF (specific pathogen free) farms in Denmark, kept in individual boxes, in climate buildings, allocated from other animals/farms.

Semen control: Semen production was organized 3 times in two weeks. Quality control was carried out through continuous third party analysis assessment (external laboratory) at two week intervals.

Semen was collected by manual fixation with gloved-hand technique. Each case of sudden drop in semen quality and in cases of constant low quality was subjected to bacterial count estimation (CFU/mL), bacterial typisation and antibiotic sensitivity test, as described in Milovanovic et al., 2012.

Semen quality control was performed at Laboratory for reproduction at the Scientific Veterinary Institute "Novi Sad" and consisted of:

1. CASA (Computer Assisted Sperm Analysis, ISAS, Proiser, Spain) for assessing concentration, total and progressive motility and spermatozoa speed parameters;

2. flow cytometry analyses (Guava Milipore-IMV, USA) for sperm chromatin structure assay – SCSA test (acridine orange, Invitrogen), and test of membrane and acrosome integrity (PNA-FITC/PI, Invitrogen);
3. cyto-morphological examination of stained sperm sample with eosin-nigrosine with phase contrast oil immersion objective, 1000 \times magnification (Olympus BX-40, Japan). The spermatozoa morphology was assessed according to Barth and Oko (1989).

Sudden drop of semen quality was noted in spring 2020. Generally, boars were affected with no clinical signs, but one suspected feed batch provoked even vomiting and hair loss at Farm A. Concentrates were analyzed for mycotoxin presence, targeting wheat and barley as a most risky grain during year 2019-2020 (primarily by DON).

Determination of DON content in feed using ELISA method was performed applying ELISA Veratox[®] for DON5/5(NE), Art No. R8331NE (Neogen, USA/Canada). The validation parameters were in accordance with recommendations given in EU Regulation 2006/401 (EC 2006). Feed samples were collected directly from pig farms.

For statistivc means, a t-test for independent samples and descriptive statistic was used (Statistica 8; Stat Soft, Inc., Tula, USA).

RESULTS

Different feed batches were analyzed 4-5 times in a row from March to June 2020 on both farms and DON presence was between 492 $\mu\text{g}/\text{kg}$ to 1160 $\mu\text{g}/\text{kg}$ (averaging at 721 $\mu\text{g}/\text{kg}$).

Table 1. Contents of DON in pig feed and feedstuffs samples

Feed (Farm A & B)	MPL* ($\mu\text{g}/\text{kg}$)	Min ($\mu\text{g}/\text{kg}$)	Max ($\mu\text{g}/\text{kg}$)	Average ($\mu\text{g}/\text{kg}$)
Complete feedmix for boars	900	492	1160	721
Complete feedmix for sows	900	556	869	612
Barley	8000	1535	1865	1650

* MAL – maximum allowed level (Pravilnik (2014))

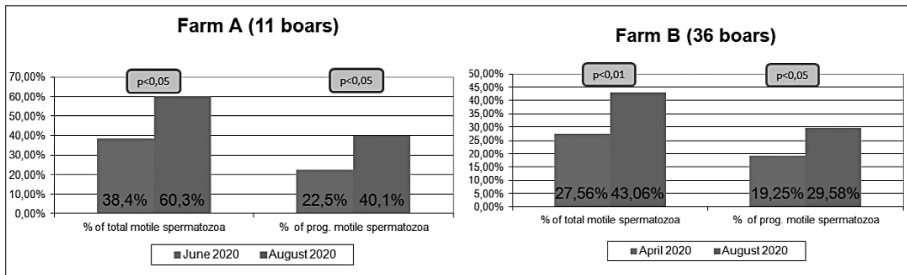
The measured value of DON of barley was up to 3.820 $\mu\text{g}/\text{kg}$. Also, zearalenone was noted at level of 101 $\mu\text{g}/\text{kg}$ and fumonisine at 541 $\mu\text{g}/\text{kg}$.

Semen quality was compared between peak of its lowest average quality (April for Farm A and June for Farm B) during mycotoxin exposure and after concentrate replacement (August 2020). Only boars that underwent control on two same specific times of analyses were included in statistic.

Comparable changes on semen quality were seen on booth farms, indicating similar DON mode of action. A high motility depression was noticed (asthenospermia – complete absence of sperm motility was noted on Farm A at 6/11 boars (54,54%) and Farm B at 20/36 boars (54,55%), respectively).

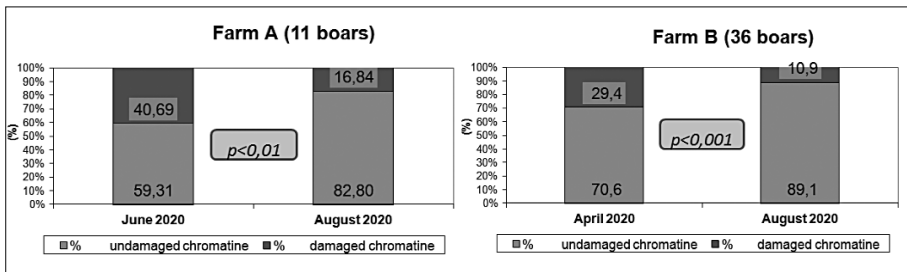
Total spermatozoa motility at DON exposure for Farm A and B were $38,4\pm 33,7\%$ and $27,6\pm 22,7\%$ and for progressive motility only $22,5\pm 23,8\%$ and $29,6\pm 20,1\%$, respectively. Values for total motility were significantly improved after food change to $69,0\pm 23,9\%$ and $43,1\pm 24,0\%$ ($p<0,05$), as well as progressive motility: $45,9\pm 19,8\%$ and $29,6\pm 20,1\%$ ($p<0,05$), respectively.

Graph 1. Total and progressive sperm motility (CASA) during DON consumption period and after, with observed statistical significance



The percentage of chromosome damage was unnaturally high ($40,7\pm 22,48\%$ and $29,4\pm 13,22\%$ - grade "Out of class"), but, after recovery it stabilized at $16,8\pm 13,68\%$ ($p<0,01$) and $10,9\pm 8,06\%$ ($p<0,01$) – grade "I class"), respectively.

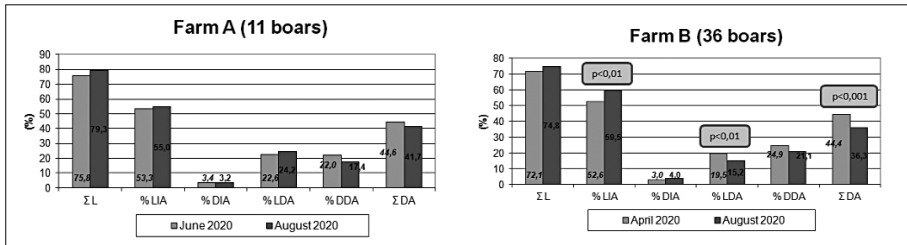
Graph 2. Percent of sperm with fragmented DNA according to SCSA test during DON consuming period and after



Legend: Total live (â L); Live with intact acrosome (LIA); Dead with intact acrosome (DIA); Live with damaged acrosome (LDA); Dead with damaged acrosome (DDA).

Sperm membrane test and acrosome tests (PNA-FITC/PI) indicate their increased sensitivity, dependent of time exposure to DON. Thus, Farm B had longer DON exposition and damaged were more prominent (statistic significant for LIA, LDA and Σ DA) in comparison to Farm B where similar pattern of defects was noted, but differences remained only numerical (*Graph 3*).

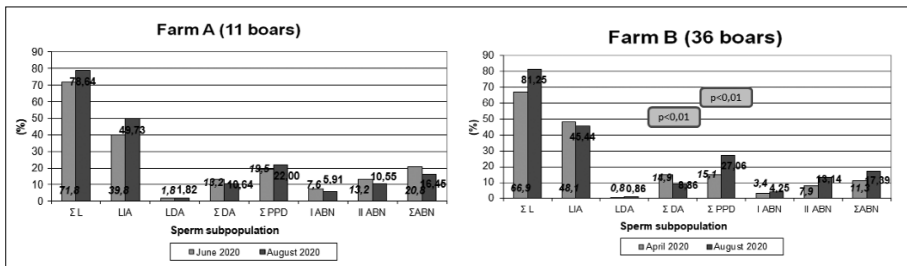
Graph 3. Membrane and acrosome integrity assay of boars' semen (flow cytometry) during DON consumption period and after, with observed statistical significance.



Legend: Total live (Σ L); Live with intact acrosome (LIA); Dead with intact acrosome (DIA); Live with damaged acrosome (LDA); Dead with damaged acrosome (DDA); total damaged acrosome (Σ DA).

Similar results were noted on cyto-morphology with statistic significance on DA ($p < 0,01$) and % of protoplasmatic droplet ($25,88 \pm 19,38\%$; $p < 0,01$) for Farm B, indicating a longer recovery process. Rate of pathological forms were not crucial for poor quality.

Graph 4. Boars' sperm subpopulation (cyto-morphological smear) during DON consumption period and after, with observed statistical significance



Legend: (Σ L=Total live/unstained spz.; LIA=Live spz. with intact acrosome; LDA=Live spz. with damaged acrosome; Σ DA=Damaged acrosome – total; Σ PPD=Protoplasmatic droplet-total; I ABN=Primary abnormalities; II ABN= Secondary abnormalities; (Σ ABN= Total abnormalities).

Bacterial count: all boars had elevated bacterial count during DON exposition in row semen and ranged from 10.000-18.000 CFU/ml, peaking with 120.000-220.000 CFU/ml (*E. coli* and *Ps. aeruginosa*, with or without the presence of saprophytic bacteria *Proteus sp.*). Main recommendations are that they should not exceed 5.000 CFU/ml. In the case of pathogenic *E. coli*, the recommendation is 3.500 CFU/ml (Maroto Martín et al., 2010). After recovery period supported with prolonged vitamins and antibiotic treatment, a bacterial number fell to values of 700-3.400 CFU/ml (1.633 ± 1.050). A period of 1-2 months is essential for recovery of semen production after adequate food change.

DISCUSSION

Deoxynivalenol, although within normal limits according to the food standards, is detrimental at chronic, cumulative exposure of approximately 600 µg/kg in complete feedmix and is probably a source of high sperm chromosome damage in boars. Mycotoxin combinations weaken the immune system, provoking next level of problem-bacterial invasion of opportunistic pathogen and sperm agglutination with no gross lesion on sperm cells. Recovery period was followed by increase of protoplasmic droplets, increased motility and quick recovery of chromatin status.

Sperm DNA fragmentation-degeneration has a negative impact on fertility and the number of offspring in pluriparic animals. This indicator is not related to sperm motility (Evenson et al., 2002). Boe-Hansen et al., (2008) claim that chromosome damage over 2,1% already has negative effects on the number of live-born piglets, while damage of over 20% results in litters with a maximum of 6,4 piglets.

On cyto-morphological analysis a high proportion of protoplasmic droplets (mostly distal PPD indicating a longer recovery process) was dominant sperm subclass compared to pathologic forms.

CONCLUSION

According to our results, the values of mycotoxins in the complete feedmix although within proposed limits can be detrimental for young breeding boars, affecting chromosome status and membrane maturation (agglutination, protoplasmic droplets, astenospermia).

The presence of mycotoxins should be taken extremely seriously because there is a possibility that boars will be disabled for further reproduction due to a long-term infection and low semen quality.

Addition of adsorbents, mycotoxin blockers, is not enough to prevent the effects of mycotoxins on semen, but they can alleviate the clinical picture.

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**Aleksandar Milovanović^{1*}, Jelena Apić¹, Tomislav Barna¹,
Milica Živkov-Baloš¹, Jasna Prodanov-Radulović¹, Sandra Jakšić¹,
Nevena Maksimović²**

¹ Scientific Veterinary Institute "Novi Sad", Serbia

² Institute for Animal Husbandry, Belgrade, Serbia

Contact person e-mail: aca@niv.ns.ac.rs

УТИЦАЈ МИКОТОКСИНА НА КВАЛИТЕТ СЕМЕНА НЕРАСТОВА У ЦЕНТРИМА ЗА ОСЕМЕЊАВАЊЕ

Сажетак

У овом раду описан је случај наглог пада квалитета семена код два нерастовска, фармска репро центра услед повишеног налаза микотоксина у концентрату (првенствено деоксиниваленола (ДОН-а)). Генерално, јечам и пшеница из рода 2019. године су назначени као најризичније категорије зрна за здравље и производњу животиња и главни извор ДОН-а. ДОН је доминантно утицао на укупну и прогресивну покретљивост сперматозоида (аглутинација и астеноспермија), као и на структуру хроматина, док су статус акросома и морфологија сперме били мање осетљиви на ове промене. Бактериолошке претраге указале су на повећано присуства бактерија. За опоравак сперматогенезе након замене концентрата неопходан је период од 1-2 месеца, подржан продуженим лечењем витаминима и антибиотицима.

Рутинска контрола сточне хране за животиње високе продукције је од суштинског значаја. ДОН утиче на производњу сперме код нерастова чак и у концентрацијама испод препоручених стандардом за храну свиња (кумулятивни ефекат) и може протицати без појаве клиничких знакова. Такође, комерцијални апсорбенти микотоксина нису ефикасни за ову осетљиву производњу.

Кључне речи: *микотоксини, ДОН, нераст, квалитет семена*



**B. Sc. Student Luka Nestic¹, M. Sc. Predrag Umicevic,¹ B. Sc. Nenad Nestic²,
M. Sc. Bratimir Nestic¹, B. Sc. Student Nikola Kostic¹**

¹ University in Niš, Occupational Safety Faculty, Nis, Serbia

² City Administration, Krusevac, Serbia

E-mail: bratimir@gmail.com

SUSTAINABLE DEVELOPMENT OF AGRICULTURE VERSUS MALNUTRITION, DISEASES AND POVERTY

Abstract

Sustainable development is defined as development that meets the needs of the present so as not to jeopardize the ability of future generations to meet their own needs. Sustainable agricultural production arose as a need to devise ways of agricultural production that do not degrade natural resources and at the same time bring high yields and incomes to agricultural producers. Malnutrition is a condition that occurs as a result of insufficient or unbalanced intake of carbohydrates, proteins and other nutrients, which negatively affects the functioning of the organism. Diseases represent any deviation from the state of health and have their characteristic symptoms, affect the whole organism or are limited to individual organs. Poverty is the lack of material goods needed to meet the most important needs of each individual, family or larger social group. These three concepts belong to the group of the biggest problems that humanity is facing today. Mankind has been working on solving these problems for many years and still without excessive progress. This paper is an attempt to answer the question of who will win the race between sustainable development based on sustainable agriculture, on the one hand, and malnutrition, disease and poverty, on the other. The real question is: Will there ever be a winner or is this a dead end race?

Key words: *agriculture, sustainable development, malnutrition, diseases, poverty*

INTRODUCTION

Sustainable development is defined as development that meets the needs of the present so as not to jeopardize the ability of future generations to meet their own needs. Sustainable development policies include institutional measures and activities in the field of environmental protection that protect the environmental system, the economic

system and the social system as a whole, as well as a set of principles of economic and social sustainability [1]. Sustainable agricultural production arose as a need to devise ways of agricultural production that do not degrade natural resources and at the same time bring high yields and incomes to agricultural producers. As agriculture largely depends on the services provided by ecosystems, sustainable agriculture seeks to reduce negative anthropogenic impacts on the environment, through the efficient use, conservation and improvement of the quality of natural resources.

Preserved natural resources and improved quality of the environment in sustainable production systems are at the service not only of present, but also of future generations. Today, three big problems often appear in the world: poverty, malnutrition and diseases. Poverty is the lack of material goods needed to meet the most important needs of each individual, family or larger social group. Malnutrition is a condition that occurs as a result of insufficient or unbalanced intake of carbohydrates, proteins and other nutrients, which has a negative impact on the functioning of the organism. Diseases represent any deviation from the state of health and have their characteristic symptoms, affect the whole organism or are limited to individual organs [1].

SUSTAINABLE DEVELOPMENT OF AGRICULTURE

Sustainable agricultural production means that farmers actively participate in the decision-making process and have concrete benefits from economic development, good working conditions and good prices for their agricultural products. The concept of sustainable agriculture can be defined as an integrated system of plant and livestock production practices that meet people's food needs in the long run, preserve the quality of the environment and natural resources, have high economic value and improve the quality of life of farmers, local communities and society as a whole [2].

Sustainable agriculture encompasses three aspects of sustainability [4]: social, economic and environmental quality. If one of these aspects is neglected, the sustainability of the others is questioned. It is crucial for the long-term socio-economic development of each country, which is especially the case with developing countries, because agriculture has a strong impact on other sectors of society and is one of the most important pillars of prosperity and development of society. The benefits of sustainable agriculture are felt by everyone: from agricultural producers who achieve direct economic benefits and better access to the market, through the economy and increased profits due to the production of quality products, to consumers who can choose quality, safe and healthy food.

Low-intensity agricultural production, quality food products, traditional crafts and rural tourism could be at the heart of sustainable rural development across the Western Balkans and thus contribute to the development of the rural economy. Sustainable agriculture provides us with safe and healthy food of natural origin, which not only has no negative consequences for human health, but also contributes to the improvement or advancement of public health. Numerous methods of sustainable agriculture help farmers to protect their agricultural production from the effects of climate change.

Sustainable farming practices are in line with the needs of animals because they do not impair their welfare and at the same time are useful for both farmers and consumers [4].

POVERTY

Nearly one billion people in the world can be considered extremely poor if the poverty line is adopted at 1 dollar per capita per day. More than 800 million people in the world are hungry and over 100 million school children are unable to attend primary school due to poverty and more than 8 million people die each year because they are too poor to continue living [1].

According to the World Bank, close to 2.6 billion people in the world, or two-fifths of the world's population, can be considered poor [2]. The problem of world poverty is a problem of a large number of people, women and children who face insurmountable obstacles in fulfilling their basic human rights and realizing their individual potentials. When the UN adopted the Universal Declaration of Human Rights in 1948, the signatory states proclaimed with their signatures that all people have the right to education, work, health care and well-being [2]. Today, however, millions of people around the world are so vulnerable to poverty that they simply cannot exercise their basic human rights. Poverty can be found in all parts of the world but is most evident in developing countries. Apart from the most endangered countries in sub-Saharan Africa and parts of Asia, poverty is also significantly present in countries in transition. Although the situation is slowly improving in these countries as well, the percentage of the poor is still high, especially in the countries of the former Soviet Union and in the Balkans.

In addition to similarities with countries in transition and developing countries, poverty in Serbia has many specifics. It is primarily a consequence of the dramatic decline in GDP – Gross Domestic Product (from \$ 2,696 per capita in 1990 to \$ 1,035 in 2000, excluding Kosovo and Metohija), as well as income during the 1990s. The decline of the social product and the standards of the citizens, the growth of unemployment and other consequences are the disintegration of the former SFRY, international isolation and sanctions, wars and bombing of Serbia [3]. Economic activities have been drastically reduced due to a ten-year general political and social crisis. The difficult economic and social situation is aggravated by the large influx of displaced persons, whose number of 750,000 in some years reached up to 10 percent of the total population. Today, the number of displaced is still very significant at around 480,000.

Poverty in Serbia is concentrated in traditionally underdeveloped areas in the south and southeast of the country, and after the 1990s it appeared in completely new areas. Poverty is higher in rural than in urban areas. In rural areas of southeastern and western Serbia, it covers 25% of the total number of poor and 14% of the total population [3]. Poverty is very pronounced among the elderly, displaced persons, persons with disabilities, children, Roma, the uneducated and the unemployed. The link between unemployment and poverty is the most direct, so one of the main causes of poverty is high unemployment.

At the end of 2002, the Government of the Republic of Serbia started drafting the Poverty Reduction Strategy (PRS). The strategy starts from poverty as a multidimensional phenomenon which, in addition to insufficient income to meet basic living needs, includes aspects related to human rights such as employment opportunities, adequate housing conditions, adequate access to social protection, health, education and utilities. The Poverty Reduction Strategy aims to halve poverty in Serbia by 2010, ie to eliminate the most pronounced forms of poverty, especially present in underdeveloped areas and concentrated among the most socially vulnerable groups. According to the Second Report of the Government of the Republic of Serbia on the Implementation of the Strategy from 2007, the number of poor people in Serbia dropped to 8.8% in 2006. The severity of poverty was 0.8%, which indicates that the number of extremely poor is very small [3].

However, the decline in economic activity, the halt in growth in employment and wages and the consequent rise in unemployment in Serbia, caused by the economic crisis in the last decade of the 21st century, led to an increase in the absolute poor in 2009 and 2010. According to estimates of absolute poverty, the most vulnerable were the population of rural areas, especially in central Serbia, children up to 14 years of age, uneducated, unemployed and inactive. The large regional differences in poverty are in line with the existing differences in the economic development of the region.

The most significant (but not the only) measure to reduce poverty in developing countries is economic growth and, as shown, data from the last decade are encouraging. It is estimated that the number of poor in developing countries at current economic growth rates could be reduced to 10% globally, if the set Millennium Development Goals are achieved. The World Bank has announced that the world's poverty rate has been declining in the first four years of the new century. Thus, in 2004, 985 million people in the world lived in extreme poverty, as opposed to one billion and 250 million in 1990 [1]. The number of poor people surviving on less than \$ 2 a day is declining, although it is estimated that 2.6 billion people (almost half of the population of developed countries) still lived below that level in 2004. Significant credit for the shift for the better is largely attributed to China and its anti-poverty campaign. In addition, the extreme poverty rate has decreased significantly in East Asia. In other parts of the world, good economic performance and low levels of poverty have resulted in population growth. In sub-Saharan Africa, the number of poor has not increased significantly, given that in 2004, 298 million people lived in extreme poverty, which is approximately the same as in 1999.

MALNUTRITION

The World Economic Forum in Davos in 2008, in its report "Global Risks 2008", marked the secure supply of food as one of the 4 biggest challenges of the world economy in the future. Long-term and short-term impacts: population growth, lifestyle changes (diet), climate change and the increasing use of food crops for biofuel production, could lead to more unstable and longer periods of high food prices. Food prices are rising everywhere in the world. This increase was 83% from 2005 to 2008,

while in the last 2 years (March 2006 to March 2008) the prices of basic cereals for human consumption: corn, rice, soybeans and wheat, increased by 95%. Global food reserves were the lowest in 25 years in 2007 [1].

The United Nations Food and Agriculture Organization (FAO) estimates that 842 million people worldwide suffered from malnutrition in 2006 [2]. The number of malnourished, however, is declining: compared to 2003, it fell by 12 million. The highest percentage refers to developing countries – over 96% and in countries in transition this number was close to 3%. There are also malnourished people in developed countries – close to 9 million. Although the number of malnourished is declining, there are many reasons for concern because the world has not even come close to achieving the goals set at the World Food Summit, held in Rome in 2006, when it is planned to halve the number of malnourished in the world by 2015. In contrast, in developing countries this number is almost not reduced at all – a decrease of 3 million compared to the early 1990s is negligible.

With the current trend of reducing the number of malnourished in developing countries of 6 million per year, it is not possible to achieve the set goals. In order to get closer to the set goal, this number should not be less than 22 million. The situation is even more difficult because only a third of the 97 countries in the FAO report actually reduce the number of malnourished, while other countries are still struggling to stop their growth.

Economic growth in some developing countries (China and India) has led to major changes in the global food market. Hundreds of millions of people in China and India have become the middle class, which can now buy not only larger quantities of domestic but also imported food. The amount of food needed to meet the needs of the increasingly affluent middle class is affecting unpredictable movements in food prices in the market. The latest analyzes show that higher temperatures that can be expected in the coming years, along with salinization of fresh water supplies due to rising sea levels caused by climate change, floods and droughts, will jeopardize agricultural production in countries with low altitudes. These are the countries where the largest number of poor people live [3].

In India, the productivity of agricultural production under this scenario could fall by up to 40% by 2080. In Africa, where 4 out of 5 people live on agricultural income, this reduction could average 30% while in some countries such as Senegal or Sudan, production could be halved. The consequence of that could be the transition from traditional cereal crops to the production of rice, which is less sensitive to increased heat. The crisis in agricultural production would not bypass the developed ones – its consequences would be experienced by both the USA and the countries of Latin America. Under this scenario, today's significant exporters of cereals (for example, Brazil) would no longer be in a position to fully cover their own market [2].

The increasing production of biofuels today posed an additional danger for providing a sufficient amount of food on the world market because the use of agricultural crops for the production of biofuels in the world is growing. This growth is often accompanied by subsidies from states, in order to reduce gas emissions and more often, in order to reduce dependence on fuel imports. It is predicted that by 2010, the areas on which corn was grown in the United States will be reduced by 30% at the expense

of growing raw materials for bioethanol production. A sharp and record rise in world oil prices could accelerate these processes, which in the long run could affect the global food market and lead to price volatility in basic agricultural products, as this would particularly affect grain-importing countries and increase the number of hungry [2].

DISEASES

Although it may seem that health care has become the number one imperative for the world's population today, the data show that despite the obvious improvements in the general situation, the health of the population is still exposed to numerous existing and new risks. Cancer and cardiovascular disease remain the leading causes of death worldwide (cancer with close to 13% and cardiovascular disease with 30% of all deaths in 2007) [3].

The modern way of life is conducive to the occurrence of these diseases, and estimates by the World Health Organization predict that their number will increase: for example, the total number of deaths from cardiovascular diseases is projected to increase from 17.6 million in 2005 to almost 20 million in 2015. Despite the common opinion that heart disease is a disease of the modern developed part of the world, the data show that close to 80% of all deaths of the cardiovascular system are recorded in underdeveloped and developing countries [2].

According to the data of the Republic Bureau of Statistics, the leading causes of death in Serbia are diseases of the circulatory system (56.8%), tumors (21.8%), symptoms, signs and pathological clinical and laboratory findings (6.14%), injuries, systemic diseases for respiration (3.98%), poisoning and the consequences of external factors (3.6%) [1]. The high share of cardiovascular and malignant diseases in the structure of death is a consequence of improper diet, smoking and alcohol, and external causes indicate inadequate protection, both at work and at home. Modern way of life, mobility and interconnectedness of people, have influenced the world to drastically increase the risk of infectious diseases and health threats associated with toxic and radioactive exposures [3].

Infectious diseases are spreading much faster today than before because the mobility of the population is higher. The number of air passengers is growing every year (in 2006, there were more than 2.1 billion). The epidemic in any part of the world today is only a "couple of hours of flight" from any other region in the world, thanks to the developed air traffic. Infectious diseases have become much "faster" because in the seventies of the last century, approximately one to two new causes of epidemics were discovered annually, while today, according to the World Health Organization, there are over forty new diseases, unknown to previous generations. In the last 5 years, over 1100 epidemics have been registered in the world. Cases of cholera, yellow fever and infectious meningitis, which were considered to have been eradicated or controlled, were re-registered. The HIV epidemic remains an unresolved problem for humanity. At the end of 2006, according to the World Health Organization, nearly 40 million people were infected with HIV in all parts of the world. In that year alone, 4.6 million

new cases were recorded, of which half a million were under the age of 15. The geographical distribution of the infected is also changing, so in Western Europe the number of infected people increased from 42 per million inhabitants in 1998 to 74 in 2006 [1].

CONCLUSION

These three concepts belong to the group of the biggest problems that humanity is facing today. Mankind has been working on solving these problems for many years and still without excessive progress. When we talk about poverty in the world, everyone gets an image of the people in African countries, but also in underdeveloped countries on other continents. The problem of poverty is accompanied by the problem of malnutrition. The inability to provide food forces people to migrate en masse to work for any wage so they can feed themselves. Of course, all this is followed by a problem with diseases that has not been solved for years. Due to poor living conditions, food, lack of drinking water and medicine, new cases of patients are constantly appearing, less often than mild but more often than more serious diseases.

The fact is that people in villages, rural areas and cities in underdeveloped countries have a big problem with poverty, malnutrition and disease. They find salvation by migrating to more developed cities or countries so that they can work and possibly live better and healthier.

Based on all the above, is it even possible to talk about sustainable development from the aspect of sustainable agriculture, when there is an intense struggle for survival all over the planet?

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Студент Лука Нешић¹, мр Предраг Умичевић¹, дипл. инж. Ненад Нешић²,
студент Никола Костић¹, мр Братимир Нешић¹

¹ Универзитет у Нишу, Факултет заштите на раду,

² Градска управа, Крушевац

E-mail: bratimir@gmail.com

ОДРЖИВИ РАЗВОЈ ПОЉОПРИВРЕДЕ НАСПРАМ НЕУХРАЊЕНОСТИ, БОЛЕСТИ И СИРОМАШТВА

Абстракт

Одрживи развој се дефинише као развој којим се иде у сусрет потребама садашњости тако да се не угрожава могућност будућих генерација да задовоље своје сопствене потребе. Сиромаштво је мањак материјалних добара потребних за задовољење најважнијих потреба сваког појединца, породице или веће друштвене групе. Неухрањеност је стање које настаје као последица недовољног или неуравнотеженог уноса угљених хидрата, протеина и других нутритивних материја што се негативно одражава на функционисање организма. Болести представљају свако одступање од стања здравља и имају своје карактеристичне симптоме, захватају цео организам или су ограничене на поједине органе. Ова три појма спадају у групу највећих проблема са којима се човечанство данас сусреће. На решењу ових проблема човечанство се задржава већ дуги низ година и даље без претераног напретка. Овај рад је представља покушај да се одговори на питање ко ће победити у трци између одрживог развоја, с једне стране и неухрањености, болести и сиромаштва, с друге стране. Право питање је: Да ли ће икад бити победника или је ово мртва трка?

Кључне речи: *одрживи развој, неухрањеност, болести, сиромаштво*

**PROCESSING OF AGRICULTURAL
PRODUCTS IN THE FRAMEWORK
OF SAFE FOOD PRODUCTION**



V.V. Zakrevskii¹

¹ North-Western State Medical University named after I.I. Mechnikov

E-mail: vzakr@list.ru

ANTIBIOTICS IN MEAT AND MEAT PRODUCTS

Abstract

The article provides data on the global consequences of the widespread use and increase in the use of veterinary antibiotics in animal husbandry. The mechanisms of resistance of microorganisms to antibiotics are described. Literature data on a high level of antibiotic-resistant strains isolated from products of animal origin are given. The materials of our own research on the hygienic safety assessment for the health of the population of meat supplied to meat processing enterprises of St. Petersburg from 12 countries of the world and Russia in 2013-2014, on the content of standardized antibiotics are presented. It is stated that in 40.0% of the samples residual amounts of antibiotics were found that did not exceed the maximum permissible levels, of which 48.5% of the samples contained tetracycline, 33.3% – streptomycin and 18.2% – chloramphenicol. Statistically significant differences according to the χ^2 criterion were established between the types of raw meat, which indicates a more intensive use of antibiotics in growing birds. It is concluded that a decrease in the content of antibiotics in food products of animal origin is possible only if the legislation of the Russian Federation in the field of the use of antibiotics in agricultural production and the development of organic animal husbandry is changed.

Key words: *antibiotics, meat, resistance of microorganisms to antibiotics*

INTRODUCTION

Of particular importance in the diet to maintain human health are meat and meat products, as they are the main source of high-grade proteins, bioavailable iron, selenium, zinc, vitamins B1, B2, B6, PP, B12 in human nutrition [2,3]. At the same time, meat and meat products may contain various contaminants of biological and chemical nature, among which antibiotics – AB are priority.

According to the European Union and WHO FAO, the volume of antibiotics used in veterinary medicine for poultry, productive animals and aquaculture is more than 2

times the volume of drugs used in medicine using the same types or classes of antimicrobials as for humans. According to a number of authors who determined antibiotics in meat and meat products of domestic and foreign production, the content of antibiotics in them exceeded or was at the MDL level, and often several antibiotics were simultaneously present in the samples at the same time [4,7]. The market structure by types of veterinary drugs in the Russian Federation is as follows: the largest share is taken by vaccines and serums (35%) and antibiotics (31%), antiparasitic and disinfectants account for 9%, others account for 16% [6], which in general similar to the structure of markets in other countries. Moreover, tetracyclines are the most common in the entire spectrum of antibiotics for agriculture, both in the Russian Federation and other countries because of their availability and low prices [13]. The number of tetracyclines (per 1 kg of biomass of farm animals) in the EU countries is more than half of all antibiotics sold for veterinary medicine.

In Russia, antibiotics are regulated by the Technical Regulations of the Customs Union (TR CU) [9,10] and the decision of the Economic Commission for Europe (ECE) [8] at the maximum allowable levels (MRLs). In accordance with the ECE decision of 2018, the list of pharmacological substances for which the MRLs are established has been expanded to 72 drugs. Now the EAEU state supervisory authorities and manufacturers must control products according to these standards. At the same time, the document recommends, but does not oblige, processors to conduct production control for the presence of all veterinary medicines included in it. In an accompanying document for unprocessed food products of animal origin, the manufacturer must indicate the name of the veterinary medicinal product, the date of its last use for a productive animal and confirmation of the timing of its removal from the body. The processor, in turn, on the basis of these documents can check the delivered products at the MDA at home. Based on information from the supplier, the processor, at its discretion, has the right to verify this information or not to verify and assess the risks.

At the same time, there are currently no methods for determining many antibiotics in livestock products in the Russian Federation (aversectin, avilamycin, amitraz, bacviloprim, imidocarb, clavulanic acid, rifampicin, flavomycin), some of the proposed methods do not meet the basic metrological requirements for quantitative methods analysis, and some of the proposed methods are characterized by a high level of error (in some cases up to 93%), there are also no instructions officially approved by the veterinary departments and to drugs which are indicated as possible removal of antibiotics from animal organism. The ECE decision also did not define the frequency of control of residues of veterinary drugs in unprocessed products and did not establish MDLs for residues of antibiotics for finished products. In fulfilling the ECE decision, processors can be infringers in any case if even minor traces of these drugs are found during the inspection of finished products.

An analysis of the current situation allows us to state that the input control at processing plants, proposed in the ECE decision, will not solve the problem of the presence of antibiotics in livestock food products. The reason lies in livestock enterprises that abuse the use of veterinary drugs, ignore the instructions of pharmaceutical

companies, insufficiently control the process of removing antibiotics before slaughter, and the legislation of the Russian Federation allows the use of antibiotics in the field of agricultural production when growing chicken broilers, cattle, pigs not only for therapeutic purposes, but also with preventive, growth-promoting, as well as in the production of feed for farm animals.

The widespread use and increase in the use of AB in livestock production currently leads to the following global consequences [12]:

- antibiotics in foods above the maximum allowable levels (MDL, mg / kg) affect the intestinal microflora in the human body;
- the constant presence of veterinary AB in the intestines of animals and in the waste produced by them contributes to the formation of forms of microorganisms resistant to antimicrobials. Antibiotic resistance does not recognize any geographical or biological boundaries; the use of antibiotics in some sectors, conditions or countries affects the spread of resistance to them in other sectors, conditions or countries.
- the presence of resistance of several groups of bacteria leads to the ineffectiveness of antibiotics in the treatment of people;
- the indirect effect of antibiotics is manifested in the formation of pathogenic microflora resistant to antibiotics in the environment.

Antibiotic-resistant bacteria carried by farm animals can be transmitted to humans, mainly through the consumption of meat and poultry products that have not undergone sufficient heat treatment, through contact with raw foods or through cross-contamination of other products, as well as through the environment (e.g. contaminated water) and direct contact with animals. Transmission factors can also be vegetables and fruits grown using organic fertilizers obtained from animals. A high level of antibiotic-resistant strains isolated from Russian-made poultry products was shown by research results from the Federal State Budgetary Institution for Nutrition and Biotechnology. *Campylobacter jejuni* was found to be resistant to 15 antimicrobial agents (8 pharmacological groups) isolated from raw poultry products and washes from surfaces of equipment of poultry processing enterprises [5].

WHO notes that discontinuing the use of antibiotics to stimulate animal growth reduces the risk to human health without any harm to animal health or economic loss in the production of animal products. The efforts of states should be aimed at reducing the unjustified use of antibiotics and limiting the spread of antibiotic-resistant bacteria [13]. It is proposed that national veterinary, agricultural and pharmaceutical governing bodies consider taking, among others, the following measures:

- cessation of the use of antibiotics as animal growth stimulants;
- the use of antibiotics in animals only as directed by the veterinarian;
- the use of antibiotics, which are of extreme importance in medicine (especially fluoroquinolones and cephalosporins of the third and fourth generations), in farm animals only if there is good reason for this.

Numerous studies in the field of microbiology, physiology, biochemistry and nutritional science have led to the development of a number of drugs (probiotics, prebiotics, symbiotics, synbiotics and phytobiotics) that are not inferior to antibiotics in terms of effectiveness and at the same time eliminating negative consequences. Their distinguishing feature is environmental safety, they do not have side effects, are disposed of by the animal organism and do not pose a threat to either the consumer of the product or the environment. All these drugs are united by the fact that they affect the microflora of the gastrointestinal tract. From these positions, they should be considered as additives to maintain the health of animals and obtain high-quality products that are safe both in bacterial and in chemical terms. Maintaining effective symbiosis between the animal organism and its intestinal microflora is today considered a necessary component of developing a feed strategy and maintaining the health of animals. One of the promising areas is the use of targeted microbial drugs – probiotics, it is they who play a leading role in replacing feed antibiotics [1,11].

As for the effect of heat treatment on reducing the content of antibiotics in meat and meat products, it should be noted a number of works in which similar studies were carried out. So, Sheveleva S.A., Bessonov V.V. [12] found that after cooking cattle, pork and poultry meat for 1 hour, the distribution of antibiotics (chloramphenicol, tetracycline, bacitracin) looked as follows: 7-12% were found in meat, 19-20% were destroyed, and 67-78% turned into broth (the broth should be drained after cooking). Kalnitskaya O.I. [4] found that in the manufacture of cooked sausages using hot steam, 89–93% of antibiotics (chloramphenicol, tetracycline, streptomycin and benzpenicillin) are found in the final product.

In this regard, a hygienic safety assessment for the health of the population of meat and meat products containing antibiotics is relevant.

The purpose of research. Hygienic safety assessment for the health of the population of meat and meat products of meat processing enterprises of St. Petersburg on the content of standardized antibiotics and development of recommendations for their reduction.

MATERIALS AND METHODS

In this work, we used the method of literary research and analysis of publications by domestic and foreign authors, the laboratory method for determining antibiotics in meat in accordance with MUK 4.1.2158-07 "Methodological instructions for determining the residual amounts of tetracycline antibiotics and sulfonamide preparations in animal products by enzyme immunoassay" as well as a statistical method.

We studied 247 samples of meat raw materials of domestic and imported origin (pork, beef, lamb, chicken, turkey meat) supplied to meat processing enterprises in St. Petersburg in 2013-2014. to determine in it the antibiotics most commonly used in livestock and poultry - tetracycline, streptomycin and chloramphenicol. Meat sampling was carried out in accordance with GOST R 51447-99 (ISO 3100-1-91). Raw materials were supplied to meat processing plants in St. Petersburg from 12 countries – Brazil,

Paraguay, Argentina, Spain, the USA, Ireland, Australia, Denmark, New Zealand, Canada, Uruguay, Germany, and also Russia.

To assess safety, the following were calculated: food exposure and chronic risks, in particular non-carcinogenic risks to public health when eating meat and meat products containing antibiotics.

RESULTS AND DISCUSSION

As a result of studies, residual amounts of antibiotics not exceeding the MDL were found in 99 (40.0%) samples, of which 48 (48.5%) samples contained tetracycline, 33 (33.3%) – streptomycin and 18 (18.2%) – chloramphenicol [7]. Statistically significant differences according to the χ^2 criterion ($p = 0.0093$) were established between types of raw meat, which indicates a more intensive use of antibiotics in poultry rearing (residual amounts were found in 59.6% of poultry samples), as well as cows and calves (residual amounts detected in 39.0% of beef samples). Antibiotics are less intensively used for fattening pigs and sheep (residual amounts were detected in 33.0% and 28.5% of the samples, respectively).

It should be noted that, as in the whole world, in Russia poultry today and for a ten-year perspective is the main supplier of the cheapest meat, and even dietary, for the broad masses of the population. Over the past half century, beef production has increased 3.3 times, pork – 6.5 times, lamb – 2.6 times, poultry – 19 times [13]. In accordance with the order of the Ministry of Health of the Russian Federation dated August 19, 2016 No. 614 "On approval of recommendations on rational food consumption standards that meet modern requirements of healthy nutrition", Russians recommend the consumption of poultry meat in the structure "meat and meat products" 31 kg / year (85 g / day), which is 4% more compared to similar recommendations given by the Ministry of Health of the Russian Federation in order No. 593n of 02.08. 2010 "On the approval of recommendations on rational food consumption standards that meet modern requirements for a healthy diet".

The frequency of contamination of raw meat with antibiotics imported from 12 countries of the world and of Russian origin is shown in the figure. Data on the frequency of contamination indicate that raw meat, regardless of the country of origin, contained antibiotics. The largest percentage of positive samples (from 50% to 70%) falls on raw materials from Germany (70.0%), Brazil (67.0%), Canada (64.3%), the United States (54.0%), Uruguay (50.0%); a smaller percentage is for raw materials from manufacturing countries such as Ireland (42.8%), Australia (28.6%), Denmark (27.7%), New Zealand (23.8%), Chile (20.0%), Paraguay (11.0%) and Spain (8.3%).

To calculate the chronic risk, the food exposure was determined in relation to the consumed meat and meat products. To do this, we studied the actual nutrition of various groups of the population of St. Petersburg in the general structure of consumed food products (students, workers of meat processing enterprises, workers professionally not associated with the production and circulation of food products). Using the developed questionnaire, the detailed structure of consumption of meat and meat products in the target population groups was studied.

It was established that students (group 1 - 321) do not consume enough meat of all kinds of animals and birds, in quantitative terms this is expressed in a deficit of 7.3 kg / year per person. In this case, the substitution of natural meat occurs due to meat-containing products: sausages (15.3 ± 0.1 kg / year), sausages (13.4 ± 0.1 kg / year), dumplings (9.3 ± 0.2 kg / year), canned meat and vegetable products (6.5 ± 0.1 kg / year). Students also consume the largest amount of offal - 1.3 ± 0.02 kg / year.

The respondents of the 2nd group (workers of meat processing enterprises – 361 people), on the contrary, noted an excessive consumption of meat and meat products by 8.7 kg / year (81.7 ± 0.5 kg / year with a norm of 73 kg / year, in 2010 – 70-75 kg / year).

In the third group (consumers whose work is not related to the production and circulation of food products – 347 people), the total amount of consumed meat and meat products is reduced by 5.6 kg / year / person.

The first stage of assessing the chronic risk to consumer health was the determination of food exposure, during which the quantitative intake of antibiotics in the adult human body with food products (in mg per kg of raw meat per day) was established.

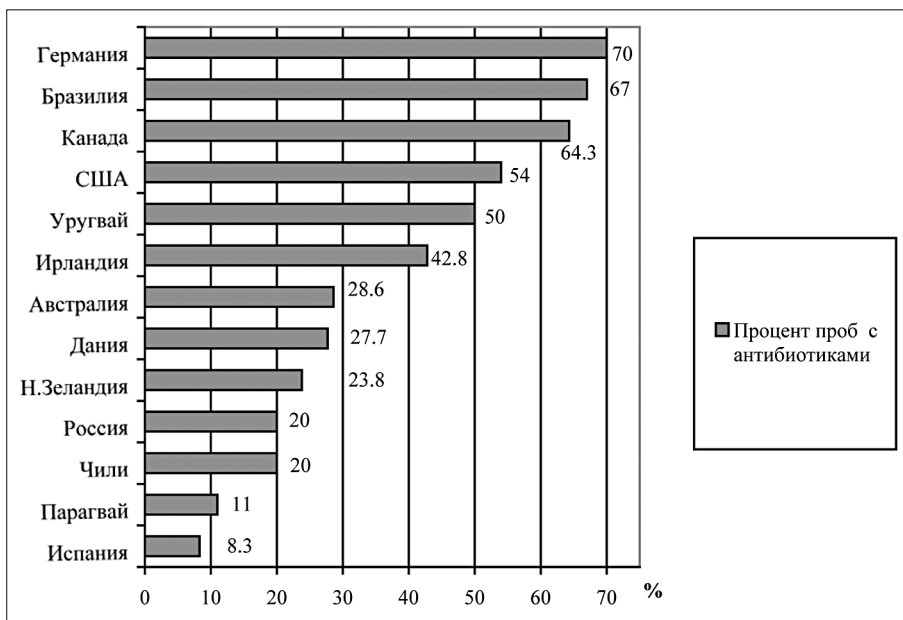


Figure – Frequency of contamination of raw meat with antibiotics (in%) imported from around the world and of Russian origin

An in-depth study of the contribution of antibiotics to health risks resulted in the following data. According to the dose load of antibiotics contained in meat (raw mate-

rials) and affecting the human body, they are ranked in the following descending order: streptomycin, tetracycline and chloramphenicol.

When calculating non-carcinogenic risk in connection with food exposure by hazard coefficient (HQ), taking into account the allowable daily doses of antibiotics, it was found that streptomycin 20.27% makes the greatest contribution to the hazard coefficient. The remaining antibiotics contribute less than 7% each.

CONCLUSION

1. A different frequency and degree of contamination of meat with antibiotics received in 2013-2014 was revealed. from 12 countries of the world and the Russian Federation to meat processing enterprises of St. Petersburg, which must be taken into account in the future when importing meat to Russia.

2. An increase in the consumption of poultry meat in the structure of "meat products" increases the risk of veterinary antibiotics entering the body of consumers.

3. A reduction in the content of antibiotics in food products of animal origin in the Russian Federation is possible only if the legislation on the use of antibiotics in agricultural production and the development of organic livestock is changed.

4. When choosing growth-promoting preparations for animals, it is necessary to focus on the use of probiotics, adaptogens, antioxidants, physiological catabolism activators, and not on feed forms of medical antibiotics.

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В.В. Закревскиј

Северозападни државни медицински универзитет имена "И.И. Мечников",
Санкт Петербург, Руска Федерација
E-mail: vzakr@list.ru

АНТИБИОТИЦИ У МЕСУ И ПРОИЗВОДИМА ОД МЕСА

Апстракт

У овом раду су дати подаци о глобалним последицама масовне употребе и повећаног коришћења ветеринарских антибиотика у сточарству. Описани су механизми резистенције микроорганизама на антибиотике. Дати су литературни подаци о високом нивоу сојева отпорних на антибиотике изолованих од производа животињског порекла. Приказани су материјали сопствених истраживања о процени хигијенске безбедности за здравље становништва меса које се испоручује меснопрерађивачким компанијама Санкт Петербурга из 12 земаља света и Русије у периоду 2013-2014, и садржају стандардизованих антибиотика. Наводи се да су у 40% узорака пронађене заостале количине антибиотика које нису прелазиле максимално дозвољене нивое, од чега је 48,5% узорака садржавало тетрациклин, 33,3% – стрептомицин и 18,2% – хлорамфеникол. Утврђене су статистички значајне разлике према критеријуму χ^2 између разних врста сировог меса, што указује на интензивнију употребу антибиотика код растућих пилића. Закључује се да је смањење садржаја антибиотика у прехранбеним производима животињског порекла могуће само ако се промени законодавство Руске Федерације у области употребе антибиотика у пољопривредној производњи и развоју органског сточарства.

Кључне речи: *антибиотици, месо, резистенција микроорганизама на антибиотике*



Popović V.¹, Ikanović J.², Rajičić V.³, Ksenija Mačkić⁴,
Ljubičić N.⁵, Kostić M.⁴, Radović M.⁵, Šarčević-Todosijević Lj.⁶

¹ Institute of Field and Vegetable Crops, Novi Sad, Serbia;

² University of Belgrade, Faculty of Agriculture, Belgrade, Serbia;

³ University of Niš, Faculty of Agriculture, Kruševac, Serbia;

⁴ University of Novi Sad, Faculty of Agriculture, Novi Sad, Serbia;

⁵ Biosens Institute, Novi Sad, Serbia;

⁶ High Medical-Sanitary School of Professional Studies "Visan", Belgrade, Serbia;

* Corresponding author: vera.popovic@ifvens.ns.ac.rs

MILLET – *Panicum miliaceum* L. PRODUCTION TREND IN THE WORLD. IMPORTANCE OF MILLET IN NUTRITION AND FOR BIOENERGY

Abstract

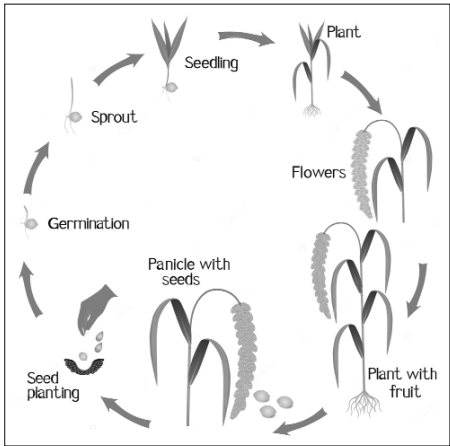
The aim of this study was to examine the productivity of millet (*Panicum miliaceum* L.; *Poaceae*) in the world and its importance in the food and in industries. Millet has a high grain yield and is an important source proteins in food. It has high biomass yield which is why it is of great importance in bioenergy production. The priority is to procure raw materials and develop the process of biofuel production in an economical way. Millet has the least need for water, of other cereals and is a significant crop in sustainable systems. Millet grain is rich in iron, calcium and vitamin B complex (B₁, B₂, B₃). In addition to their nutritive value, helps prevent cancer and cardiovascular diseases, reduce tumor incidence, lower blood pressure, the risk of heart disease, cholesterol and rate of fat absorption have been reported for millet.

Key words: *Millet, production, nutritive value, biofuels*

INTRODUCTION

Millet (*Panicum miliaceum* L.; *Poaceae*) is the very significant old-new cultivated plants in the world. It produces high yields of biomass and grains and is an important source of energy and proteins (Popović et al, 2018; 2019; Lakić et al., 2018). There are about 500 species of millet worldwide but only a few species of millet are commonly

cultivated as food crops: pearl millet (*Pennisetum glaucum*) is the most commonly produced type of millet (Africa and India), Finger millet (*Eleusine coracana*), proso millet (*Panicum miliaceum*), fonio millet (*Digitaria exilis*), millet (*Panicum germanicum*) and foxtail millet (*Setaria italica* or synonym *Panicum italicum*), Picture 1-4. Millet are important crop species in developing countries. It is a gluten free cereals. As we know "gluten free" foods have become incredibly popular in recent years as many people recognize the fact that they simply feel healthier by eliminating the 3 grains containing gluten (wheat, rye and barley). Millet is one of the most important drought-resistant crops and the 6th cereal crop in terms of world agriculture production. Also, millet has resistance to pests and diseases, short growing season, and productivity under drought conditions, compared to major cereals (Devi et al., 2011). Millet grains



Picture 1. A growth cycle of foxtail millet plant on a white background. 281123230



Picture 2. Common millet



Picture 3. Foxtail millet



Picture 4. *Setaria* millet
Chromosome number: $2n=18$

are now receiving specific attention from developing countries in terms of utilization as food and from some developed countries in terms of its good potential in the manufacturing of bioethanol and biofilms (Li et al., 2008).

Millet is one of the oldest domesticated diploid C4 Panicoid crop, having a short life cycle, and an inbreeding nature. Millet has characteristics that classify it as an excellent model for examine several aspects of the architectural, evolutionary and physiological importance of crops, especially biofuel crops. Millet is a staple crop used extensively for food and fodder in certain parts of Asia and Africa. In its long history of cultivation, it has adapted to arid and semi-arid areas of Asia, North Africa, South and North America. Millet would be useful as bioenergy grass species (Glamočlija et al., 2015; Popović et al., 2018). Vast quantities of agricultural and agro-industrial residues that are generated as a result of a diverse agricultural process represent a valuable and rich energy resource. Unuse of produced biomass in large quantities yearly results in a huge loss of potential valuable and nutritional materials which when processed, could contribute a good seed yield, and a variety of chemicals for humans and animals alike. Biomass currently contributes about twenty five percent of the world energy requirements, which is equivalent to twenty million oil barrels of fuel per day. It is currently the leading economic force are of Brazil and the United States where biomass contributes three percent of their total energy consumption. Millet can be used as a quick growing catch crop, planted into corn and sorghum stubble fields. It is well planted in combination with cowpea or soybeans (Glamočlija et al., 2015). It has one of the lowest water requirements then any cereal, and could be useful in low-input sustainable systems. Early sowing plants give the largest amount of biomass.

Agro-technology has a significant effect on plant productivity. Traditional farmers valued millet for its nutritional content and health promoting properties, its ability to grow in low input conditions as well as its tolerance to extreme environments, especially drought. In a world facing limited natural resources and climate change, these crops hold tremendous potential as valuable instruments in the New Green Revolution (Glamočlija et al., 2015; Popović, 2015; Popović et al., 2018; 2019). Hopefully germplasm resources combined with modern genomic tools will help acceleration exploitation of biodiversity. The aim of this study was to show millet production in the world and determine its significance and applicability considering that he owns great technological quality of grain.

MATERIAL I METODS

This paper analyses the millet production parameters in the world during the period from 2016-2018. The research is based on the available data already existing in related statistical publications. Data from FAO 2020 were used (<http://faostat.fao.org/>). For the calculation included in this study we used a basic statistical method comprising of the following for standard deviation. All results are presented in tables and pictures.

RESULTS AND DISCUSSION

In the tested period 2016-2018, cereals (maize, wheat, rice, barley, sorghum, oats millet and buckwheat) occupied an area of 721.96 million hectares, producing about 2,878.24 million tons of grains (Table 1). The largest areas were under wheat (217.27 mill. ha), followed by maize (195.50 mill. ha), rice (165.37 mill. ha), sorghum (48.09 mill. ha), barley (43.28 mill. ha), millet (31.90 mill. ha), oats (9.83 mill. ha) and buckwheat (3.34 mill. ha). In terms of area, millet ranks 6th in world grain production. World production of millet grains amounted to about 29.04 million tons on 31.90 million hectares. Average grain yield of millet in tested period is 0.9 t ha⁻¹, Table 1. Millet grain is used for human, bird and other animal consumption, but also for ethanol production, etc. Millet is one of the most important drought-resistant crops and the 6th cereal crop in terms of world agriculture production. Also, millet has resistance to pests and diseases, short growing season, and productivity under drought conditions, compared to major cereals (Devi et al., 2011). The millet annual needs for water are about 500 mm, which makes it an important crop for the areas that are too dry for maize production. Millet is known for its drought tolerance. It is tolerant to different soil types (Popović et al., 2018). Millet grains are now receiving specific attention from these developing countries in terms of utilization as food as well as from some developed countries in terms of its good potential in production of bioethanol and biofilms (Li et al., 2008). The world average production of millet grains at tested years was 3.31 mill. tons. Areas under millet record a growth trend, and vary from 30.51 mill. ha (2017) to 33.56 mill. ha (2018) (Table 1). The largest areas under millet are in India. Millet is known as ragi and mandia in the Bastar region of Chhattisgarh and it offers both nutritional and livelihood security for human beings and also feed security for diverse livestock populations of dry-land of rural India regions (Pradhan et al., 2010).

Table 1. Growing area, production and yield of the most common cereals [FAO 2020]

Plant	Year	Maize	Wheat	Rice	Barley	Sorghum	Oats	Millet	Buck-wheat	Total
World										
Area, mill. ha	2016	195.6	219.10	162.9	48.19	46.13	9.49	31.64	3.02	707.07
	2017	197.2	218.42	166.1	48.16	41.56	10.16	30.51	3.99	716.10
	2018	193.7	214.29	167.1	47.93	42.14	9.85	33.56	3.01	742.72
Average		195.5	217.27	165.37	43.28	48.09	9.83	31.90	3.34	721.96
Std. Dev.		1.75	2.60	2.19	2.49	0.14	0.34	1.54	0.56	18.53
Yield, t/ha	2016	5.76	3.42	4.16	3.03	1.38	2.49	0.87	1.01	22.12
	2017	5.89	3.54	4.64	3.09	1.39	2.57	0.90	1.00	24.69
	2018	5.92	3.43	4.68	2.95	1.41	2.34	0.92	0.97	24.04
Average		5.86	3.46	4.49	1.39	3.02	2.47	0.90	0.99	23.62
Std. Dev.		0.09	0.07	0.29	0.02	0.07	0.12	0.03	0.02	1.34

Production, mill. t	2016	1126.9	748.4	751.9	145.9	63.7	23.65	27.71	3.06	2791.21
	2017	1164.4	773.5	769.8	149.1	57.7	26.11	28.37	3.97	2955.10
	2018	1147.6	734.1	782.0	141.4	59.3	23.05	31.03	2.91	2921.40
Average		1146.3	751.9	767.9	60.24	145.5	24.27	29.04	3.31	2878.24
Std. Dev.		18.78	19.9	15.14	3.07	3.8	1.62	1.76	0.57	75.37
Serbia										
Plant	Year	Maize	Wheat	Ray	Barley	Sorghum	Oats	Millet	Total	
Area, 000 ha	2016	1010.01	595.12	4.89	91.53	2.62	27.54	0.106	1731.82	
	2017	1002.32	556.12	4.67	84.69	2.59	28.54	0.129	1679.26	
	2018	901.75	643.08	4.74	105.74	2.61	26.11	0.086	1749.54	
Average		971.36	598.11	4.83	93.99	2.61	49.20	0.110	1720.20	
Std. Dev.		60.41	43.56	0.08	10.74	0.02	36.66	0.02	36.55	
Yield, t/ha	2016	7.30	4.85	2.90	4.32	3.05	2.95	0.98	26.35	
	2017	4.01	4.09	2.41	3.61	3.06	2.44	1.33	17.95	
	2018	7.72	4.57	2.83	3.88	3.07	2.86	1.33	26.26	
Average		6.34	4.50	2.71	3.94	3.07	2.75	1.21	23.52	
Std. Dev.		2.03	0.38	0.27	0.36	0.01	0.27	0.20	4.82	
Production, t	2016	7376.74	2884.54	14.20	395.50	7.99	81.34	104.00	10864.31	
	2017	4018.70	2275.62	11.25	305.49	7.94	69.54	172.00	6860.54	
	2018	6964.77	2941.60	13.42	410.14	7.97	74.71	114.00	10526.61	
Average		6120.07	2700.59	12.96	370.38	7.97	75.20	130.00	9417.15	
Std. Dev.		1931.46	369.14	1.53	56.67	0.03	5.92	36.72	2220.52	

Millets are placed as a single important commodity in the North American and European food-basket at the present time, but its their importance as an ingredient in multi-grain food and gluten-free cereal products has been highlighted. However, in many African and Asian areas, millets serve as a major food component and various traditional foods and beverages, such as bread (fermented or unfermented), porridges, and snack foods are made of millet, specifically among their societies non-affluent segments (Chandrasekara and Shahidi, 2011a; Chandrasekara et al., 2012). The Serbia, at tested years, average yield of millet grains was 1.2 t ha⁻¹ and production was 130 tons. Areas under millet varied from 86 ha (2018) to 129 ha (2017), Table 1.

Technological quality of millet. In addition to its nutritive value, several potential health benefits of millet have been reported: preventing cancer and cardiovascular diseases, reducing tumor incidence, lowering blood pressure, risk of heart disease, cholesterol and rate of fat absorption, delaying gastric emptying, and supplying gastrointestinal bulk have been reported for millet (Truswell, 2002; Gupta et al., 2012). Millet grains, before consumption and for preparing of food, are usually processed by commonly used traditional processing techniques include decorticating, malting, fermentation, roasting, flaking, and grinding to improve their edible, nutritional, and sensory properties.

Millet grain contains 364 kCal Energy, polysaccharides, proteins and lipids. Their grain content varies depending on the genotype, environmental conditions, location and production technology. Millet grain contains 12-13% protein, 3.5% fat, 64% starch, crude fiber 5.2%, ash 3.1-4%, Ca 8 mg, Fe 2.9 mg. Millet sprouts are rich in B-complex vitamins. Niacin (vitamins B₃), which is the main ingredient (0.41%), is accompanied by vitamins B₁-thiamin 0.41 mg and vitamin B₂-riboflavin (0.28 mg), tab.2.

*Table 2. Nutrient composition of cereals
(per 100 g edible portion, 12% moisture)*

Food**	Protein*	Fat	Ash	Grude fiber	Carho-hydrate	Energy	Ca	Fe	Thia-min	Ribo-flavin	Niacin
Crops	g					kcal	mg				
Maize	9.2	4.2	1.2	2.8	73.0	358	26.0	2.7	0.38	0.20	3.60
Wheat	11.6	2.0	1.6	2.0	71.0	349	30.1	3.5	0.41	0.10	5.10
Rice	7.9	2.7	1.3	1.0	76.0	362	33.1	1.80	0.41	0.04	4.30
Sorghum	10.4	3.1	1.6	2.0	70.7	329	25.0	5.4	0.38	0.15	4.34
Common millet	12.5	3.5	3.1	5.2	63.8	364	8.0	2.9	0.41	0.28	4.50
Foxtail Millet	11.2	4.0	3.3	6.7	63.2	351	31.0	2.8	0.59	0.11	3.21
Little millet	9.7	5.2	5.4	7.6	60.9	329	17.0	9.3	0.30	0.10	3.20

* All values except protein are expressed on a dry weight basis. Sources: Hulse et al. (1980); United States National Research Council/National Academy of Sciences (1982); USDA/HNIS (1995); FAO (1995).

** Saleh et al., 2013

Millet has great nutritional value, does not contain gluten and is easily digested (Hulse et al., 1980). Nutritional value of cereal grains as animal feed is shown in Table 3. The digestible energy of millet is about 2665 kcal kg⁻¹. Millet contains about 89% dry matter, 12% protein, total digestible nutrients about 61%, Ca 0.12% and about 0.46% P, Table 3. Environmental conditions have important effects on production of quality grain of millet (Popovic et al., 2017; 2018). Grain quality of millet is a comprehensive trait, including nutritional quality as well as cooking and eating quality (Suman et al., 2015). The quality of millet grains is significantly affected by the choice of variety / genotype. Another major environmental factor that affected grain quality of millet was precipitation. At different growth stages, precipitation of July (booting-heading stage) showed the greatest effect on the grain quality of millet. For millet, the stage when the fructification organ of foxtail millet is completely developed and ready to be filled is period when water-consuming is largest. In this stage, if there is sufficient water and smooth transport of nutrients, the ear node will quickly extend the flag leaf and the ear can be fully developed, which is conducive to the formation of high-quality foxtail millet with high protein and fat content (Zhao et al., 2002).

Table 3. Nutritional value of cereal grains as animal feed

Food	Dry matter (%)	Protein (%)		TDN*	Energy (kcal/kg)		Ca (%)	P (%)
		Total	Digestible		Digestible	Metabolizing		
Maize	89.12	9.21	6.82	81	3571	2928	0.12	0.31
Wheat	89.21	13.04	10.12	78	3449	2820	0.50	0.40
Barley	90.14	8.72	6.92	79	3483	–	0.06	0.33
Sorghum	87.15	15.21	7.33	86	3772	3093	0.12	0.44
Oats	89.24	11.84	8.85	68	2998	2458	0.10	0.35
Millet	89.05	11.91	5.15	61	2665	2185	0.12	0.46

* TDN – Total Digestible Nutrients; Source: Somani i Taylor 2003.

The precipitation at the other growth stages had less effect on the grain quality of foxtail millet. Diurnal temperature range was also an important environmental factor affecting grain quality of foxtail millet. At different growth stages, the diurnal temperature range of July-September (booting, heading, and grain filling stages) showed greater effects on the grain quality of millet. This period is critical for the formation of grain quality of millet, when a large diurnal temperature range is conducive to the formation and accumulation of starch, fat, protein and other nutrients in the grain of foxtail millet. Owing to warmer daytime temperatures, photosynthetic enzyme activity increases in crops, leading to an enhancement of photosynthesis. The temperature is relatively low at nighttime, therefore the respiratory enzyme activity decreases and respiration is attenuated. This results in higher synthesis and lower consumption, which favors the formation, accumulation, and transformation of nutrients in crop grains, thereby contributing to the accumulation of secondary metabolites (Zhao and Li, 2005; Li et al., 2011). Nutritional quality of food is a key element in maintaining human overall physical well-being because nutritional well-being is a sustainable force for health and development and maximization of human genetic potential. Therefore, for solving the problem of deep-rooted food insecurity and malnutrition, dietary quality should be taken into consideration (Singh and Raghuvanshi, 2012). Millets are also rich sources of phyto-chemicals and micronutrients (Mal et al., 2010; Singh et al., 2012). Millet protein characterization showed that its protein concentrate is a potential functional food ingredient and the essential amino acid pattern suggests possible use as a supplementary protein source to most cereals because it is rich in lysine (Mohamed et al., 2009).

Millet is also of great importance for energy purposes. In order to improve energy security from the aspect of environmental protection, highly developed countries introduce programs production of alternative biofuels methane, ethanol and biodiesel from products of plant origin. From alternative biofuels in application can be found: methanol, biomethanol, bioethanol, biodiesel, natural gas, hydrogen, etc. The most common raw materials for biomass from agriculture are: sugar cane, sugar beet, sugar sorghum, maize, wheat, barley, millet, buckwheat, oilseed rape, sunflower, flax, pota-

toes, olives, palm trees as well as the remains of forest masses, some types of waste (municipal and secondary; etc.). The main advantages of biofuels are, that it is a renewable and inexhaustible source of energy-fuel, which emits less pollution into the atmosphere than conventional fuel. In addition, these fuels are CO₂ neutral, which means, they broadcast, but also consume CO₂. Main agricultural product, grain is used in the diet as a health safe product, while for obtaining biofuels biomass can also be used. Biofuels, derived from biomass, have the potential to replace petroleum fuels, thus preserving the environment and sustainability but also reduce fuel and emission costs. The priority is to get the basic raw materials and develop the process of biofuel production from renewable sources (Petrović et al., 2011; Popović et al., 2018) from crop biomass. Millet is of great importance in nutrition and medicine. Zang et al. (2014) points out that millet has antioxidant and antiproliferative properties. The bound fraction contributed about 65% of the total phenolic content of the tested millet varieties. Millet is also rich in bioactive phytochemicals, including ferulic acid, chlorogenic acid, syringic acid, caffeic acid and p-coumaric, suggesting its potential benefits to human health.

CONCLUSION

Millet is of great importance in nutrition, medicine also of great importance for energy purposes, in production biofuels. Millet has great nutritional value, does not contain gluten and is easily digested. Environmental conditions have important effects on production of quality grain of millet. Millet grain contains protein, fat, starch, crude fiber, ash, Ca, Fe, and are rich in B-complex vitamins; niacin (vitamins B₃), thiamin (vitamins B₁) and vitamin B₂ – riboflavin. In addition to their nutritive value, helps prevent cancer and cardiovascular diseases, reduce tumor incidence, lower blood pressure, the risk of heart disease, cholesterol and rate of fat absorption have been reported for millet.

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**Поповић В.¹, Икановић Ј.², Рајичић В.³, Ксенија Мачкић⁴,
Љубичић Н.⁵, Костић М.⁴, Радовић М.⁵, Шарчевић-Тодосијевић Љ.⁶**

¹ Институт за ратарство и повртарство, Нови Сад, Србија;

² Универзитет у Београду, Пољопривредни факултет у Београду, Србија;

³ Универзитет у Нишу, Пољопривредни факултет, Крушевац, Србија;

⁴ Универзитет у Новом Саду, Пољопривредни факултет, Нови Сад, Србија;

⁵ Биосенс Институт, Нови Сад, Србија;

⁶ ВМСШС "Висан", Београд, Србија;

* Одговорни аутор: vera.popovic@ifvcns.ns.ac.rs

ТРЕНД ПРОИЗВОДЊЕ ПРОСА – *Panicum miliaceum* L. У СВЕТУ. ЗНАЧАЈ ПРОСА У ИСХРАНИ И ЗА БИОЕНЕРГИЈУ

Извод

Циљ ове студије био је да се испита продуктивност проса (*Panicum miliaceum* L.; *Poaceae*) у свету и прикаже његов значај у исхрани и у индустрији. Просо има висок принос зрна и важан је извор протеина у храни и има висок принос биомасе због чега има велики значај у производњи биоенергије. Приоритет је набавити сировине и развити процес производње биогорива на економичан начин. Просо има најмање потребе за водом од осталих жита и значајан је усев у одрживим системима. Зно проса богато је са гвожђем, калцијумом и комплексом витамина Б (Б₁, Б₂, Б₃). Поред његове храњиве вредности, помаже у превенцији карцинома и кардиоваскуларних болести, смањењу инциденције тумора, сни-жавању крвног притиска, ризику од болести срца, холестерола и брзини апсорпције масти.

Кључне речи: *просо, производња, храњива вредност, биогорива*



Vladimir Filipović Ph.D.¹, Ivana Filipović M.Sc.², Milica Nićetin Ph.D.¹,
Biljana Lončar Ph.D.¹, Violeta Knežević Ph.D.¹, Jelena Filipović Ph.D.²

¹ University of Novi Sad, Faculty of Technology, Bul. cara Lazara 1,
Novi Sad, Serbia

² SP Laboratory, Industrijska 3, Bečej, Serbia

³ University of Novi Sad, Institute for Food Technology, Bul. cara Lazara 1,
Novi Sad, Serbia

E-mail: vlada.filipovic@gmail.com

FOOD SAFETY ASPECTS OF OSMOTIC DEHYDRATION PROCESS

Abstract

Osmotic dehydration process represents partial removal of water from food, due to immersion in high osmotic solutions concentrations, which are proven to affect parameters of microbiological growth in treated materials. The goal of this research was to present safety and production hygiene aspects of osmotic dehydration process of different raw materials. Obtained results have shown that both food safety and process hygiene criteria were satisfied in the process of osmotic dehydration of all tested raw materials. Statistically significant decrease of all tested microorganisms occurred after the osmodehydrating process on all osmodehydrated raw materials, while molasses as an osmotic solution has shown better results in microorganisms reduction than aqueous osmotic solution.

Key words: *food safety, osmotic dehydration, sugar beet molasses, Escherichia coli, Listeria monocytogenes, Salmonella spp*

INTRODUCTION

Osmotic dehydration is an important food preservation method in the food processing industry due to many advantages including mild processing temperatures, base waste materials and low energy requirements (El-Aouar et al. 2006)

High osmotic solution concentrations is proven to affect parameters of microbiological growth in osmodehydrated materials. The use of high concentrated osmotic solutions is recommended in effort of minimizing microorganisms adhesion and growth inhibition in final product (Gianotti et al., 2001).

Microorganisms encounter osmotic stress during a shift to a hyperosmotic solution or due to dehydration. Changes in osmotic pressure pose significant stress on bacterial cells by causing dehydration and shrinkage under hypertonic environments (Csonka, 1989; Sleator and Hill, 2002).

Osmodehydrated biological materials are more stable during storage than untreated due to lowered water activity values, via water loss in the osmotic dehydration process (Tortoe 2010).

According to Regulation of general and special conditions of food hygiene at any stage of production, processing and transport, Official Gazette of RS 72/2010 and 62/2018, food safety and production hygiene criteria put focus on *Salmoenlla* spp., *Escherichia coli* and *Listeria monocytogenes*.

Exposure of *Salmonella* spp. to osmotic stress results in the loss of water that causes considerable shrinkage of the microbial cell due to water loss, with a consequent increase in concentrations of all the intracellular metabolites. Sudden plasmolysis may result in the inhibition of a variety of physiological processes, ranging from nutrient uptake to DNA replication (Burgess et al. 2016).

Escherichia coli encodes many mechanisms to withstand osmotic and desiccation stress and can exhibit long-term survival in challenging environments. It is important to be cognisant of its tolerance to low water activity values and therefore its potential to survive different preservation methods (Burgess et al. 2016), such as osmotic dehydration.

Listeria monocytogenes, have evolved to cope with increased osmotic pressure by the intracellular accumulation of compatible solutes and by adaptive cell envelope and proteome modifications (Csonka 1989; Sleator and Hill 2002). In *Listeria monocytogenes*, a number of proteins have been shown to be involved in salt stress response (Sleator et al. 2003). This includes transporters for the uptake of compatible solutes, proteins for cell wall modification, regulatory proteins, as well as general stress proteins (Burgess et al. 2016).

Sugar beet molasses is an alternative medium for osmotic dehydration, with the advantages of high dry matter (80%) and specific nutrient content. The specific chemical composition and high content of solids provide high osmotic pressure of the osmotic solution, providing the base for reduction of present microorganisms in dehydrating raw material (Filipović et al., 2018).

The goal of this research is to present safety and production hygiene aspects of osmotic dehydration process of different raw materials.

OSMOTIC DEHYDRATION PROCESS

Osmotic dehydration has shown potential for obtaining food products of improved characteristics, where water from raw material is removed at low processing temperatures where quality of final product is upgraded due to dehydrated product solid gain, which is specific for osmotic dehydration process (Fito et al., 1998).

Osmotic dehydration is mainly used as primary stage in complete process of high water content foods conservation, which is followed by freezing, lyophilization (Haw-

kes and Flink, 1978), vacuum drying (Dixon and Jen, 1977) microwave heating (Nelson and Datta, 2001), convective drying (Mandala et al., 2005).

Osmotic dehydration process by its mechanism preserves quality characteristics of initial raw material, but also changes and enhances nutritive characteristics of dehydrated products, due to specific osmotic dehydration secondary process mass transfer – solid gain (Filipović and Lević, 2014).

Solid gain leads to the changes of sensory and chemical profile of osmotically dehydrated material in comparison to initial raw material (Nićetin et al., 2013).

Osmotic dehydration process statistically significantly reduces initial number of present microorganisms and increase of process temperature leads to further reduction (Filipović et al., 2012).

MICROBIOLOGICAL METHODES

Standard methods used for food safety and production hygiene aspects of osmotic dehydration process are, as following:

Enumeration of total number of bacteria:

– ISO 4833-1:2013: Microbiology of the food chain – Horizontal method for the enumeration of microorganisms – Part 1: Colony count at 30 degrees C by the pour plate technique

Enumeration of *Enterobacteriaceae*:

– ISO 21528-2:2017: Microbiology of the food chain – Horizontal method for the detection and enumeration of *Enterobacteriaceae* – Part 2: Colony-count technique

Enumeration of *Escherichia coli*:

– ISO 16649-2:2001: Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of beta-glucuronidase-positive *Escherichia coli* Colony-count technique at 44 degrees C using 5-bromo-4-chloro-3-indolyl beta-D-glucuronide

Enumeration of *Salmonella* spp:

– ISO 6579-1:2017: Microbiology of the food chain – Horizontal method for the detection, enumeration and serotyping of *Salmonella* – Part 1: Detection of *Salmonella* spp.

Enumeration of *Listeria monocytogenes*:

– ISO 11290-2:2017: Microbiology of the food chain – Horizontal method for the detection and enumeration of *Listeria monocytogenes* and of *Listeria* spp. – Part 2: Enumeration method.

SAFETY AND PRODUCTION HYGIENE ASPECTS OF OSMOTIC DEHYDRATION PROCESS

Food safety aspects of osmotic dehydration process will be discussed on treated material of plant and animal origin.

Wild garlic samples for analysis were prepared according to the procedure described in Filipović et al. (2018). Average number and standard deviation of tested microorganisms of raw and wild garlic osmotically dehydrated in two osmotic solutions are shown in table 1.

Table 1. Microbiological profile of raw and osmodehydrated wild garlic (Flipović et al., 2018)

	Raw wild garlic	Wild garlic osmodehydrated in aqueous osmotic solution	Wild garlic osmodehydrated in molasses
Food safety criteria			
<i>Salmonella</i> spp. (negative/25g)	Negative	Negative	Negative
Production hygiene criteria			
Total number of microorganisms (cfu/g)	$(22 \pm 2) \cdot 10^5$ ^a	$(11 \pm 1) \cdot 10^3$ ^b	$(1 \pm 0) \cdot 10^4$ ^b
<i>Enterobacteriaceae</i> (cfu/g)	$(64 \pm 4) \cdot 10^2$ ^a	$<10 \pm 0$ ^b	$<10 \pm 0$ ^b
<i>Escherichia coli</i> (cfu/g)	$(11 \pm 1) \cdot 10^2$ ^a	$<10 \pm 0$ ^b	$<10 \pm 0$ ^b

^{a-b} Different letters in superscript in the same table column indicate on statistically significant difference between values, at level of significance of $p < 0.05$ (based on post hoc Tukey HSD test)

The results of the microbiological analysis of *Salmonella* spp. had shown that *Salmonella* spp. was not detected in all tested samples (raw and osmodehydrated). The results of the *Salmonella* spp. analysis indicate that all tested wild garlic samples satisfy food safety criteria, according to Commission Regulation (EC) No 2073/2005 on microbiological criteria for foodstuffs, (2005).

Regarding production hygiene criteria of the osmotic dehydration of wild garlic process, the results of total number of microorganisms, *Enterobacteriaceae* and *Escherichia coli*, have shown that all microorganisms statistically significantly decreased after the process of osmotic dehydration in both osmotic solutions.

Pork meat samples were prepared following procedure described by Filipović et al. (2012).

In table 2. average number and standard deviation of selected microorganisms before and after pork meat osmotic dehydration in two osmotic solutions, are shown. It can be seen that *Salmonella* spp. was not detected in all tested samples (fresh and osmodehydrated pork meat in both solutions), indicating that all samples satisfy food safety criteria. The results of total number of microorganisms, *Enterobacteriaceae* and

Escherichia coli, have shown that all tested microbiological parameters statistically significantly decreased after the process of osmotic dehydration in both osmotic solutions, satisfying production hygiene criteria. Increased process temperature decreased numbers of all tested microorganisms.

Table 2. Average number of selected microorganisms before and after pork meat osmotic dehydration process (Filipović et al., 2012)

	Fresh meat cut in laboratory	Dehydrated meat in aqueous osmotic solution		Dehydrated meat in molasses	
		4°C	22°C	4°C	22°C
Temperature of the process:					
Average numbers and standard deviation ($\cdot 10^2$) of:					
Food safety criteria					
<i>Salmonella</i> spp (negative/10 g)	0.00 ±0.00 ^a	0.00 ±0.00 ^a	0.00 ±0.00 ^a	0.00 ±0.00 ^a	0.00 ±0.00 ^a
Production hygiene criteria					
Total number of microorganisms (cfu/g)	4666.67 ±577.35 ^a	1833.33 ±577.35 ^b	2166.67 ±763.76 ^b	1833.33 ±288.67 ^b	1166.67 ±288.67 ^b
<i>Enterobacteriaceae</i> (cfu/g)	143.33 ±5.77 ^a	13.33 ±5.77 ^b	2.00 ±1.00 ^c	11.67 ±2.89 ^b	1.67 ±1.15 ^c
<i>Escherichia coli</i> (CFU/g)	1.30 ±0.26 ^a	0.47 ±0.06 ^b	0.00 ±0.00 ^c	0.37 ±0.06 ^b	0.00 ±0.00 ^c

^{a-c} Different letters in the superscript of the same table row indicate on statistically significant difference between values, at level of significance of $p < 0.05$ (based on post hoc Tukey HSD test)

Preparation of chicken meat samples were done by procedure described by Filipović et al. (2019).

In table 3 average number and standard deviation of selected microorganisms that were inoculated to the fresh meat and subjected to osmotic dehydration in two osmotic solutions of different concentrations, are shown. Since the methodology of the research implied artificial inoculation of fresh chicken meat, and then analysis of the survivability of selected microorganisms throughout the osmodehydration process, safety and production hygiene aspects can not be analysed by Commission Regulation (EC) No 2073/2005 on microbiological criteria for foodstuffs, (2005) defined limits.

Number of all tested microorganisms statistically significantly decreased after the osmotic dehydration process in both osmotic solutions, and at all tested concentrations.

Osmotic solution concentration statistically significantly affected reduction of present numbers of all tested microorganisms, statistically significantly decreasing number of microorganisms on osmodehydrated chicken meat with increasing osmotic solution concentrations.

Obtained numbers of all tested microorganisms on osmodehydrated chicken meat were statistically significantly lower in process where molasses was used in comparison to the aqueous osmotic solution.

Table 3. Average number of selected microorganisms before and after inoculated chicken meat osmotic dehydration process (Filipović et al., 2019)

		<i>Escherichia coli</i> (cfu/g)	<i>Listeria monocytogenes</i> (cfu/g)	<i>Salmonella</i> spp. (cfu/g)	<i>Enterobacteriaceae</i> (cfu/g)
Raw chicken meat		(475.00± 3.53) · 10 ^{2 a}	(440.00± 10.00) · 10 ^{2 a}	(460.00± 10.00) · 10 ^{2 a}	(965.00± 15.00) · 10 ^{2 a}
Chicken meat dehydrated in AOS					
Aqueous osmotic solution concentration (% d.m.)	45	(49.50± 1.50) · 10 ^{2 b}	(11.00± 1.00) · 10 ^{2 b}	(190.00± 10.00) · 10 ^{2 b}	(265.00± 5.00) · 10 ^{2 b}
	52.5	(43.00± 2.00) · 10 ^{2 c}	(5.00± 1.00) · 10 ^{2 c}	(160.00± 10.00) · 10 ^{2 c,d}	(225.00± 5.00) · 10 ^{2 c}
	60	(19.00± 1.00) · 10 ^{2 d}	(3.50± 0.50) · 10 ^{2 c}	(110.00± 10.00) · 10 ^{2 e}	(145.00± 5.00) · 10 ^{2 e}
Chicken meat dehydrated in sugar beet molasses					
Molasses concentration (% d.m.)	60	(17.50± 1.50) · 10 ^{2 d}	(6.00± 0.00) · 10 ^{2 b,c}	(175.00± 15.00) · 10 ^{2 b,c}	(215.00± 5.00) · 10 ^{2 c}
	70	(14.50± 1.50) · 10 ^{2 d,e}	(2.00± 0.00) · 10 ^{2 c}	(140.00± 10.00) · 10 ^{2 d}	(185.00± 5.00) · 10 ^{2 d}
	80	(12.00± 1.00) · 10 ^{2 e}	(1.00± 0.00) · 10 ^{2 c}	(104.00± 6.00) · 10 ^{2 e}	(130.00± 10.00) · 10 ^{2 e}

^{a-c} Different letters in the superscript of the same table column indicate on statistically significant difference between values, at level of significance of $p < 0.05$ (based on post hoc Tukey HSD test)

CONCLUSION

From presented results it can be concluded that:

- Both food safety and process hygiene criteria were satisfied in the process of osmotic dehydration of wild garlic, chicken and pork meat;
- Process of osmotic dehydration has led to statistically significant decrease of all tested microorganisms (*Salmonella* spp., *Escherichia coli*, *Listeria monocytogenes*, *Enterobacteriaceae* and total number of microorganisms) on all osmodehydrated raw materials;
- Sugar beet molasses has shown better results in microorganisms reduction than aqueous osmotic solution, during process of osmotic dehydration of all raw materials.

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**Др Владимир Филиповић¹, М.Сц. Ивана Филиповић²,
Др Милица Нићетин¹, Др Биљна Лончар¹, Др Виолета Кнежевић¹,
Др Јелена Филиповић³,**

¹ Универзитет у Новом Саду, Технолошки факултет, Бул. цара Лазара 1,
Нови Сад, Србија

² СП Лабораторија, Индустијска 3, Бечеј, Србија

³ Универзитет у Новом Саду, Научни институт за прехранбене технологије,
Бул. цара Лазара 1, Нови Сад, Србија
E-mail: vlada.filipovic@gmail.com

ЗДРАВСТВЕНО-БЕЗБЕДНОСНИ АСПЕКТИ ОСМОТСКИ ДЕХИДРИРАНЕ ХРАНЕ

Сажетак

Осмотска дехидратација представља процес делимичног уклањања воде из прехранбених сировина, услед потапања у осмотске растворе високих концентрација, што је доказано да утиче на параметре раста микроорганизама у осмодехидрираним материјалима. Циљ овог истраживања је приказивање аспеката здравствене безбедности и хигијене процеса осмотске дехидратације различитих сировина. Приказани резултати су показали да су задовољена оба критеријума, здравствене безбедности и хигијене процеса, осмотске дехидратације свих испитиваних сировина. Дошло је до статистички значајног смањења свих испитиваних микроорганизама након процеса осмотске дехидратације свих сировина, док је меласа, као осмотски раствор, показала боље резултате у смањењу броја микроорганизама у поређењу са воденим осмотским раствором.

Кључне речи: *здравствена безбедност хране, осмотска дехидратација, меласа шећерне репе сремуш, меласа шећерне репе, микробиолошка безбедност, Escherichia coli, Listeria monocytogenes, Salmonella spp*



**Snežana Đorđević¹, Ljubica Šarčević-Todosijević², Vera Popović³,
Marija Perić², Ljubiša Živanović⁴, Nikola Đorđević¹, Aleksandar Stevanović²**

¹ Biounik, Belgrade, Serbia;

² High Medical – Sanitary School of Professional Studies "Visan", Belgrade, Serbia;

³ Institute of Field and Vegetable Crops, Novi Sad, Serbia;

⁴ Faculty of Agriculture, University of Belgrade, Serbia;

* Corresponding author: ljsarcevic@gmail.com

HEALTH SAFE FOOD – RISK OF CARCINOGENIC SUBSTANCES

Abstract

Food is a substance must be taken into the human organism in order to preserve homeostasis. Foods can be of plant, animal and mineral origin, and by chemical composition belong to carbohydrates, proteins, fats, vitamins and minerals. However, various toxic and carcinogenic substances can be found in food, which originate from natural sources, the environment, or are formed during the food processing process. In the production of health safe food, it is extremely important to reduce their amount in food or eliminate them completely. In this paper, carcinogenic substances, which can be found in food and pose a risk to food safety are considered.

Key words: *food safety, carcinogenic substances, carcinogenic effect, pollutants*

INTRODUCTION

Food is a substance that must be taken into the human organism in order to preserve homeostasis. Food health monitoring is the responsibility of the World Food Programme and the Food and Agriculture Organization (FAO) within the United Nations. The main goal of these organizations is to improve food production and the elimination of hunger in the world, and one of the basic human rights is the right to food. Foods can be of plant, animal and mineral origin, and according to their chemical composition, they belong to carbohydrates, proteins, fats, vitamins and minerals. Plant-based food products form the basis of food chains in almost all ecosystems on the planet and have exceptional nutritional value and positive impact on human health, thanks to their

high content of proteins, vitamins, flavonoids, phytosterols, dietary fibers and antioxidants (antimutagenic, anticancer and anti-inflammatory effects). Among foods of plant origin, cereals are a very important source of starch and other carbohydrates, which is why they are used in human and animal nutrition. Cereals (family Poaceae) are a source of minerals such as manganese, magnesium, copper, phosphorus, potassium and zinc, which are important for the proper functioning and development of body tissues, glands and enzymes. Regular intake of cereals helps prevent digestive tract diseases, hypertension, cardiovascular disease and cancer (Popović, 2001; Popović et al., 2015; Šarčević-Todosijević et al., 2019; Kolarić et al., 2019; Živanović et al., 2017). However, on the other hand, it has been proven that certain substances from food can play a significant role in certain pathological processes in the human body, and even in carcinogenesis. Carcinogenic chemicals that can be found in food, come from natural sources, the environment, or are formed during the food processing process. Also, a significant number of chemical compounds are added to food in order to improve the smell, taste, color or extend the shelf life. These substances can have mutagenic and carcinogenic effects in the human organism.

In this paper, carcinogenic substances, which can be found in food and pose a risk to food safety are considered.

CARCINOGENIC FOOD CONTAMINANTS

Cancer is one of the leading causes of death in the world. During malignant transformation, cells undergo morphological and functional changes, which enable them to acquire new properties. The most significant new trait acquired by a malignant cell is immortality. Thanks to the new properties, malignant cells make maximum use of nutritional and energy resources, adapting the surrounding tissues to their needs, overcoming them in number and finally occupying new organs and tissues for their growth. Experiments performed on cells transformation *in vitro*, using DNA isolated from a cancer cell, unequivocally indicated the genetic mechanisms of carcinogenesis. However, the complex changes that occur during cell transformation cannot be the result of just one gene mutation or altered activity of just one gene. Based on empirical data confirmed in a number of experimental models, it has been concluded that mutation or activation of one gene is not sufficient, but may be a trigger for a cascade process, i.e. mutation or activation of a number of other genes. It is assumed that at least two or more mutations are necessary for physiologically normal cells to become malignant. There are three types of evidence for this claim: evidence based on DNA analysis from different stages of carcinogenesis; evidence based on increased expression in cell cultures and experimental animals of oncogenes, i.e. genes encoding proteins, capable of inducing carcinogenesis in a living organism; as well as evidence from epidemiology. Namely, all cancer cells have a clonal origin, and the incidence of cancer increases with age (Zimonjić et al., 1990; Marinković and Marinković, 2012).

It has been proven that certain substances from food can play a significant role in the described genesis of malignant processes in the organism. A large number of chemical compounds are added to food in order to improve the smell, taste, color or

prolong the shelf life. Various additives have a mutagenic effect, such as synthetic dyes and artificial sweeteners, while nitrites are used in the meat industry. And in the process of heat treatment of food, some natural ingredients of foods give reactive derivatives of genotoxic nature (Sofradžija et al., 2003). Carcinogenic substances can enter the food uncontrollably from the environment or they can be residues of treatments that man have carried out at different stages of food production. Carcinogenic chemicals that can be found in food, depending on their source, can be divided into: natural, such as mycotoxins derived from fungi; environmental substances such as dioxins, polycyclic biphenyls, polycyclic aromatic hydrocarbons; substances derived from food processing, such as acrylamide; cleaning agent residues (Šarkanj, 2010). Of all the known mycotoxins, aflatoxin is considered to be the greatest potential threat to human health. It is a product of the fungal species *Aspergillus flavus* and *Aspergillus parasiticus*, which are widespread in nature due to spores. These species of fungi often contaminate cereals, almonds, walnuts, peanuts, cottonseeds, and sugar cane. Their development can occur as a result of damage to food by insects, slow drying and storage in humid conditions (Đukić and Đorđević, 2004; Šumić, 2009; Živanović et al., 2017).

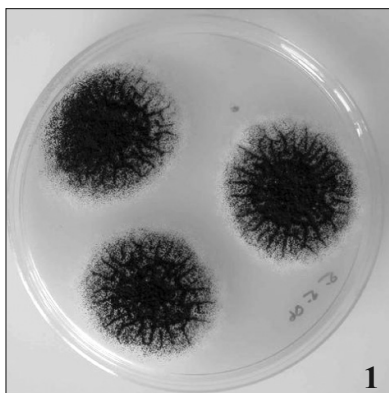


Figure 1. *Aspergillus* sp.
(source: <http://fungi.myspecies.info/file-colorboxed/945>)

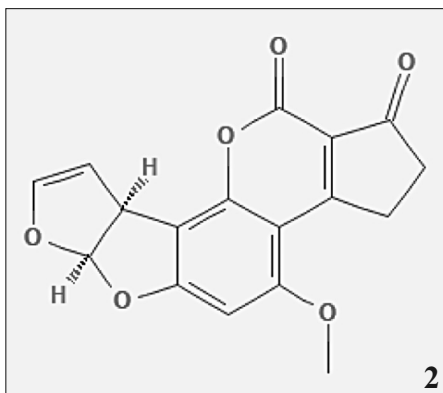


Figure 2. Aflatoxin B1
(source: <https://pubchem.ncbi.nlm.nih.gov/compound/Aflatoxin-B1>)

Aflatoxins are a mixture of related chemical compounds. The series of aflatoxins designated as B has a cyclopentane ring in the structure of molecules, which has been replaced by lactone in the G series. Three structural variations of aflatoxin molecules provide a family of eight aflatoxins, and of the eighteen toxins known to date, aflatoxin B1 is the most important in terms of presence and toxicity (Šumić, 2009). Aflatoxin B1 (AFB1) is the most carcinogenic substance of biological origin. It is found in agricultural products, cereals, coffee, rice, peanuts, pistachios, and in the organism of mammals it transforms into an active form. Based on numerous epidemiological studies conducted on experimental animals, the carcinogenic effect of AFB1 has been proven, especially on the liver. Long-term intake of AFB1 is a risk factor for the development

of primary hepatocellular carcinoma. Reduction of carcinogenicity is impossible to ensure by heat treatment of food, because it tolerates very high temperatures. Only by applying physical, chemical and biological procedures, drying cereals, primarily proper storage, chemical antifungal agents, strong acids and oxidizing agents, the amount of aflatoxins in food can be reduced. In large doses, aflatoxins are acutely toxic; cause significant liver damage, intestinal and peritoneal bleeding, which eventually leads to death. Clinical signs of acute aflatoxicosis include loss of appetite, lethargy, weight loss, neurological disorders, jaundice of mucous membranes, and convulsions (Šumić, 2009, Živanović et al., 2017). However, on the other hand, the discovery made by Conde et al. (1989) is very important. They found that metabolites of certain species of the genus *Aspergillus* can serve as cytotoxic agents, directed against the cells of some types of human carcinoma. They observed that the protein toxin restrictocin, isolated from the species *Aspergillus restrictus*, inactivates protein synthesis in eukaryotic cells by blocking the ribosome elongation cycle. This protein acts as a specific nuclease that cuts off a small fragment from the 28S rRNA in eukaryotic cells. Biochemical and biological characterization of this toxin, indicated that it is a non-glycosylated polypeptide of Mr 16836, which shows property of inhibition protein synthesis (Conde et al., 1989).

Ochratoxins are a group of close derivatives of dihydroisocoumarin, whose most toxic representative is ochratoxin A (OA). It is a colorless, crystalline compound, moderately stable, and to some extent tolerates most food processing operations. Ochratoxin A produce two genera of fungi: *Aspergillus* in tropical areas and *Penicillium* in cooler climates. Factors influencing OA production include: temperature, humidity, pH of the substrate, type of substrate, presence of competitive microflora, as well as strain of fungi (Đukić and Đorđević, 2004; Clark and Snedeker, 2007).

Ochratoxin A (OA) is a natural mycotoxin known to contaminate a variety of foods and beverages. It is found in corn, wheat, rye, barley, rice, soybean, nuts, dried fruit, wine, beer, grape juices, pork and poultry, dairy products, spices and chocolate.

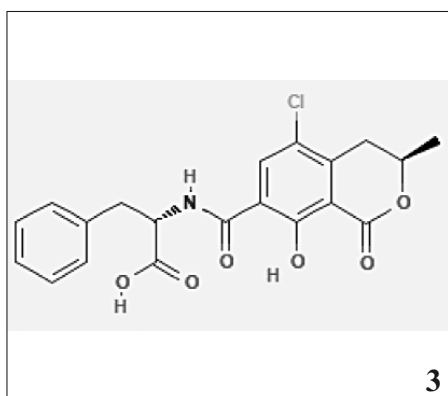


Fig. 3. Ochratoxin A
(source:<https://pubchem.ncbi.nlm.nih.gov/compound/Ochratoxin-A>)



Fig. 4. *Penicillium* sp., isolated
from natural ecosystems
(Lalević, 2009)

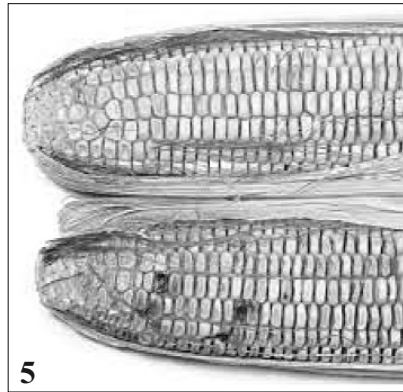


Fig. 5. Fumonisin contaminated maize
(source:https://www.who.int/foodsafety/FSDigest_Fumonisin_EN.pdf)

Ochratoxin A moves through the food chain and has been found in the tissues and organs of animals, including human blood and breast milk. OA is associated with various health risks in the organisms to which they are exposed. OA acts as a potent nephrotoxin and is associated with the development of kidney disease in livestock and the human population (Clark and Snedeker, 2007).

The results of biological tests on rodents, which were conducted within the National Toxicology Program in the USA, indicate a statistically significantly increased incidence of mammary gland tumors in female rats and kidney tumors in male and female rats given ochratoxin A orally. Liver tumors in female mice fed OA in the diet have also been observed. Although Clark and Snedeker (2007) state that no epidemiological study has yet adequately assessed the risk of developing cancer in the human population due to ochratoxins exposure, data on tumor development, derived from long-term rodents bioassays, give a good reason to study ochratoxin A and its potential impact on human health. Studies have certainly shown that OA is genotoxic and immunotoxic, although its mode of action is not fully understood. In humans, exposure to ochratoxins is most commonly associated with the kidney disease Balkan endemic nephropathy (BEN), symptoms of which include tumors of the kidney and urinary tract (Clark and Snedeker, 2007).

Fumonisin are natural toxins, produced by several species of the genus *Fusarium*. Several different types of fumonisins are known, but B1, B2 and B2 are the most toxic and major forms found in food. According to the World Health Organization (WHO) report (2018), fumonisins can have significant negative health effects on livestock and other animals. In the studied animal models, fumonisins disrupt fat metabolism, exhibit potential immunotoxicity, reducing specific and nonspecific immune response, as well as indirect mutagenicity (DNA damage). There are serious indications that fumonisins have a carcinogenic and teratogenic effect on humans, as well as that they can affect the appearance of birth defects. The fungal species *Fusarium verticillioides*, *F. proliferatum* and *F. fujikuroi*, as well as some less widespread species of the genus *Fusarium*, are common contaminants of maize, and to a lesser extent of wheat and other

cereals, included nutritious products based on said cereals. Species of the genus *Fusarium* occur worldwide, but are most common in warm climate and warm tropical areas where maize is grown. Accordingly, during 2016, high concentrations of fumonisin B1 were reported in food products, which originated from Africa, Central and South America and some countries in the Western Pacific Region (WHO, 2018). Westhuizen et al. (2008) indicate high incidences of oesophageal cancer, associated with the consumption of subsistence-grown maize by rural populations in the Eastern Cape Province of South Africa. In a joint expert assessment by the FAO and the WHO, it was found that maize and its products have the highest concentration of fumonisin B1 compared to any other cereal or products based on it (WHO, 2018).

Contaminants from the environment reach the food from the soil in which the plants grow, or from the environment in which the animals are raised or live. Dioxins are the most widespread toxic substances in the environment. They reach the environment as a consequence of human technological activities. They are carcinogenic, destroy the immune system and can cause problems in reproduction and development. They slowly decompose in the human organism and accumulate, which is especially dangerous for people who are chronically exposed to dioxins. Since dioxins accumulate in adipose tissue, the skin should be removed when consuming fish and poultry, in order to reduce the risk of poisoning. Polycyclic aromatic hydrocarbons (PAHs) are compounds that consist of two or more condensed aromatic (benzene) rings and have carbon and hydrogen atoms in their composition. They reach the food from the environment during the industrial production of food and during the preparation of food in the household. The highest concentration of PAHs was found in cereals and seafood (fishes, shellfish). Certain food processing procedures, such as smoking, drying, heat treatment (cooking/baking/grilling) of food, are usually the main sources of contamination with these substances. Studies on animals have shown that polycyclic aromatic hydrocarbons cause mutagenic and carcinogenic changes, so it is assumed that they have such an effect on humans (Cvijan, 2000; Šarkanj, 2010).

By heat treatment of food at high temperatures, certain types of toxic substances are created. Scientists have discovered high concentrations of acrylamide in food rich in starch, such as chips, french fries and bread. Numerous scientific studies have confirmed that acrylamide has neurotoxic, genotoxic and carcinogenic properties (Semla et al., 2017). Kumar et al. (2018) emphasize the detrimental effects of acrylamide on the nervous system, reproductive system, immune system, and liver.

CONCLUSION

Foods can be of plant, animal and mineral origin. Products of plant origin form the basis of food chains in almost all ecosystems on the planet and have an exceptional nutritional value and a positive impact on human health. However, it has been proven that certain substances from food, including food of plant origin, can play a significant role in certain pathological processes in the human body, and even in carcinogenesis. Carcinogenic chemicals in food can come from a variety of sources, so in the production of safe food, it is extremely important to reduce their amount in food or eliminate them completely.

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**Snežana Đorđević¹, Ljubica Šarčević-Todosijević², Vera Popović³,
Marija Perić², Ljubiša Živanović⁴, Nikola Đorđević¹, Aleksandar Stevanović²**

¹ Biounik, Beograd, Srbija;

² VZŠŠSS "Visan", Beograd, Srbija;

² Institut za ratarstvo i povrtarstvo, Novi Sad, Srbija;

⁴ Poljoprivredni fakultet, Univerzitet u Beogradu, Srbija

E-mail: ljsarcevic@gmail.com

ZDRAVSTVENO BEZBEDNA HRANA – RIZIK OD KANCEROGENIH MATERIJA

Apstrakt

Hrana je materija koju je neophodno unositi u ljudski organizam da bi se očuvala homeostaza. Životne namirnice mogu biti biljnog, životinjskog i mineralnog porekla. Međutim, u hrani se mogu naći i razne toksične i kancerogene materije, koje potiču iz prirodnih izvora, okoline, ili nastaju u toku procesa obrade hrane. U proizvodnji zdravstveno bezbedne hrane, izuzetno je važno smanjiti njihovu količinu u hrani ili ih potpuno eliminisati. U ovom radu, razmatraju se kancerogene materije, koje se mogu naći u hrani i predstavljati rizik za zdravstvenu bezbednost hrane.

Ključne reči: *zdravstveno bezbedna hrana, kancerogene materije,
kancerogeni efekat, zagađivači*



**Sonja Simić¹, Biljana Pajin ScD¹, Jovana Petrović ScD¹, Ivana Lončarević ScD¹,
Dragan Psodorov ScD², Dragana Stanisavljević ScD³,
Violeta Mickovski Stefanović ScD⁴**

¹ Faculty of Technology, Bulevar cara Lazara 1, 21000 Novi Sad, Serbia

² Colledge of Management and Business Communications, Modene 5,
21000 Novi Sad, Serbia

³ Academy of Vocational Studies Southern Serbia – Department of Agricultural
and Food Technology, 1 Ćirila i Metodija St, 18400 Prokuplje, Serbia

⁴ Institute "Tamiš" doo, Novoseljanski put 33, 26000 Pančevo, Serbia
E-mail: vikivms15@gmail.com

CHEMICAL PROPERTIES OF BISCUITS WITH THE ADDITION OF CORN GRITS EXTRUDATE ENRICHED WITH SUGAR BEET PULP

Abstract

Fine bakery products (biscuits and related products) are very common in the human diet. The main focus of the food industry is the search for inexpensive materials that are a potential source of functional ingredients. By-products of the food industry are raw materials rich in fiber and numerous biologically active components. Thus, they are interested the food industry. The chemical properties of biscuits with addition of corn grits extrudate enriched with sugar beet pulp were examined. The obtained results were processed in the Box-Behnken experimental design, and show us a significant increase in protein and dietary fiber content, as well as a decrease in fat content.

Key words: *biscuits, by-products of food industry, functional food, dietary fibers*

INTRODUCTION

Biscuits and related products take an important place in the human diet, they can be the main meal, diet product, luxury gift, as well as food for children. Biscuits consumption per capita; Europe 13,6 kg; USA 10 kg; Japan 7,5 kg and India 21 kg (Ahmad and Ahmed, 2014). Such a large presence on the market is due to: pleasing sweet taste,

a large number of variations in shape, size, taste and packaging, as well as relatively cheap production and long shelf life.

The food industry is facing a numerous challenges today. On the one hand, it is necessary to satisfy the increase of demand for food, which will not only satisfy basic needs, but will also have a positive impact on human health. Due to its chemical composition (large amounts of fat and sugar), biscuits are not considered favorable for human health. However, one should take into account the fact that the biscuit was originally made as an energy product with a long shelf life and was used in case of natural disasters. Therefore, the basic task of the modern food industry is the use of new and inexpensive raw materials that are a source of functional ingredients, and the goal is to modify the basic raw material composition and introduce nutritional components into the human diet.

In developed countries, food waste in the food industry is up to 40% (Jašić and Grujić, 2013). A large amount of waste, in addition to a large loss of valuable substances, also raises a serious problem, both from an economic and environmental point of view. Many of the by-products have the potential to be reused as raw materials in production (Mirabella and Sala, 2014). The food industry is facing a numerous challenges today. It has the task of satisfying the basic needs for food, and on the other hand, that the obtained products have a favorable impact on human health and that they are acceptable. One of the main guidelines for the development of the food industry is finding new, inexpensive raw materials as a source of potentially functional ingredients. The change in the raw material composition of biscuits enables certain nutritionally valuable components to be successfully introduced into human nutrition (Petrović, 2018).

Research has shown that sugar beet pulp is a source of antioxidants, phenolic compounds and fibers (Gadhe, 2017). This by-product has a high moisture content, and is very unstable and prone to biodegradation. This imperfection is successfully eliminated by the extrusion process, which is carried out with relatively little effort and does not require investment costs (Moscicki, 2011).

MATERIAL AND METHODS

MATERIAL

- Preparation of extrudates and determination of their chemical characteristics
- Preparation of mixture flour-extrudate sugar beet pulp (85:15, 70:30 and 55:45)
- Production of biscuits
- Determination of chemical properties of the final product

Extrudate preparation:

The inlet extrusion mixtures were prepared by mixing corn grits and extracted sugar beet pulp in a laboratory mixer in portions of 15, 30 and 45% by weight of corn grits. By adding water, the moisture content of the mixture was adjusted to 15%. The

mixtures were extruded on a single-screw laboratory extruder 19/20 DN, Brabender GmbH Duisburg, at a temperature profile of 135/170/170°C, screw configuration 4: 1 and opening 4 mm. The obtained extrudates were grounded on a laboratory mill IKA MF 10 and sieved through a sieve to obtain three fractions of particles: <250µm, 250-1000µm and 1000-2000µm.

METHODS

Determination of chemical characteristics of extrudates and final product was performed by the following methods (Pajin, 2009):

- Water content (thermogravimetric method)
- Protein content (Kaydahl method)
- Fat content (Soxhlet method)
- Ash content (incineration)
- Fiber content (AOAC method 991.43 (1991))

Experiment plan

Box-Behnken experimental design was used to assess the influence of particle size and the share of corn grits extrudates, enriched with the addition of extracted sugar beet pulp, to the quality of biscuits (Petrović, 2018).

Factor A – particle size of extrudates <250µm – granulation 1, 250-1000µm – granulation 2 and 1000-2000µm – granulation 3

Factor B – share of by-product in the extrudate (15.30 and 45% based on the weight of corn grits)

Factor C – percentage of wheat flour replacement by extrudate (5.10 and 15% calculated on the weight of flour).

RESULTS AND DISCUSSION

Chemical characteristics of extrudates

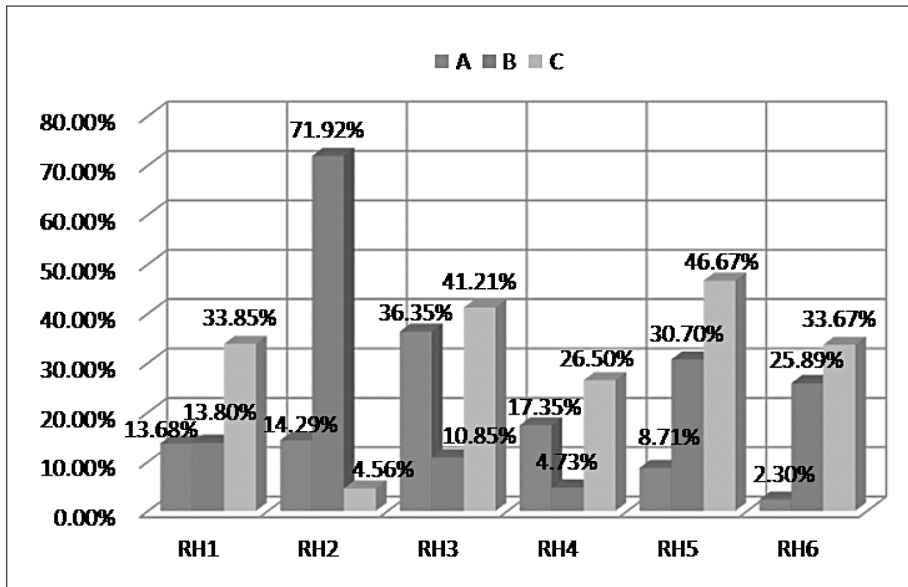
Wheat flour has a significantly lower content of ash and dietary fiber compared to extrudate samples. The content of mineral substances and the content of fibers, both total and insoluble, increases with the increase of the share of beet pulp in the extrudate, and also with the increase of the particle size of the extrudate. The increase in these parameters can be explained by an insufficiently homogeneous mixture of corn grits and extracted beet pulp during extrusion. Another possible explanation is that during the grinding of the obtained extrudates, there was a greater shredding of corn grit particles than beet pulp, as a result of which, after sieving in fractions with a larger particle size, the share of beet pulp was higher. On the other hand, corn grits have a higher fat content, so that the higher fat content in smaller fractions of extrudates is also an indication that these fractions contain a higher proportion of corn grits than beet pulp.

Chemical characteristics of the final product

Table 1. Regression coefficients for the responses RH1-RH6

	RH1	RH2	RH3	RH4	RH5	RH6
β_0	4,14	6,8	13,67	0,6246	5,01	3,96
β_1 (A)	-0,2825*	0,0775	-0,135*	0,0263*	0,31*	0,175
β_2 (B)	-0,2838*	0,1737*	0,0737*	0,0138	0,5825*	0,5875*
β_3 (C)	0,4438*	-0,0437	-0,1438*	0,0325*	0,7175*	0,67*
β_{12} (AB)	-0,2925*			-0,0175	0,3375	0,48*
β_{13} (AC)			-0,06			
β_{23} (BC)			0,0675	0,015		-0,385
β_{11} (A ²)	-0,5017*	-0,0533	0,0611			-0,7242*
β_{22} (B ²)	-0,2342	0,0742		-0,0431*	0,3338	-0,2092
β_{33} (C ²)	-0,2992*			0,0444*	-0,3112	-0,3492*
R ²	0,9218	0,7283	0,8783	0,8951	0,9063	0,9749
Lack of Fit	0,4017	0,0703	0,31	0,6303	0,0325	0,1436

* p<0,05; RH1: moisture; RH2: proteins; RH3: fat; RH4: ash; RH5: total fibers; RH6: insoluble fibers



Picture 1. Contributions of the influence of input factors (A, B and C) on the chemical characteristics of biscuits with the addition of corn grit extrudate enriched with sugar beet pulp (RH1-moisture; RH2-proteins; RH3-fat; RH4-ash; RH5-total fiber; RH6-insoluble fiber)

The addition of corn grits enriched with sugar beet pulp significantly increases the share of minerals and fibers (total and insoluble) in biscuit samples. In Table 1 it can be seen that the values of the coefficient β_2 have a positive sign for the responses RH3, RH5 and RH6, which means that increase of the share of by-product in the extrudate, increase of the stated chemical characteristics, only the moisture content RH1 decreases (negative coefficient β_2). Figure 1 indicates that the largest influence of the content of beet pulp in the extrudate (factor B) is actually on the protein content in tea biscuits (71.92%).

The share of extrudates in the raw material composition of biscuits (factor C) also has a statistically significant effect ($p < 0.05$) on the chemical characteristics of biscuits. With the increase of the percentage of wheat flour replacement by extrudate during the production of biscuit samples, there was a significant increase in the content of mineral substances and dietary fiber in relation to the control sample, while the fat content decreased significantly (RH3 response). The highest content of dietary fiber was shown by the sample with the highest proportion of extrudates in biscuits and the highest proportion of sugar beet pulp in the extrudate. Such results were expected given that sugar beet pulp contains significant amounts of dietary fiber

The particle size of the extrudate (factor A) was shown by a statistically significant effect ($p < 0.05$) on all chemical parameters of biscuits (Table 1), while the moisture content and fat content were decreased (coefficient β_1 has a negative sign for the responses RH1 and RH3), and the content of proteins, minerals and dietary fiber increases with the increase extrudate particle size. Influence of factor A is the most pronounced on fat content (RH3 response). Such results are also expected, because the chemical composition of the extrudates themselves significantly depends on the particle size, which was later reflected to the chemical composition of the tea biscuit samples.

CONCLUSION

There is a large amount of by-products in the food industry, which, if not used in the production of animal feed, is considered as waste that greatly pollutes the environment. By-products are inexpensive and quality raw materials suitable for increasing the nutritional value of the product. The successful application of the obtained results would be reflected in the production of nutritionally enriched products that can preventively affect human health, while being sensory acceptable to consumers. This paper also contributes to the formation of models for the development of related products enriched with other by-products of the food industry. The biggest benefit of this work would be the industrial production of new functional products, which would provide both economic and environmental benefits.

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**Sonja Simić¹, Biljana Pajin¹, Jovana Petrović¹, Ivana Lončarević¹,
Dragan Psodorov², Dragana Stanisavljević³, Violeta Mickovski Stefanović⁴**

¹ Tehnološki fakultet, Bulevar cara Lazara 1, 21000 Novi Sad, Srbija

² Visoka škola strukovnih studija za menadžment i poslovne komunikacije,
Modene 5, 21000 Novi Sad, Srbija

³ Akademija strukovnih studija Južna Srbija, Odsek za poljoprivredno-prehrambene
studije, Ćirila i Metodija 1, 18400 Prokuplje, Srbija

⁴ Institut "Tamiš" doo, Novoseljanski put 33, 26000 Pančevo, Srbija
E-mail: vikivms15@gmail.com

HEMIJSKE KARAKTERISTIKE ČAJNOG PECIVA SA DODATKOM EKSTRUDATA KUKURUZNE KRUPICE OBOGAĆENE REPINIM REZANCIMA

Rezime

Fini pekarski proizvodi (keks i srodni proizvodi) su veoma zastupljeni u ljudskoj ishrani. Glavno usmerenje prehrambene industrije je potraga za jeftinim sirovinama koje su potencijalni izvor funkcionalnih sastojaka. Sporedni proizvodi prehrambene industrije predstavljaju sirovine bogate vlaknima i brojnim biološki aktivnim komponentama. Usled toga, predstavljaju predmet interesovanja prehrambene industrije. Ispitivane su hemijske osobine čajnog peciva sa dodatkom ekstrudata kukuruzne krupice obogaćene repinim rezancima. Dobijeni rezultati su obrađivani u Box-Behnken eksperimentalnom dizajnu, te nam pokazuju značajno povećanje sadržaja proteina i prehrambenih vlakana, kao i smanjenje sadržaja masti.

Ključne reči: keks, sporedni proizvodi prehrambene industrije, funkcionalni proizvodi, prehrambena vlakna



Miloš Ćirić¹, Ivana Janković¹

¹ University of Novi Sad, Faculty of Science, Novi Sad, Serbia

E-mail: milos.ciric.gastronom@gmail.com

SAFE FOOD AS THE MAIN INDICATOR FOR SUCCESSFUL BUSINESS OPERATIONS OF HOSPITALITY FACILITIES

Abstract

Day by day, the guests' concern for their own health is growing, and people's awareness has increased significantly. That is why choosing a good restaurant or hospitality facility for enjoying food is very important. Employees working in a hospitality facility play a key role in making a profit and attracting guests. Hence the idea to examine how much they are instructed in the proper and adequate storage, reception, preparation and heat treatment of food. The aim of this paper is to determine whether hospitality workers sell healthy-and-safe food to consumers. While the purpose of the paper is to examine what those places are and the ways in which food can be contaminated.

Key words: *safe food, cross-contamination, hospitality*

INTRODUCTION

Healthy-and-safe food represents a very important factor in hospitality facilities. According to the World Health Organization, 23 million people get sick every year due to foodborne illness, including 5.000 death cases (WHO, 2015), while it's also worth mentioning that the European Food Safety Authority states in its report that 48.70% of epidemics are related to hospitality (EFSA, 2010) with a tendency to grow, considering that in 2018 that number is 61% (EFSA, 2018). On the territory of the European Union, out of the total number of epidemics those 31% of them are related to hospitality facilities, such as: restaurants, bars, cafes, pubs, hotels, while 17% of epidemics occurred in mass food distribution institutions, such as food chambers in school, kindergartens, mass events and nutrition at work (Pichiler et al., 2016).

The number of those infected as a result of food poisoning is still at a high level, even in spite of a handful of studies conducted on the topic of food safety, and also in addition to a large number of preventive measures applied in the food and hospitality industry (Havelaar et al., 2010). Diseases that occur due to improper and inadequate management during food preparation, reception and serving pose a serious public health problem even in developed countries creating a social and economic burden on the health system (Martins et al., 2012), and also on the hospitality and tourism sector, considering that this sector employs the largest number of people with a low level of formal education (Demunter, 2008). There are several sources of contamination, such as: chemical, parasitic, among which microbiological sources stand out as very harmful to the public health of the population (Rebouças – Tannus, et al., 2016).

During improper handling of ingredients during production and processing, hands are the main carriers of pathogenic microorganisms, while the second most common case of infection is improper and inadequate handling of heat treatment, food preparation and storage (Rebouças – Tannus, et al., 2016). The most common food-borne diseases occur due to poor hygiene (Pichler, et al., 2014) and cross-contamination between raw materials and food products, storage and inadequate heat treatment, using contaminated equipment or utensils (Suwaidi et al., 2015), while delivery vehicles can also be carriers of pathogenic microorganisms, such as salmonella, staphylococcus aureus and E. coli (Rosmawati, et al., 2015). The handling process includes all phases, food storage from very receipt to final product and its distribution, meaning from field to table (FAO, PAHO, 2017), while production and hospitality workers have direct contact with food and play an important role in preventing or reducing food contamination (Smigic et al., 2016). Establishing good hygiene practice in production and hospitality facilities is essential to protect consumers from foodborne illness (Martins et al., 2012). The food safety system has only been harmonized with European legislation in the past few years (Smigic et al., 2015). Knowledge of adequate food safety measures as well as the level of practical utilization of hygienic food handling is very important for the consumer (Gomes et al., 2014), which is a very important fact in the business of hospitality facilities, where the utilization of good hygiene practice and personal hygiene in production and hospitality facilities is essential for the protection of consumers from diseases caused by pathogenic microorganisms (Martins et al., 2012).

The most common food handling errors which caused certain diseases are food handling by an infected person who is a carrier of certain pathogenic microorganisms that are transmitted by touch or food handling, improper hand washing and usage of insufficiently clean food preparation equipment (Norrung, Buncic, 2008). In this regard, adequate and effective training and mastering new skills can greatly improve food quality by reducing the negative effects of contamination on human health and the economy of the hospitality facility. The level of knowledge about food safety can be influenced by food handling, experience, education and many other factors. In addition to training, the level of knowledge about food safety can also be influenced by other factors, such as age, education or work experience (Panchal et al., 2013).

MATERIALS AND METHODS

The research was conducted on the basis of a poll questionnaire on the territory of the Republic of Serbia in the period from 07.06.2020 to 20.08.2020. Employees in hospitality on the territory of Serbia participated in the research. The study was modeled on the study of Bolton et al. (2008) and Rebouças et al. (2016) where questionnaire from those studies was modified for the needs of this research. The questionnaire was modified by a team of gastronomes. Data were processed using the SPSS statistical data processing program. During data processing, methods of comparison, deduction and data synthesis were used.

RESULTS

SOCIO-DEMOGRAPHIC ANALYSIS OF CHARACTERISTICS OF RESPONDENTS

In order to collect real data on employees in the hospitality industry, a socio-demographic analysis of the respondents was performed first. The analysis of the collected data led to different findings presented in the tables and graphs in the next part of the research.

Table 1. Socio-demographic characteristics of respondents in hospitality

Question	Category	Number of Respondents	Margin (%)
Gender	Male	48	68.60
	Female	22	31.40
Age	From 18 to 26 years old	18	25.70
	From 27 to 34 years old	24	34.30
	From 35 to 42 years old	18	25.70
	From 43 to 50 years old	6	8.60
	From 51 to 57 years old	4	5.70
	From 58 to 65 years old	0	0
Education	High school	37	52.90
	Vocational school	20	28.60
	University	3	4.30
	Master's degree	9	12.90
	Doctorate	1	1.40

70 respondents participated in the research, of which 68.60% were males and 31.40% were females. As for the age range of respondents among which the research was conducted, the age range is from 18-65. The largest number of respondents is aged 27-34 years old with a share of 34.30%, followed by respondents aged 18-26 years

old and 35-42 years old with a share of 25.70%, with a share of 8.60% are respondents aged 43-50 years old, while employees aged 51-57 years old were represented by 5.70%. Employees aged 58-65 years old not participate in this study. It can be stated that the largest number of respondents is middle-aged.

As one of the leading questions that contributes to the better affirmation of restaurants, the respondents also stated about their level of education. The largest number share employees with high school which is 52.90%, which represents half of the respondents, in second place are respondents with a vocational school education with a share of 28.60%, followed by respondents with a Master's degree of 12.90%, while university-educated respondents are represented with a share of 4.30%. While the smallest share of respondents with doctorates with only 1.40%. This shows that the respondents who work in the hospitality industry do not normally have a higher education.

According to the research that we connect with work experience and skills at work, the question arises for the respondents, how long have you been working in the hospitality industry. Among which, the majority of respondents work from 5-10 years with a share of 27.10%, while there are slightly fewer respondents who work from 10-15 years with a share of 21.40%. With a share of 18.60%, there are respondents who work from 1-5 years and over 20 years, while respondents with work experience of 15-20 years are represented by 12.90%. The smallest share of respondents are those employed for up to one year with a share of 1.40%. Based on these results, it can be stated that a larger number of respondents have relevant work experience in the hospitality industry.

PREVENTION OF CROSS-CONTAMINATION ANALYSIS DURING RECEPTION AND HEAT TREATMENT

Table 2. Reception control, storage and prevention of contamination

Question	Answer	Margin (%)	Answer	Margin (%)	Answer	Maring (%)
Do you regularly control suppliers when receiving goods?	Yes	91,4	No	8,6	/	/
What is the optimal temperature in your refrigerators?	1-5°C	82,9	6-10°C	10	lower than 1°C 0-4°C 2-8°C 3-8°C	7,1
Do you have a thermometer or equivalent in your facility?	Yes	87,1	No	12,9	Not Sure	/
What material are your cutting boards made of?	Plastic	95,7	Wooden	4,3	/	/

In order to minimize contamination during the reception and preparation of food, and based on the question of whether you regularly control suppliers when receiving goods, most respondents control with a share of 91.40%, while 8.60% of respondents do not control suppliers when receiving goods. Which is very satisfying.

This raises the question of food storage in order to determine the storage temperature. Based on the question of what is the optimal temperature in your refrigerator, most respondents store food at a temperature of 1-5°C as much as 82.90%, while 10% of respondents store food at a temperature of 6-10°C and the answers on: lower than 10°C, 0-4°C, 2 -8°C, 3-8°C in total was given by 7.1% of respondents. We can observe that the respondents store food properly.

In order to confirm the accuracy of the data, the respondents were asked whether they have a thermometer or equivalent in the hospitality facility. The answer "Yes" gave 87.10%, the answer "No" gave 12.90% and the answer that they are "Not Sure" was not given by any respondent. Thus, we come to conclusion that most of them have a thermometer or equivalent.

One of the most important elements for contamination is certainly the space and accessories they work with, so they were asked whether the boards they work on are made of wood or plastic. Where 95.70% said that they use plastic boards for food processing and 4.30% use wooden boards that are not suitable nor good for work in the kitchen because they are very good carriers of bacteria and microorganisms.

A very important task is how and in what way we store heat-treated food. The largest number of respondents 84.30% said they leave it to cool down and then put in the refrigerator, a share of 8.60% said they leave it to cool down and then in the freezer, and the remaining 7.10% said they store it at room temperature, in a cylinder, refrigerator for a sudden drop in temperature, to service in Bain-marie or souse form, at a temperature above 65°C and cooling in the shock chamber and then the refrigerator. On the basis of which we can see that people who do not know the basics of food storage in the hospitality industry.

When asked how you know that food is at a given temperature, from which you can see the skills and art of hospitality workers, the largest share of 67.10% said that they use a probe during processing, which is one of the safest indicators for determining temperature, 25.70% of respondents said that they are doing it by checking the food with one of their techniques and 7.10% of the respondents answered that they did not know the way. This share among the respondents that they do not know how to check food is not negligible for consumers.

As the types of meat that are most common on our table, we asked the respondents how they know that poultry and pork are sufficiently heat-treated. A total of 42.90% of respondents said they do it with a probe, while 40% of respondents said they do it based on previous experience in preparation which is quite an approximate percentage among respondents, 8.60% of respondents said they evaluate it by touching meat, while 2.90% said it does so based on the appearance of the meat and the other share of 5.60% said it does so when meat juice leaks, when it has a brown or crispy crust. Research related to heat-treated food reveals that knowledge based on previous experiences is used a lot in hospitality and with the help of a probe, which is an extremely good tool for determining heat so that beginners can be sure that the food they served is safe.

CONCLUSION

As there is a growing demand today for healthy-and-safe food in the world and in our region, the idea came to examine hospitality workers who play a key role in food safety in primary production. The main goal of this research is the knowledge and experience of hospitality workers, based on whose answers we can conclude that they are largely informed about healthy-and-safe food. When asked how they store and whether they have a thermometer and the equivalent, the majority answered that they do, which shows that there is a high sense of dedication and diligence in their work. Among the main sources of general contamination and contamination of food are also the staff and the accessories or inventory which they use. Every day, many rules are prescribed that should be followed in order to maintain the most proper hygiene in the hospitality facility. Based on that, it can be concluded on the basis of questions for the use of adequate equipment that the majority of respondents are aware of contaminants and try to work as well as possible in the given conditions. Temperature plays one of the leading roles in contamination routes, so the research emphasizes how and in what way hospitality workers can assess whether meat is roasted, and based on that it can be concluded that they are familiar with new techniques, but that there are also persons who hold experience as chief assessor. Based on the collected results, it can be concluded that the workers are well versed in the ways and sources of contamination, thus they work diligently and strive to deliver food to the consumer's plate as safely and secure as possible.

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Miloš Ćirić¹, Ivana Janković¹

¹ Univerzitet u Novom Sadu, Prirodno-matematički fakultet, Novi Sad, Srbija
E-mail: milos.ciric.gastronom@gmail.com

ZDRAVSTVENO BEZBEDNA HRANA KAO GLAVI INDIKATOR ZA USPEŠNO POSLOVANJE UGOSTITELJSKIH OBJEKATA

Abstract

Iz dana u dan sve je veća zabrinutost gostiju za sopstveno zdravlje, svest kod ljudi je znatno povećana. Zbog toga je odabir dobrog restorana ili ugostiteljskog objekta za obedovanje hrane jako bitna. Zaposleni koji rade u ugostiteljskom objektu igraju ključnu ulogu u ostvarivanju profita i privlačenja gostiju. Otud ideja da se ispituju koliko su upućeni u pravilno i adekvatno skladištenje, prijem, pripremu i toplotnu obradu hrane. Rad ima za cilj da utvrdi da li ugostiteljski radnici konzumentu prodaju zdravstveno bezbednu hranu. Dok je zadatak rada da ispita koja su to mesta i načini na koje hrana može biti kontaminirana.

Ključne reči: *zdravstveno bezbedna hrana, unakrsna kontaminacija, ugostiteljstvo*



Nemanja Ristić¹, Dragana Stanisavljević¹, Svetlana Lakićević², Predrag Ilić³,
Violeta Mickovski Stefanović⁴

¹ Academy of Vocational Studies Southern Serbia – Department of Agricultural
and Food Technology, Prokuplje, Serbia

² University of Niš, Faculty of Technology, Leskovac, Serbia

³ University of Niš, Faculty of Philosophy, Niš, Serbia

⁴ Institute "Tamiš", Pančevo, Serbia

E-mail: draganastanisavljevic72@gmail.com

CONTENT OF TOTAL PHENOLS AND FLAVONOIDS OF SOME COMMERCIAL BEERS

Abstract

Beer is a low-alcohol drink with a characteristic aroma and a pleasant bitter taste. The main raw materials for beer production are malt, brewer's yeast, hops and water. The total phenolic content as well as the total flavonoid content in selected beer samples shows significant differences depending on the type of beer and ranges from 263.3 mg gallic acid/L in light to 590.7 mg gallic acid/L in dark beers, respectively and 53.9 mg catechin/L for light beers up to 214.8 mg catechin/L for dark beers. The presence of phenolic components is also important because of the sensory characteristics they can give to beer.

Keywords: *beer, quality, sensory characteristics, total phenols, total flavonoids*

INTRODUCTION

Beer is a mild alcoholic beverage produced by the process of alcoholic fermentation from malt, hops, water and brewer's yeast (Leskošek-Čukalović, 2002; Kunze, 1998). Barley is first converted into malt, from which liquid malt extract is produced by the extraction of the active ingredients in malt and hops and then fermented into beer. Depending on the type of yeast used for fermentation, beers can be divided into: "bottom fermentation" and "top fermentation" beers, lager beer, respectively called "Ale" and "Alt" beers (Kišgeci, 2001; Hornsey, 2004; Kišgeci, 2007). As a biologically

balanced drink, it is a rich source of nutritionally and pharmacologically active ingredients such as vitamins, minerals and antioxidants, and is rightly often called "liquid bread". Numerous studies show that due to its content of carbohydrates, amino acids, vitamins and provitamins, organic acids, phenolic compounds and bitter hops, etc., when ingested in moderation beer can have a beneficial effects on the body (Leskošek-Čukalović, 2016). In addition, beer contains polyphenols similar to those in red wine. They are not much different in reactivity and polyphenols originating from hops are even more reactive than those present in wine. Looking globally, beer is the most consumed beverage in the world (Halonen et al., 2014). In the Republic of Serbia, the most popular alcoholic beverage was beer, followed by spirits and wine (Organization, 2014).

MATERIALS AND METHODS

For the analysis, 4 types of light and dark beers (Guinness, Zaječarsko tamno, Zaječarsko svetlo and Merak) were purchased from local markets in Serbia. The studies included an examination of the phenolic compounds content, as well as sensory analysis of four types of beer.

The analysis was performed in the laboratory of the Department of Agricultural and Food Technology of the Academy of Vocational Studies Southern Serbia using appropriate apparatus and reagents.

Organoleptic evaluation of the samples was performed to determine their ultimate quality. The evaluation was performed according to the DLG scheme of sensory evaluation and the values were recorded in the beer rating sheet.

DETERMINATION OF TOTAL PHENOL CONTENT

The total content of phenolic compounds was determined using the Folin–Ciocalteu method (Singleton and Rossi, 1965). Distilled water (7.9 ml), Folin Ciocalteu (0.5 ml) and aqueous solution of Na₂CO₃ (1.5 ml, ω=20%) were added to the analyzed 0.1 ml beer samples. Folin-Ciocalteu reagent (0.5 ml), aqueous solution of Na₂CO₃ (1.5 ml, ω=20%) i 8 ml of distilled water were added to the blind test. After 30 minutes incubation in a dark place and at room temperature, the absorbance of the reaction mixture at 765 nm compared to the blind test was measured on a spectrophotometer (GENESYS 10S UV-VIS). By recording the absorbances of a series of standard solutions of gallic acid, the calibration curve and the equation of the standard curve were obtained:

$$\text{Absorbance at 765 nm} = 0.0010 c_{\text{gallic acid}}(\text{mg/L}) + 0.049, R^2 = 0.9960$$

Total phenol content is expressed as mg gallic acid/dm³ (that is, a liter of tested beer).

DETERMINATION OF TOTAL FLAVONOID CONTENT

Total flavonoid content in the analyzed beers was determined by spectrophotometric method with aluminum chloride, which is based on the formation of flavonoids-aluminum complex (Kim et al., 2003). A solution of NaNO₂ (0.3 ml, 0.5% solution) was added in the zero moment to a beer sample of 1.0 ml. After 5 minutes, the solution of AlCl₃ was added (0.3 ml, 10% solution). In the sixth minute a solution of NaOH (2 ml, 1 mol/L) and 2.4 ml of distilled water were added. Measurement of absorbance at a wavelength of 510 nm compared to distilled water was immediately performed. Recording the absorbance of a series of standard catechin solutions yielded the calibration curve and the standard straight equation:

$$\text{Absorbance at 510 nm} = 0.003 c_{\text{catechin}}(\text{mg/L}) + 0.037, R^2 = 0.9990$$

The total flavonoid content is expressed as mg catechin / L beer.

SENSORY ANALYSIS OF THE SAMPLES BEER

Sensory analysis of the samples was performed by the consumers (laypeople). Sensory evaluation was done with strictly defined rules. The test was conducted on 20 subjects, 10 of which were male and 10 female. Their age profile ranged from 20 to 60 years. Consumers did not have any formal training or any greater experience in evaluating beer. The rating room was adequately lit. The temperature of all samples served was within certain limits. Samples were tested one by one, from left to right. Smell and taste neutralization between each sampling was performed using crackers. Samples were presented in glass beakers with codes, and rated according to a 1 to 5 scoring system (1-lowest rating, 5-highest rating). The aroma, smell, fullness of taste, bitterness and recentness were tested. The results were statistically processed and presented graphically in the form of radar „spider web“ diagrams.

All tests were done in triplicate. The obtained experimental data was processed using appropriate methods in Origin 8.0, Microsoft Excel 2007, and Sigma Plot Trial 2000.

RESULTS AND DISCUSSION

The paper analyzed 4 samples, two types of beer (light and dark). The characteristics of the analyzed commercial beers are given in Table 1.

Table 1. Characteristics of the analyzed commercial beers

Sample	Brand	Type of beer	Alcohol content (%v/v)	Country of origin
1	Guinness	Dark	5.0	Ireland
2	Zaječarsko	Light	4.5	Serbia
3	Zaječarsko	Dark	5.2	Serbia
4	Merak	Light	4.3	Serbia

The results of spectrophotometric determination of total phenolic and flavonoid content of different types of beer are shown in Table 2.

Table 2. Total phenolic and flavonoid content beer samples

Type of beer	Total phenols, mg gallic acid/L	Total flavonoids, mg catechin/L
Guinness	452.3±4.16	202.3±6.12
Zaječarsko light	263.3±12.86	53.9±2.55
Zaječarsko dark	590.7±4.04	214.8±5.50
Merak	343.7±22.30	83.3±4.91

^a The values shown in the table are given as mean ± standard deviation (n = 3)

Total phenolic content varies depending on the type of beer and ranges from 263.3 mg gallic acid/L in light to 590.7 mg gallic acid/L in dark beers, with Zaječarsko tamno (dark) having the highest total phenolic content and Zaječarsko svetlo (light) having the lowest content. The results obtained by the Folin–Ciocalteu method are similar to the results obtained Shahidi and Naczk (1995) (270–600 mg gallic acid/L), Piazzon et al. (2010) (366–622 mg gallic acid/L). Differences in results may be due to the presence of redox-active compounds, such as proteins (Davalos et al., 2003) which are present in beer at a concentration of 3–5 g/L of beer (Bamforth, 2002). The total phenolic content is higher in dark compared to light beers. Similar to the total phenolic content, the total flavonoid content (Table 2) in the selected beer samples showed significant differences depending on the type of beer and ranged from 53.9 mg catechin/L for light beers to 214.8 mg catechin/L in dark beers, with Zaječarsko tamno (dark) being the richest in flavonoids, while Zaječarsko svetlo (light) had the lowest content. Vinson et al. (2003) and Gorjanovic et al. (2010) also obtained higher content of polyphenols in dark beers compared to lights.

Beer is one of the main sources of phenolic compounds. Their presence in beer contributes to its taste and color. Also, phenolic compounds can contribute to maintaining redox balance (homeostasis) in the human body (Scalbert and Williamson, 2000).

Beers rich in antioxidants have better quality, taste and aroma, foam stability and longer shelf life compared to beers with less antioxidant content (Guido et al., 2007).

Beer contains a large number of phenolic components, most of which come from malt and hops. Due to their specific characteristics, their presence is interesting from both technological and physiological aspect. They are one of the key factors responsible for foam quality, physical and chemical stability, and shelf life (not biological turbidity). Their presence is also important because of the sensory characteristics they can give to beer. Thus, for example, *p*-coumaric acid can contribute to an acidic, bitter and tannic taste. Gallic acid can contribute to bitter, harsh, tannic and sweet, while vanillin gives a sweet-bitter, and tannic taste (Preedy, 2011).

Consumer's first contact with beer is the moment beer is poured into a glass. Consumers generally assume that fine, creamy and persistent foam also means good taste. The fact that in some countries consumers will not drink beer served without foam shows how important a factor it is. Therefore, its quality was tested using a method that measures the stability of beer foam.

Table 3. The height and duration of the sampled foam

Sample	Foam height (cm)	Foam duration time (min.)
Guinness	9.0	6.0
Zaječarsko svetlo	7.1	5.3
Zaječarsko tamno	7.8	5.0
Merak	7.7	4.6

An evaluation of the sensory properties of commercial beers conducted by twenty evaluators is given graphically in the form of the radar diagrams below. The evaluators gave points for: beer smell, beer taste, fullness of taste, recentness and bitterness. The grades obtained for the individual sensory characteristics of beer ranged from 1.0 to 5.0. These results are very interesting and can be of benefit to beer producers who, in recent years, have been struggling to win over the female population that has traditionally been less represented in the beer market. Females tend to prefer less bitter beers and those with more complex aroma (Muggah and McSweeney 2017). Of course, there are numerous factors that can be found as a reason for such results, from demographic to various internal and external, objective and subjective (Gabrielyan et al. 2014).

When it comes to the smell of tested beer samples, the smell of Zaječarsko tamno was rated best, followed by the Merak, then Zaječarsko svetlo. Lastly, the smell of Guinness was rated as the worst one. Zaječarsko tamno and Merak were rated as the best tasting ones, followed by Zaječarsko svetlo, while Guinness tasted the worst. According to the test, Merak had the fullest taste followed by Zaječarsko tamno, then Guinness, and Zaječarsko svetlo was rated the worst. The highest rated beer according to its recentness was Merak, followed by Zaječarsko tamno and Zaječarsko svetlo,

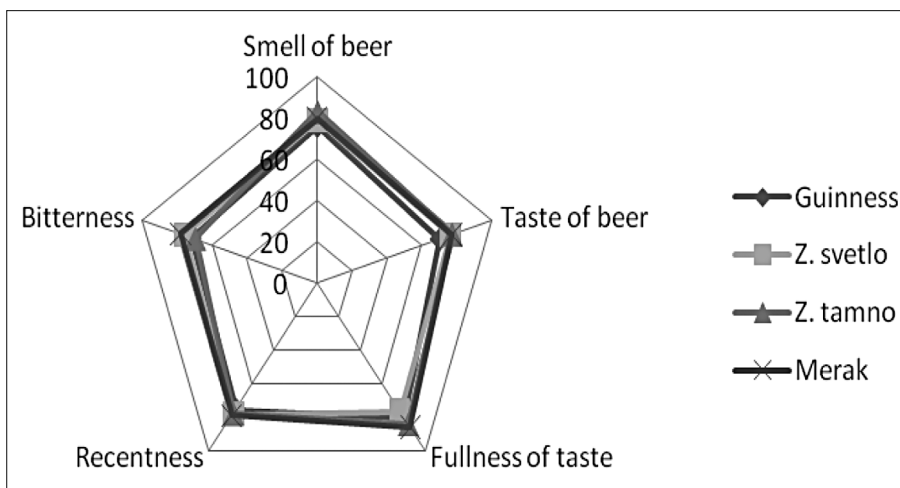


Figure 1. The total score of sensory characteristics of beer

while the worst rated was Guinness. Beer with the most pleasant bitterness was Merak, followed by Zaječarsko svetlo and Guinness, while Zaječarsko tamno was in the last place according to this parameter.

CONCLUSION

The total phenolic content varies depending on the type of beer and ranges from 263.3 mg gallic acid/L in light to 590.7 mg gallic acid/L in dark beers. Similar to the total phenolic content, total flavonoid content in selected beer samples shows significant differences depending on the type of beer and ranges from 53.9 mg catechin/L for light to 214.8 mg catechin/L for dark beers. The results of sensory analysis showed that in terms of taste and aroma, Zaječarsko tamno was the highest rated, while the recentness of Merak beer was ahead of Zaječarsko tamno. With regard to bitterness, Zaječarsko tamno received fewer points than all other tested beers, which can be explained by the statement that beer bitterness is an otherwise very complex issue and depends on the psychophysical perception and the interaction of taste on the one hand and the individual perception on the other.

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**Nemanja Ristić¹, Dragana Stanisavljević¹, Svetlana Lakićević², Predrag Ilić³,
Violeta Mickovski Stefanović⁴**

¹ Akademija strukovnih studija Južna Srbija – Odsek za poljoprivredno-prehrambene
studije, Prokuplje, Srbija

² Univerzitet u Nišu, Tehnološki fakultet, Leskovac, Srbija

³ Univerzitet u Nišu, Filozofski fakultet, Niš, Srbija

⁴ Institut „Tamiš“, Pančevo, Srbija

E-mail: draganastanisavljevic72@gmail.com

SADRŽAJ UKUPNIH FENOLA I FLAVONOIDA NEKIH KOMERCIJALNIH PIVA

Abstract

Pivo je piće sa niskim sadržajem alkohola, karakterističnom aromom i sa prijatnim gorkim ukusom. Osnovne sirovine za proizvodnju piva su pivski slad, pivski kvasac, hmelj i voda. Sadržaj ukupnih fenola, kao i sadržaj ukupnih flavonoida u odabranim uzorcima piva pokazuje značajne razlike u zavisnosti od vrste piva i kreće se u rasponu od 263,3 mg GAE/L kod svetlih do 590,7 mg GAE/L kod tamnih piva, odnosno 53,9 mg katehina/L za svetla piva do 214,8 mg katehina/L kod tamnih piva. Prisustvo fenolnih komponenti je bitno i zbog senzornih karakteristika koje mogu da daju pivu.

Ključne reči: *pivo, kvalitet, senzorne karakteristike, ukupni fenoli,
ukupni flavonoidi*



**B. Sc. Nenad Nestic¹, M. Sc. Predrag Umicevic², B. Sc. student Luka Nestic²,
B. Sc. Student Nikola Kostic², M. Sc. Bratimir Nestic²**

¹ City Administration, Krusevac, Serbia,

² University in Nis, Occupational Safety Faculty, Nis Serbia

E-mail: bratimir@gmail.com

PROTECTION OF FOOD FROM CONTAMINATION WITH EXAMPLES FROM PRACTICE

Abstract

Common people have never been more "hungry" than today, for the truth about food, its influence to health and diseases, regardless of the fact that they are formally "bombed" with, most of all, frightening information coming from newspapers, magazines, radio and TV stations, advising what to eat, what to skip, what are "miraculous" characteristics of some food types and plant preparations, often without any scientific or expert support, but only with profit making purpose. The goal of this paper is to help in preventing food pollution in order to protect human health.

Key words: *food, pollution, prevention, health*

INTRODUCTION

"Make food your medicine and medicine your food."

– Hippocrates

Modern man is rightly worried about his health. There is an increasing number of various chemicals that are in use and that are encountered at home, at work, on the street, and there is not enough information about their effects on people and the environment. Today, over 15,000 chemicals are used worldwide that are known to be toxic or otherwise harmful to humans. Every year, more than 1000 new chemicals are synthesized in various laboratories, about which little or not enough is known. Many of these chemicals are mandatory ingredients in detergents, cleaners, personal hygiene products, cosmetics, disinfectants, pest control agents, furniture materials, food and

crocery packaging and can be found in drinking water and food, even and that intended for children [1,3].

FOOD CONTAMINATION

By applying a large number of agrochemicals and other substances, as well as modern mechanization, the quantity and quality of food products have been significantly increased. However, in contrast to these positive achievements, there have been undesirable consequences such as environmental pollution (soil, water and air) and thus food pollution. By their nature, pollutants can be living organisms (bacteria, viruses, rickettsiae, parasites and fungi), when it comes to biological contamination of food or chemicals (pesticides, additives, fertilizers, heavy metals, etc.). Radioactive substances (long-lived radionuclides strontium and cesium), as food contaminants, are extremely harmful [2].

Living beings are "open systems", so they do not receive from the external environment only "pure and useful" substances necessary for their growth and development, but also all others that are present in their environment. Therefore, no matter where they are (soil, water, air), pollutants are included in the general cycle of matter circulation. The way in which they reach the food used by humans and animals is very complex. Plants absorb water and minerals through their roots for their development. If there are large amounts of nitrates from artificial fertilizers or radioactive isotopes or pesticide residues used in plant protection in the soil, they will also be absorbed. In this way, plants as a basic food source become contaminated. If such plants are used as animal feed, the cycle continues. Since man uses both plant and animal food, pollutants thus reach the human body. Since man is the last link in the food chain, the danger of the harmful effects of pollutants is the greatest for him. In the human body, pollutants originating from food can reach concentrations several hundred thousand times higher than the initial ones in the original environment [1,2].

There are other much shorter routes. During production, processing and distribution, food can be contaminated with chemical and biological contaminants through dirty hands and work clothes of employees. Many chemicals of organic and inorganic origin can get into food from production devices and utensils as well as from packaging. Food can also be primarily contaminated, for example, meat and meat products with antibiotic and hormone residues due to the treatment of diseased livestock or the presence of biological agents as a consequence of infection. Food contamination can also occur through vectors of contaminants such as various insects and rodents [3].

ALIMENTARY INTOXICATIONS

Alimentary intoxications are acute gastrointestinal diseases due to the intake of contaminated (contaminated) food or food that contains toxic substances as its natural ingredient. Symptoms of these diseases are vomiting (vomiting), abdominal pain, diarrhea, fever and minor or major disorders of the general condition of the body. Food

contaminants can be of microbial or chemical origin (See Table 1). Acute food poisoning of microbial origin occurs by ingesting food contaminated with microorganisms that do not have the pathogenic power to cause the clinical picture of a specific infectious disease, but have a harmful effect through their toxins. Intensive multiplication of bacteria and secretion of toxins occurs in conditions when food is stored for a long time at room temperature (3-4 hours). If the food is thermally insufficiently processed (cooking, baking) or is liquid or semi-liquid, then the danger of poisoning is even greater [1].

Table 1. Alimentary intoxications [1]

Microbial origin	Chemical origin
I Intoxications – Toxin (<i>Clostridium botulinum</i>) – Enterotoxin (<i>Staphylococcus aureus</i>)	I Primary – Poisonous fungi: <i>Amanita phalloides</i> , <i>Amanita muscaria</i> ; – Poisonous herbs: sprouted potatoes (solanine), <i>Atropa belladonna</i> , <i>Hyoscyamus niger</i> ; – Poisonous moles: weed, principal.
II Toxinfections 1. <i>Salmonella</i> 2. Conditionally pathogenic bacteria: <i>B. Proteus</i> , <i>Escherichia coli</i> , <i>Paracoli</i> , <i>Enterococcus</i> .	II Secondary: Metals, Pesticides, Mineral Fertilizers, Antibiotics, Hormones.

In addition to bacterial intoxications, there is a large group of intoxications of chemical origin. Primary chemical intoxications occur by ingesting food that by its nature already contains poisonous substances (poisonous mushrooms, poisonous herbs, poisonous monsters). Secondary intoxications of chemical origin occur more often than primary ones. They are caused by numerous chemical substances that reach food in different ways. The most common causes of food poisoning are heavy metal salts and pesticides.

CHEMICAL POLLUTIONS

Food can be contaminated with chemical toxic substances on every part of the road from the land and the barn to the table. If the land and water on which agricultural production is carried out are contaminated with toxins, there is a high possibility that food will be primarily contaminated. For example, fish, shellfish and seafood near large ports or industries located along the coast may contain some of what is discharged into the water as waste (heavy metals, hydrocarbons, etc.). The application of pesticides additionally contaminates food. Particularly dangerous are pesticides that are difficult

to degrade (organochlorine) and those that contain heavy metals (mercury, arsenic) and which are used to treat seeds [2].

In the process of industrial production, food is polluted by the use of additives: canning, inadequate packaging and storage. It should be emphasized that additives are not food contaminants in the true sense. They are intentionally added to food in the production process for canning, improving organoleptic characteristics (smell, taste, color) or for enrichment with vitamins and minerals. If they are ingested in large quantities at once, they cause acute poisoning. Taking small amounts over a long period of time leads to chronic poisoning, often with general symptoms and signs that do not initially indicate a specific disease. Preservatives whose use is allowed are nitrites and nitrates (nitrites: 0.1 to 0.2 grams per kilogram of meat and nitrates: 1 gram per kilogram of meat), sulfur dioxide (0.2%), formic acid (0.25 %) and benzoates (0.25%). Table 2 shows three different types of food and possible contaminants during their production [1,3].

Table 2. Groceries and possible contaminants [1]

Grocery type	Possible contaminants
Cookies	<ul style="list-style-type: none"> – Antioxidants; – Aromas (natural and artificial); – Emulsifiers; – Colorants; – Pesticides.
Fresh meat	<ul style="list-style-type: none"> – Preservatives and dyes; – Pesticides; – Antibiotics; – Hormones.
Wine	<ul style="list-style-type: none"> – Preservatives; – Sweeteners (adding sugar to the must); – Addition of acids and salts; – Acid withdrawal, – Adding tannins; – Colors; – Pesticides; – Encouragement of fermentation, etc.).

On the example of only 3 types of different foods, you can see how many different additives and other substances can contaminate food during production.

BIOLOGICAL POLLUTIONS

The most common biological contaminants of food are: bacteria, viruses, parasites, insects, molds and their toxins. Food can be contaminated during production, transport,

trade and preparation. Contamination of food of animal origin (meat, eggs, milk and dairy products, fish) occurs mainly, while contamination of food of plant origin is less frequent. Food can be a carrier of many diseases: infectious jaundice, dysentery, cholera, typhoid fever, etc. Bacterial food poisonings that occur due to the action of multiplied bacteria or bacterial toxins from food on the body stand out as a special group of diseases. Some of these bacteria multiply or release toxins only after they reach the intestines. This group includes salmonellosis (caused by salmonella), botulism (caused by a toxin released by the bacterium *Clostridium botulinum*), staphylococcal poisoning (caused by a toxin secreted by staphylococcal bacteria) and food poisoning contaminated with a toxin secreted by the bacterium *Clostridium* 1.

Parasites are also food contaminants. Trichinosis is an infectious disease caused by the larvae of the *Trichinella spiralis*. Poisoning by molds or their toxins can be caused by the intake of food prepared from grains of wheat, wheat, corn and peanuts on which the fungi *Aspergillus flavus* have multiplied. There are other causes of poisoning that should be taken into account when procuring food: insects (weevils, mealworms, mealworms), some species of fish (mackerel and tuna) and mushrooms (green and white bud, fly agaric, panther, etc.) [1,3].

RADIOLOGICAL POLLUTIONS

Food can be contaminated with radioactive particles from the environment (water, air and soil). Nature normally has a certain background (amount) of radioactivity, but cosmic radiation also contributes to the increase of radioactivity. Other sources of radioactivity are artificial and come from experiments and bombings with nuclear weapons, from nuclear reactors (especially after accidents), industrial plants and health organizations. The human body can be damaged by radiation after direct exposure or after ingestion of radioactive substances through food and water. Radioisotopes that enter the atmosphere after accidents in nuclear reactors are knocked down by precipitation on the ground. In that way, grass and water are contaminated, and through them, cows, milk and man as the last in this food chain. Radioactive radiation causes radiation sickness that can manifest itself in various symptoms and signs depending on the radiation dose. For example, very high doses (100 g) can cause death within hours or days, while 100 times lower doses can cause cancer after a few years [1,2].

PROTECTION OF FOOD FROM CONTAMINATION

Ways to protect food from contamination are [4]:

- Control of industrial production;
- Control of the use of additives and pesticides;
- Control of storage, transport and packaging conditions;
- Food safety control – laboratory analysis;
- Organic agriculture development.

Legislation determines the permitted amounts (doses) of toxic substances and microorganisms in food. The laws applicable to this area are: the Food Safety Act [5] and the Consumer Protection Act [6].

EXAMPLES FROM PRACTICE; AFLATOXIN AND OHRATOXIN A

Two fungi: *Aspergillus flavus* and *Aspergillus parasiticus* are present in soil and air. When the spores of the fungus fall from the air on the corn grain, after a while, aflatoxin is created, which is introduced into the body of domestic animals that give milk, through food. The danger is that neither pasteurization nor homogenization of milk destroys aflatoxin. On the other hand, processing milk into yogurt, sour milk and similar foods reduces the possibility of aflatoxin survival. Aflatoxin poses a health hazard because it contributes to the development of malignant diseases and the reduction of the body's immune functions. The permitted level of aflatoxins in milk is 0.05 micrograms per liter. At the end of February 2013, the Government of Serbia increased this allowed level 10 times, ie to 0.5 micrograms per liter [4].

Another example is the strudel with figs, produced in Serbia, which was withdrawn from the EU market because it contained an illegal level of Ochratoxin – A, a toxic substance that is potentially carcinogenic in large doses [4]. According to EU regulations, the allowed amount is 3 micrograms per kilogram for adults and 0.5 micrograms per kilogram for children. The strudel from Serbia contained more than 15 micrograms per kilogram. The potential carcinogenic effect of Ochratoxin is associated with the development of endemic nephropathy, it is primarily nephrotoxic which means that it can damage the urinary system and in large doses it is hepatotoxic which means that it can damage the liver.

CONCLUSION

During production, processing, transport, storage and sale, foodstuffs can be exposed to various biological, chemical and physical influences. In unfavorable conditions, food pollution and spoilage can occur, which then has a detrimental effect on human health, so the protection of food from pollution should be carried out at all levels, from producers to consumers. This is achieved through strict implementation of prescribed protection measures, systematic control of food products and conscientious work of food producers.

During primary production, a large role is played by veterinary authorities and experts who are obliged to implement legal regulations for the prevention and control of infectious animal diseases, it is necessary to control feed for livestock and poultry in terms of pesticides, heavy metals, mycotoxins, etc. Competent agricultural experts should control the rational and prescribed use of artificial fertilizers and pesticides in order to use the most efficient and at the same time the least toxic preparations.

During the secondary production and processing of food, the rational use of additives is very important. It is also very important to maintain hygienic conditions in all plants where food is produced, processed, packaged, equipped and sold. The drive should function so that the process takes place from the dirty to the clean side. Workers must be provided with clean work clothes and shoes. The working staff must be healthy and there must be no callers among them. Body hygiene, especially hands, should be impeccable. In the trade of food, it is necessary to provide hygienic conditions during transport, storage and handling of food.

Means of transport and packaging must be hygienically correct and clean. Refrigerated vehicles (trucks, ships and refrigerated wagons) are often used for perishable food in transport. Food storage facilities must be secured against insects and rodents. Food handling, especially food preparation in mass food facilities (restaurants, kitchens, butchers, bakeries, ...) must be organized according to all hygiene regulations. In order to be able to implement preventive measures for the protection of foodstuffs from pollution and to prevent their harmful impact on human health, a number of regulations have been enacted in the form of the Law on Health Safety of Foodstuffs and Items of General Use.

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Дипл. инж. Ненад Нешић¹, мр Предраг Умичевић², студент Лука Нешић²,
студент Никола Костић², мр Братимир Нешић²

¹ Градска управа, Крушевац, Србија

² Универзитет у Нишу, Факултет заштите на раду, Ниш Србија

E-mail: bratimir@gmail.com

ЗАШТИТА ХРАНЕ ОД ЗАГАЂИВАЊА СА ПРИМЕРИМА ИЗ ПРАКСЕ

Абстракт

Обични људи никада нису били "гладнији" него данас, истине о храни, њеном утицају на здравље и болести, без обзира на то што су формално "бомбардовани", пре свега застрашујућим информацијама које долазе из новина, часописа, радио и ТВ станице, саветујући шта треба јести, шта прескочити, које су "чудесне" карактеристике неких врста хране и биљних додатака, често без икакве научне или стручне подршке, али само са сврхом профита. Циљ овог рада је да допринесе спречавању загађења хране ради заштите здравља људи.

Кључне речи: *храна, загађење, превенција, здравље*



**Nemanja Lakić¹, Vesna Vujasinović¹, Biljana Rabrenović², Sanja Dimić³,
Miloš Bjelica⁴**

¹ University of Novi Sad, Faculty of Sciences, Novi Sad, Republic of Serbia

² University of Belgrade, Faculty of Agriculture, Zemun, Republic of Serbia

³ BIMAL SUNCE d.o.o., Sombor, Republic of Serbia

⁴ University of Novi Sad, Faculty of Technology, Novi Sad, Republic of Serbia

E-mail: nlakic7@ gmail.com

REVIEW OF THE QUALITY OF OIL DURING FOOD FRYING IN CATERING FACILITIES

Abstract

Having in mind the importance of proper use of fat, as well as the thermal regime of food processing, in order to obtain a healthy safe fried product, a survey was conducted in restaurants in Belgrade, on the conditions and manner of use, and the quality of the oil when frying food in deep fat. Sampling of oil was performed after frying foods of plant and animal origin. It has been established that palm oil is most often used for frying in deep fat, followed by sunflower oil. Based on the results of chemical quality tests, it can be said that the samples of oil taken from the fryer after frying process in 30 restaurants are not of adequate quality from the health and safety aspect of food.

Key words: *food frying, frying oils, peroxide, acid and anisidine values*

INTRODUCTION

Nowadays, more and more attention is paid to the production of natural and "healthy", i.e. health-safe food. From that point of view, the use of oils and fats in the preparation of meals has become increasingly important. In catering, sunflower oil is widely used today, both for heat treatment and in the production of dressings, sauces, vinaigrettes and other emulsions that are used to season dishes.

In addition, palm oil and its fractions (e.g. palmolein), which is most often used when frying foods in deep fat, has a very large application (1). The very way of "fast

life" leads to the formation of restaurants that aim to quickly prepare gastronomic products and thus resort to heat regimes such as deep fat frying. Edible oils in catering have a wide application in food preparation. The most common types of oil used in restaurants are:

- palm oil and its fractions, which have the greatest application in deep fat frying;
- refined sunflower oil used for frying in shallow fat;
- virgin olive oil (2), as well as other types of cold-pressed oils (3) that are used to season various types of salads and dishes.

Heat treatment of food by frying takes place at a temperature of 160-200 °C, where part of the oil is absorbed into the product being fried, while some parts of the product is separated and remains in the oil. Various physical and chemical changes occur in the oil itself, which can be different in different types of oils. These changes depend on the chemical composition of the oils, as well as the method, i.e. temperature of frying (4). These changes are reflected in the nutritional, sensory and rheological characteristics of the fried product. Three types of reactions occur during deep frying: thermolytic, oxidative, and hydrolytic.

Deep fat frying is a traditional and popular method used around the world due to its practicality and unique effects on food taste and texture. The oil after frying, however, may contain more than 400 different compounds, due to heat-induced reactions, most of which are also absorbed in fried foods. Many of these compounds are harmful to human health (5). It must be noted, however, that the amount of fat absorbed in a fried food is different, e.g. potato chips absorb about 40%, donuts about 22%, and skinless chicken about 10% fat (6).

Heat treatment of food can be defined as the exchange of energy between heat sources and food, which changes their composition, structure, taste, smell, aroma, appearance, destroying microorganisms, making the taste better and food more suitable for chewing, swallowing and digestion. Frying in deep fat (in a deep fryer) is a method by which foods are heat-treated by convection, then by conduction in fat or oil, heated to a temperature of 160-190 °C. The choice of fats and oils in the food preparation process is a very important factor. Not all types of fats are suitable for preparing fried products. This depends primarily on the fatty acid composition of the frying medium (7).

In the process of frying food in deep fat, various products of fat phase degradation are released, which have the common name of total polar matter – TPM. Oil darkening is the most noticeable change that occurs and can be used as a parameter that indicates the quality of frying oil. The content of free fatty acids and the level of total polar compounds are classified as the most commonly used methods for determining the quality of frying oil (8).

The methods for determining the "age" or suitability of the oil for use in the processes used for heat treatment of food are as follows:

- Determination of total polar matters;
- Determination of free fatty acids and
- Application of the Testo 270, Edible Oil Tester (6).

When testing oil, the best results are obtained if the following indicators related to the proper use of oil are observed:

- Frying temperature not to exceed 175 °C;
- To set the optimal frying temperature of food;
- To take into account the quantities of food that are fried at once (so that the temperature does not fall sharply during frying);
- Turn off the fryer when not in use, so that the oil is not unnecessarily exposed to heat (6).

The aim of this paper was to, based on the survey, show the respondents' awareness of the procedure of heat treatment of food in deep fat, as well as knowledge of the application of temperature regimes in order to produce healthy safe fried food. In addition, the quality of used fat from the frying process in deep fryers in several catering facilities was examined from the aspect of basic quality indicators.

MATERIAL AND METHODS

The research was conducted in the period from 01.02.2020. to 15.05.2020. year in 30 "a la carte" catering facilities in Belgrade, whereby 15 facilities were with a daily capacity of 100 meals, 11 facilities with a daily capacity of 150 meals and 4 restaurants with a daily production of more than 250 meals.

Research within this paper was conducted:

- by the method of surveying catering workers (chefs and managers) through a questionnaire;
- descriptive analysis of survey questionnaire data;
- analysis of the chemical quality of oil samples from the frying process by determining the acid, peroxide and *para*-anisidine values, as well as Totox value. For this purpose, standard test methods were applied: ISO 3960: 1998 for peroxide value (PV), ISO 660: 2019 for acid value (AV) and ISO 6885: 1988 for *para*-anisidine value (AnV). The Totox value was calculated based on the equation $Totox = 2 PV + AnV$.

RESULTS AND DISCUSSION

ANALYSIS OF THE SURVEY

Analyzing the offer of dishes in 30 catering facilities, it was found that 25% of dishes are heat-treated by frying in deep fat. On average, each facility has 10 dishes that are prepared by frying. By interviewing the management and chefs about the familiarity with the temperature regimes when frying food in deep fat, we came to the results shown in Table 1.

Table 1. Results of a survey of respondents in the hospitality industry related to deep fat frying

Question	Answer	Share (%)	Answer	Share (%)	Answer	Share (%)
Knowledge of temperature mode	Yes	77	–	–	No	23
At what temperature is frying performed?	180–200°C	73	220°C	23	>220°C	4
When is changed the oil in the fryer?	2–3 days	53	–	–	5–7 days	47

Based on the data from Table 1, it can be concluded that the vast majority of respondents are familiar with the temperature regime of frying food in deep fat. The results show that in most of the facilities frying is performed at lower temperatures, i.e. 180-200 °C, which is favorable, because it contributes to greater health-safety of fried products. However, it is disappointing to learn that in almost half of the examined facilities, the oil in the fryer changes only every 5-7 days.

When asked whether they combine two or more types of oil when frying, 80% of them said not to combine, and 20% to combine, most often with sunflower oil. Also, the survey found that in 70% of cases, when frying in deep fat, several types of food are fried in the same fat.

It is also disappointing that the obtained data show that no catering facility controls the "age of oil". This finding initially deviates from the standardization and uniform quality of food prepared by frying in deep fat, and thus calls into question the health of fried gastronomic products.

ANALYSIS OF THE QUALITY OF OIL USED IN FRYERS IN THE FOOD FRYING PROCESS

The most important chemical indicators that change during the food frying process and indicate the change in oil quality in that process are shown in Table 2 and Table 3.

Table 2. Acid value of oil samples taken from fryers after frying food in catering facilities

AV (mgKOH/g) Range	Number of restaurants	Frequency (%)
0.50 – 0.99	6	20
1.00 – 1.50	15	50
1.51 – 2.00	8	27
greater than 2.00	1	3

The range of content of free fatty acids in the oil, that is, the acid value indicates the hydrolytic degradation of triacylglycerol molecules under conditions of high temperatures in the presence of water. Thus, an increase in the acid value during the frying process indicates the inevitable irreversible deterioration in the quality of the fat used. The higher the acid number, the lower the quality of the oil. At the same time, the increase in acidity directly indicates the length of use of oil in the frying process. According to the data shown in Table 2, it is clear that the acidity of the oils used in the fryers is very different. The acid value ranges from 0.58 to as much as 3.80 mgKOH/g. In 27% of restaurants the acidity was above 1.50 mgKOH/g. Relatively small share, 20% of restaurants had frying oil in a fryer with an acid value up to 1 mgKOH/g, which can be considered as a relatively good quality oil from the aspect of acidity. According to the Rule book on edible oil quality (9), the maximum allowed value of acidity of edible refined oils is up to 0.6 mgKOH/g.

Parameters indicating oxidative changes in the oil, i.e. peroxide and anisidine value, as well as the Totox value, their interval of variation and percentage of participation in the total number of examined restaurants are shown in Table 3.

Table 3. Indicators of oxidative changes of oil samples taken from fryers after frying food in catering facilities

PV ¹ (mmol/kg)		AnV ² (100A ^{15,350nm})		Totox value ³	
Range	Share (%)	Range	Share (%)	Range	Share (%)
20 – 40	27/(8)*	8 – 30	10/(3)	40 – 100	13/(4)
41 – 80	57/(17)	31 – 60	43/(13)	101 – 200	60/(18)
81 – 120	13/(4)	61 – 90	40/(12)	>201	27/(8)
>120	3/(1)	>91	7 (2)	–	–

¹ peroxide value; ² *para*-anisidine value; ³ Totox value (2PV+AnV); * number of restaurants

The peroxide value that indicates the content of primary oxidation products in the oil ranges from 20.18 to an incredible 121.39 mmol/kg. In more than half of the restaurants (57%) PV ranged from 41 to 80 mmol/kg. An increase in PV in the oil can occur during the frying process itself, however it can still increase, even between two fryings in the case of discontinuous fryer operation, which is often the case in restaurants. Frequent reheating and cooling of the oil has a particularly negative effect on PV changes. However, it should be said that PV is not a reliable parameter for assessing the deterioration of the oxidative state of oil, since peroxide compounds decompose at high temperatures. Thus, the anisidine value undoubtedly provides a better insight into the quality of the oil used, as it indicates the content of secondary oxidation products formed from the peroxide in oil. In over 80% of restaurants, *p*-anisidine value of oil from fryer was extremely high, ranging from 30 to 90, and 7% had values even above 91. Oil of this quality is extremely unfavorable for consumption from a health aspect. Anisidine value of oil is not limited to international or domestic

quality regulations, however, in fresh and high-quality refined sunflower oil *p*-AnV ranges from 8 to 15 (10).

According to the results of PV and *p*-AnV, the calculated Totox value, which indicates the total oxidative state of the oil, was extremely high, too. Almost 90% of fryer oil samples had a Totox value above 100, in three restaurants as many as 300.

CONCLUSION

Based on the obtained answers to the survey, as well as chemical quality tests, it can be said that oil samples taken from the fryer in 30 restaurants in Belgrade are not of adequate quality from the aspect of safe food. The obtained data confirmed that no one facility controls the "age of oil" during frying.

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**Nemanja Lakić¹, Vesna Vujasinović¹, Biljana Rabrenović², Sanja Dimić³,
Miloš Bjelica⁴**

¹ University of Novi Sad, Faculty of Sciences, Novi Sad, Republic of Serbia

² University of Belgrade, Faculty of Agriculture, Zemun, Republic of Serbia

³ BIMAL SUNCE d.o.o., Sombor, Republic of Serbia

⁴ University of Novi Sad, Faculty of Technology, Novi Sad, Republic of Serbia

E-mail: nlakic7@gmail.com

ОСВРТ НА КВАЛИТЕТ УЉА ТОКОМ ПРЖЕЊА ХРАНЕ У УГОСТИТЕЉСКИМ ОБЈЕКТИМА

Абстракт

Имајући у виду значај правилног коришћења масноће, као и топлотног режима обраде хране, у циљу добијања здравствено безбедног прженог производа, спроведено је истраживање у ресторанима на подручју Београда, о условима, начину коришћења, као и квалитету уља приликом пржења хране у дубокој масноћи. Узорковање уља је извршено након пржења намирница биљног и животињског порекла. Установљено је да је палмино уље најчешће коришћено за пржење у дубокој масноћи, након чега следи сунцокретово уље. На бази резултата хемијских испитивања квалитета, може се рећи да узорци уља узетих из фритезе након пржења хране у 30 угоститељских објеката нису адекватног квалитета са аспекта здравствено безбедне хране.

Кључне речи: *пржење хране, уља за пржење, пероксидни, киселински и анисидински број*

**ECONOMIC ASPECTS AND MARKETING
AS SEGMENTS OF THE PRODUCTION
SAFE FOOD**



Marija Bukilica¹, Ana Radulović¹

¹ Faculty of Maritime Studies Kotor

E mail: bukilica.marija@gmail.com

ORGANIC ECONOMY-CONCEPT OF SUSTAINABLE DEVELOPMENT

Abstract

In the process of development of the human population and civilization, technical and technological progress and development are inevitable. The civilization of the 21st century requires an increasing consumption of natural resources and energy. The result is the emission of harmful gases into the air, water and soil, so changes in the environment were obvious. These changes have catastrophic consequences for the survival of humanity. Therefore, the end of the XX and the beginning of the XXI century is characterized by a deep conviction about the necessity of efficient protection of resources, improvement of the environment, finding alternative energy sources, and especially the production of healthy safe food. Organic production was created as a reaction to ecological degradation and poor quality food. Its goal was to better preserve the environment with better quality production.

Key words: *organic production, marketing, organic food, market*

INTRODUCTION

In the world, more and more funds are allocated for research in the development of methods for obtaining energy from renewable sources, in order to harmonize the economic and environmental principles of sustainable development. In addition, they are working on finding clean technologies, recycling waste, protecting water, air, land and biodiversity. Methods are being developed to encourage cycles of matter and energy circulation. In all this protection of the agroecosystem belongs an important place. Modern trade (domestic and international) and food consumption are characterized by high concern of customers as well as increasing demands in terms of hygienic-toxicological and any other correctness (safety) of food. The result of this situation is a systematic effort to create and promote efficient and effective management systems throughout the "food chain" which, through various preventive activities and documen-

tation support, should enable the maximum possible correctness and safety of food for the health of consumers.

All markets today are dynamic. Changes are happening all around us and as such are affecting strategy. The winning strategy that rules today, tomorrow, does not have to be successful or even relevant enough. Therefore, it is imperative to develop a strategy that will dominate the modern market environment, understanding and anticipating the actions of other participants and especially competitors. It is also the only path that leads to a sustainable competitive advantage.

ECONOMIC ATTITUDE OF ORGANIC FOOD PRODUCTION

In order to devise simple and effective strategies, it is important to know what the organization is particularly good at and what it is not, as well as what resources and assets it has or does not have at its disposal. For this purpose, internal analysis is used, which provides important information about organizational resources, skills and work activities. An important part of this analysis involves assessing intangible sources that are difficult to assess, as well as tangible sources. The basic forms of intangible sources or intangible assets are: knowledge and skills of employees, the ability to innovate, know-how, close relationships with customers, brand strength, unique organizational design, and business culture. Although the valuation of intangible assets is difficult, its significance is enormous because numerous pieces of evidence confirm that intangible assets are the main source of competitive advantage. A company can be in many ways stronger and weaker than its competitors, with lower costs and a greater degree of differentiation being the two main sources of competitive advantage. Competitive advantage cannot be seen by looking at the company as a whole, so an analysis of activities is needed.

PORTER'S MODEL

Biological waste treatment is a type of treatment that most resembles natural processes. In fact it is the decomposition of biodegradable organic waste, in the presence.

The characteristics of the sector and the capacity to raise added value are presented in accordance with two general types of activities:

- primary activities – inbound logistics, production, outbound logistics, marketing and services,
- secondary activities – human resources management, financing, technology development and procurement.

In order to identify the strengths and weaknesses of the structure that makes up the sector and that leads it to sustainable development, it is important to explore the characteristics of each activity in the value chain individually. Inbound logistics of

organic production reveals several weaknesses of the organic food sector, especially in countries where it is underdeveloped. In most countries, including Serbia, organic food producers face common difficulties related to the lack of seed material as well as plant protection products and animal medicines. The main reason for this should be sought both in the lack of interest of distributors to take the risk of distribution of these products, and in the administrative barriers (eg outdated variety list) for their import. Production as the next primary activity can also face certain obstacles that come to the fore through:

- underdeveloped land lease market,
- difficult purchase and information on machines specially designed for solving
- certain problems of organic production, lack of organic manure,
- weak motivation of farmers to invest in warehouses, packaging equipment and modern
- machines for soil cultivation, insufficiently developed and outdated processing processes.

In contrast to the above difficulties, the procurement of packaging materials and certification services are generally not a problem.

Secondary activities of the value chain relate to the level of technology development, management and development of human resources, the possibility of financing and providing services. Most services for the needs of the organic food sector are provided through projects, mainly supported by government funds. This sector is still underdeveloped to be able to use the services of marketing and other agencies, due to the high cost of these services. The financing of a given sector is correlated with the level of economic development and development of the financial market of a certain country. In many countries, organic production does not have sufficient financial support from the state and commercial banks, which can be an obstacle to the faster development of their national organic food markets. In addition, organic production requires professional and educated staff who will be able to meet the requirements of this type of production. The growing number of educational centers and study programs in the field of organic agriculture is encouraging, which will benefit the development of human resources. In terms of technology development, it should be noted that primary organic agricultural production, both due to its nature and the size of farms, does not require huge technological solutions. Organic production itself is an innovative solution of modern society that is becoming aware of the importance of a new approach in food production. Based on the above, it is not difficult to conclude that the value chain in some parts is not strong enough, and they need to be improved in order to create conditions for sustainable development of this sector. This requires, above all, significant investments and greater organization and motivation of producers in order to strengthen both input logistics and output logistics.

Analysis of trends and changes in the population is of great importance as people form and determine the market. Among the demographic factors that can have a significant impact on the marketing of organic food are: population, age structure, household structure, migration and education of the population. In contrast to this factor, the global aging trend creates great opportunities for organic food producers. Members of

the "baby boom" generation approaching the sixties are the most numerous. As they are now in the years when they earn the most and spend the most, they represent a profitable market in terms of this type of product. In addition, forecasts suggest that the world's population will age faster in the next half century than ever before, and an increase in the elderly population will mean an increase in demand for health-related products, whose main leader is organic food. Changes in the structure of the household in terms of the growing number of single households and married couples without children can also increase the demand for organic food. Since these families have more disposable income than other multi-member families, they can devote more time and attention to themselves, primarily to their health, by buying groceries of organic origin.

The emergence of new technologies, especially information and communication, has caused major changes in the economy and society. The Internet is becoming an increasingly integral part of every business and every company strategy. This also applies to this sector, where new technologies need to provide better communication with consumers, more efficient distribution, processing and packaging of products, concentrating knowledge within business networks and increasing its exchange. In contrast, the process of primary organic production itself is not as dependent on new technological solutions as in other industries. The technological environment is also significant in that it creates dangers for this type of business.

A company can achieve a competitive advantage by designing an offer that better meets the needs of a potential customer than the offer of competitors. That is why it is very important to know your competitors, both existing and potential, as well as possible. To this end, the company needs to answer a few very important questions: Who are its competitors? What are their goals? What are their strategies? What are their strengths and weaknesses? What are their reactions? These are also the main stages in the analysis of competition. The competitive match takes place in the branch. Given the constant trend of increasing participants, the organic food industry is in the process of transition from an emerging branch to a fragmented branch. Usually, there are a large number of small and medium-sized enterprises in fragmented branches, where none of the participants has a significant market share or is able to significantly affect the average results. However, competition in the industry exceeds existing participants. In addition to existing participants in the industry, competing forces include customers, suppliers, companies intending to enter the industry and substitutes. Namely, according to M. Porter, the competitive environment is determined by "5 competitive forces", which are:

- rivalry of competitors in the branch,
- supplier power,
- customer power,
- possibility of entry,
- substitute pressure.

Large quantities of organic food are sold in the markets. It is a form of integration in advance, which improves the power of suppliers. Some suppliers are small in size so they do not have a large market influence. The nature of the organic food business indicates that product quality, and often geographical location, are of great importance

to the retailer. Some retailers place emphasis on offering local products that severely limit their choice of suppliers. When it comes to quality, according to the regulations of organic agriculture in force in the EU, only products that consist of 95% or more of organic ingredients can be labeled as organic. When it comes to individual customers, customer power does not grow, but it strengthens the power of marketing channels as a customer. Larger retailers are increasingly turning to organic food sales as consumers increase their purchases of these products driven by a healthy eating trend. The growing presence of legislation related to the development of land under organic production and methods of food production has increased the need for large retailers who need to integrate organic food products into their range.

New competitors can come from four main sources:

- (1) companies competing in a related product market;
- (2) companies with related technologies;
- (3) companies that already target similar consumer groups with different products;
- (4) companies competing in other geographical regions with similar products.

In the organic food industry, there is a serious threat from new entrants.

Starting from the degree of product substitution, F. Kotler distinguishes between four levels of competition:

1. Brand competition – occurs when a company sees as its competitors other companies that offer the same product or service to the same customers at a similar price;
2. Branch competition – occurs when a company sees as its competitors all companies that produce the same product or service;
3. Form competition – occurs when a company sees as its competitors all companies that produce products that provide the same service;
4. Generic competition – occurs when a company sees as its competitors companies that compete for the same dollar of consumers.

The study of food in the 21st century is filled with "paradoxes, confusion and dynamics". and the interests of other stakeholders.

Although consumers have a penchant for and interest in organically produced food, a small percentage of customers regularly buy organic food. This means that there is a mismatch between consumer preferences and behavior. This disagreement is a consequence of several limiting factors. The most important reasons for not buying organic food are the high price, limited availability, satisfaction with conventional food and lack of information and trust in relation to the given products. One of the most frequently mentioned obstacles when buying organic food products is their higher price, ie insufficient readiness of consumers to pay more for the selected product of organic origin in relation to the similar product of conventional production. Most previous studies state that only 5-20% of consumers will buy organic food when premium prices are higher than 30%. Premium prices between 10-30% attract 10-50% of all consumers to buy this type of food. In general, the demand for organic food is

more sensitive to price changes than the demand for conventional food. Price elasticity also depends on product categories, so demand for dairy products and meat will be more sensitive than demand for bread / cereals and other foods. In addition to the price, insufficient supply and weak presence in marketing channels, as well as inadequate marketing channels, affect the level of organic food consumption. Consumers are often not informed about the place of sale, but also about the labeling of organic products, which promotes consumer distrust in the products. That is why it is very important to label products according to regulations with consumer education.

CONCLUSION

Organic (ecological) agriculture is based on the concept of sustainable development, which creates a reliable basis for the proper use of all non-renewable resources in agriculture, the environment and more productive agricultural production. Organic products have a higher dry matter content. They are rich in potassium, iron, phosphorus, magnesium, and do not contain chemicals that would pollute water, air and soil.

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Марија Букулица^{1*}, Ана Радуловић¹

¹ Поморски факултет, Котор

* Одговорни аутор; E-mail: bukulica.marija@gmail.com

ОРГАНСКА ЕКОНОМИЈА-КОНЦЕПТ ОДРЖИВОГ РАЗВОЈА

Резиме

У процесу развоја људске популације и цивилизације технички и технолошки напредак и развој су неизбежни. Цивилизација 21. века захтева све већу потрошњу природних ресурса и енергије. Као резултат емисије штетних гасова у ваздух, воду и земљиште, промене у околини су биле очигледне. Те промене имају катастрофалне последице за опстанак човечанства. Стога крај XX и почетак XXI века карактерише дубоко уверење о неопходности ефикасне заштите ресурса, побољшања животне средине, проналаска алтернативних извора енергије, а посебно производње здравствено безбедне хране. Органска производња настала је као реакција на еколошку деградацију и неквалитетну храну. Циљ јој је боље очување животне средине уз квалитетнију производњу.

Кључне речи: *органска производња, маркетинг, органска храна, тржиште*



**M. Sc. Bratimir Nesic¹, M. Sc. Predrag Umicevic¹, B. Sc. Nenad Nesic³,
B. Sc. student Luka Nesic¹, M. Sc. Nemanja Petrovic², M. Sc. Natalija Tosic²,
B. Sc. Dusan Milincic², B. Sc. Aleksandar Aleksic², M. Sc. Dusan Stevanovic²**

¹ University in Nis, Occupational Safety Faculty, Nis, Serbia

² Academy of Technical-Educational Vocational Studies - Department, Nis, Serbia

³ City Administration, Krusevac, Serbia

E-mail: bratimir@gmail.com

COST AND PROFIT ANALYSIS OF PROPOSED COMPOSTING TECHNOLOGY IN PWW COMPANY

Abstract

Man is the only being on the planet who consciously creates waste. Due to the growing quantities and harmfulness to the environment, waste is considered one of the most significant environmental problems of the modern world. Man, with his activities, is a decisive factor in changing the environment. All these activities are related to meeting the needs of life. Much of the need is created artificially and the question is whether we need so many different products, which will become waste after use.

Our civilization is producing more and more waste and there is nothing to indicate the imminent changes in this trend. However, thanks to technological advances and the development of environmental awareness, the fight against waste is becoming much more successful. Waste generation is the result of the overall economic activity of each country and as such is in direct correlation with the national economy.

This paper presents a cost-benefit analysis of the proposed technology for composting biodegradable waste in the company PWW. This technology is one of the widely used technologies for obtaining compost, a product that is deservedly called "black gold". The importance of this process is confirmed by the fact that schools, for example, in England, teach how to properly implement composting technology.

Key words: *analysis, cost, profit, technology, composting*

INTRODUCTION

Composting is defined as the rapid, but partial, decomposition of moist, solid organic matter, food waste, garden waste, paper, cardboard, by microorganisms and under

controlled conditions [1]. Composting is an aerobic process, ie it takes place in the presence of air and is carried out by microorganisms that need oxygen for growth, development and reproduction.

As a product of composting, the so-called compost, a useful humus-like material that has no unpleasant odor and can be used as a soil conditioner or as a fertilizer. The advantages are as follows: the final product has a certain market value, which should result in a return on a certain part of the invested funds, the space required for the location of the plant is relatively small and transport costs are not so high. On the other hand, such plants may require large capital investments. The market for the obtained product is not always secured and the storage of the final product can be a problem in itself. The quality of a composted product is important if there is a market for it.

Experience shows that although the organic material from the landfill can be successfully transformed into compost, contamination (especially from glass, metal and plastic particles) causes potential consumers to become reluctant to use it. Therefore, organic waste for composting must be separated at the source and before disposal at the landfill. In principle, composting is carried out in two levels:

- collection and separation of organic components (kitchen waste and garden waste) for composting in compost fields or in special plants (usually of the regional type);
- promotion of independent composting "in your own backyard" through education and establishment of small composting bunkers.

Given the EU Landfill Directive and the ban on the disposal of biodegradable waste in landfills, composting has become important as an alternative treatment option for biodegradable waste [2].

DESCRIPTION OF PROPOSED COMPOSTING TECHNOLOGY

The initial projected capacity of the composting plant is about 11,520 tons per year. By researching the market and considering the amount of waste, existing composting technologies, existing solutions of composting plants in the world as well as their characteristics, a composting plant solution was chosen that uses composting technology using static piles / types, with natural aeration of materials and constant process monitoring. The composting process would take about 45 days [3].

In the mentioned plant, the biological and organic fraction of municipal waste would be processed into compost. The reuse or recycling of organic waste significantly reduces the total amount of waste for disposal at the regional sanitary landfill for non-hazardous waste in Leskovac. According to some calculations and empirical data, this reduction is 50% of the total mass of biological and organic waste.

COST STRUCTURE OF PROPOSED COMPOSTING TECHNOLOGY

The total costs of the plant, which otherwise include investment and operating costs, amount to about € 1,000,000 and the time period of construction and commissioning is about 3 months. Investment costs amount to around € 800,000 and operating costs for a period of one year amount to around € 200,000. The planned projected annual production capacity of the plant would be around 5,760 tons of compost [3]. In Table 1, the basic operational data of the composting plant are given.

Table 1. Basic operational data of the composting plant [3]

DATA	MEASUREMENT UNIT	QUANTITIES
Quantities of input material	t / year	11.520
	t / month	960
	t / day	36
Quantities of output material	t / year	5.760
	t / month	480
	t / day	18
Material flow (inlet / outlet)	t / day	36
	t / h	2,57
	t / shift	18
Number of working days per year	day / year	320
Number of working hours per year	h / year	4.477
Number of working days per week	day / week	6,15
Number of working hours per day (without break)	h / day	14
Number of working hours per shift	h / shift	8
Number of shifts per day	shift / day	2
Tour length (both directions)	km	1
Average truck speed	km / h	40
Tour duration	h / tour	0,03
Truck capacity per tour	t / tura	9
Number of tours	tour / day	2
	tour / month	53,33
	tour / year	640
Number of shifts per truck	shift / day	2
Number of trucks required	pieces	1
Fuel consumption (truck)	l / 100 km	25

Table 2 summarizes the total costs of the composting plant, which include investment and operating costs.

Table 2. Summarized total costs of composting plant [3]

INVESTMENT COSTS	€
Machinery and parts	36.500
Mobile equipment	328.000
Electrical equipment and works	118.000
Construction projects and works	311.850
TOTAL	794.350
OPERATING COSTS	€/god
Electricity	415
Fuel	13.474
Maintenance	17.472
Labor, general, administrative and other costs	61.432
Financing costs	106.354
TOTAL	199.147
SUM TOTAL	993.497

PROFIT OF COMPOSTING TECHNOLOGY

Economic benefits of composting technology

The contribution of composting technology in the economic field is multiple because it includes not only the profit from the sale of compost as a finished product but also the economic value of savings achieved by applying composting technology [3]. In this particular case, the annual projected amount of bio-organic waste for composting is 11,520 tons and the amount of compost produced is 5,760 tons. By selling this amount of finished compost at a price of € 110 per ton [4], it is possible to make a gross profit of € 633,600. After deducting the annual operating costs per ton of output material or compost in the amount of € 17.29 / t, a net profit of € 534,010 is obtained. Based on that, it can be concluded that the time period of return on investment costs (€ 794,350) is about a year and a half or about 18 months, which makes the chosen technology extremely profitable [3].

Also, by composting the projected amount of bio-organic waste of 11,520 tons or 23,040 cubic meters, valuable landfill space is saved. The cost for 1 cubic meter of landfill space is € 60, so in this way you can save as much as € 1,382,400 (23,040 X 60) [3].

In addition, it saves on landfill costs of € 22.11 per tonne of waste. In this case, when the total amount of composting waste expressed in tonnes is taken into account, the savings amount to € 254,707 (11,520 X 22.11) [3].

This means that the total economic profit is the sum of all the above components, ie a total of € 2,171,117 (534,010 + 1,382,400 + 254,707) [3].

Ecological benefits of composting technology

Ecological profit, ie the contribution of composting and compost technology in terms of environmental protection is multiple [4]:

1. Preventing the negative effects of organic waste storage in landfills on our ecosystem, because uncontrolled decomposition of organic matter produces very strong toxins - dioxins, either as a product of microorganisms or chemically, whose impact is very negative. During the uncontrolled decomposition of organic matter, substances are formed in the liquid and gaseous state. A part of gaseous substances goes into the atmosphere and creates compounds which, after falling to the surface of the Earth, cause negative consequences (smog, acid rain, etc.). The other part of gaseous substances, which are lighter than air, goes to the ionosphere, where it is the only one with ozone, which directly affects the reduction of this layer. Some of the liquid substances sink through the soil and rocks and pollute the groundwater that feeds the watercourses that are used as the purest water - drinking water. The other part is directly washed away by atmospheric precipitation into watercourses.

2. Composting creates substances needed by the plant and soil ecosystem, carbon dioxide, water, plant growth stimulants, minerals, stable organic matter that is in such a state that plants can use compost, which increases the number of living microorganisms in symbiosis with plants.

3. The use of compost eliminates the need for artificial fertilizers, which is a direct contribution to the production of safe food because compost is the famous organic substrate for its production;

4. The use of compost produces healthy plants because there is no need to treat them with various chemicals, because their natural immunity is restored, fertility is increased, the plants themselves produce more oxygen, which creates preconditions for a healthier life for people and the whole planet;

5. Reducing the amount of organic waste, creating new knowledge about compost and transferring that knowledge as well as their impact on the ecosystem.

6. Compost is an excellent soil conditioner. It improves its structure, nutritional value, looseness, moisture retention capacity. It alleviates the pH value of the soil, reduces erosion, reduces the requirements for the use of artificial fertilizers and pesticides because it suffocates certain plant diseases and parasites. The use of compost reduces the content of weed seeds that are destroyed during composting.

CONCLUSION

Economic and technological development is accompanied by waste generation. The main problem is the limited space for waste disposal. Therefore, it is necessary to renew resources from waste, through material recycling, composting or through the energy of fuel obtained from waste.

Some EU member states still dump 80% of their waste. The 1999 EU directive obliges member states to reduce the storage of organic waste in landfills, progressively over the next 15 years to 35%. Among other things, it is required to actively increase and optimize the recovery of resources from waste, both materials and energy.

Decomposition of organic waste on the body of the landfill produces landfill gas, which usually consists of 55% methane and 40% carbon dioxide. Methane is the gas that has the greatest effect on creating the greenhouse effect. Rain and groundwater by filtering through waste carry with them into the soil and some undesirable substances, such as some acids that contaminate the soil, which is thus permanently contaminated.

Recycling materials can solve the problem to some extent. The option of burning materials is expensive and not very accepted by the people, so we are left with composting as the most acceptable option.

As there is less and less free land, there will be more and more pressure for composting organic waste. As the soil becomes increasingly impoverished by cultivation, compost will be needed in increasing quantities to maintain fertility. Landscapes, farms, public institutions and individuals require high quality compost. As the cost of waste disposal increases, composting is becoming an increasingly financially attractive technology, as a source of income.

The ecological benefits of composting technology as a method of organic waste management are reflected in less pollution of water, air and soil. Raising the level of quality of the environment, without waste, is extremely important. The application of technology of biological origin is both an ecological and human need, either locally to get rid of dirt, garbage and waste, or globally to reduce the presence of methane and carbon dioxide in the atmosphere and thus reduce global warming and combat the greenhouse effect.

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**M. Sc. Bratimir Nestic¹, M. Sc. Predrag Umicevic¹, B. Sc. Nenad Nestic³,
B. Sc. student Luka Nestic¹, M. Sc. Nemanja Petrovic², M. Sc. Natalija Totic²,
B. Sc. Dusan Milincic², B. Sc. Aleksandar Aleksic², M. Sc. Dusan Stevanovic²**

¹ University in Nis, Occupational Safety Faculty, Nis, Serbia

² Academy of Technical-Educational Vocational Studies - Department, Nis, Serbia

³ City Administration, Krusevac, Serbia

E-mail: bratimir@gmail.com

АНАЛИЗА ТРОШКОВА И ДОБИТИ ПРЕДЛОЖЕНЕ ТЕХНОЛОГИЈЕ КОМПСТИРАЊА У КОМПАНИЈИ РWW

Абстракт

Човек је једино биће на планети које свесно ствара отпад. Због све већих количина и штетности по животну средину, отпад се сматра једним од најзначајнијих еколошких проблема савременог света. Човек је са својим активностима одлучујући чинилац у промени животне средине. Све те активности су повезане са задовољавањем животних потреба. Велики део потреба је створен вештачки и питање је да ли нам је потребан толики број различитих производа, који ће након употребе постати отпад.

Наша цивилизација производи све више отпада и ништа не указује на скоре промене овог тренда. Ипак, захваљујући технолошком напретку и развоју еколошке свести, борба против отпада постаје много успешнија. Настајање отпада је резултат укупне економске активности сваке државе и као такво у директној корелацији је са националном економијом.

У раду је приказана анализа трошкова и добити предложене технологија компстирања биоразградивог отпада у компанији РWW. Ова технологија представља једну од широко заступљених технологија за добијање компоста, производа који се заслужено назива "црно злато". Важност овог процеса потврђује се тиме што се и у школама, на пример, у Енглеској, учи како се правилно спроводи технологија компстирања.

Кључне речи: *анализа, трошкови, добит, технологија, компстирање*

**FOOD STORAGE, TRANSPORTATION
AND PACKAGING**



**Dragana Stanisavljević¹, Violeta Mickovski Stefanović², Predrag Ilić³,
Milić Vojinović¹, Sonja Simić⁴**

¹ Academy of Vocational Studies Southern Serbia – Department of Agricultural
and Food Technology, Prokuplje, Serbia

² Institute "Tamiš", Pančevo, Serbia

³ University of Nis, Faculty of Philosophy, Niš, Serbia

⁴ University of Novi Sad, Faculty of Technology, Novi Sad, Serbia

E-mail: draganastanisavljevic72@gmail.com

PACKAGING IN FOOD PRODUCTION AND PROCESSING

Abstrakt

Agriculture is a strategic branch of the economy of every society because it supplies the population with food. Customers are increasingly attaching importance to product quality assurance, nutritional value, geographical origin, as well as product safety itself. Branding of agricultural products, as well as processing, adds value to the products. It allows customers to consume products of a particular geographical area, produced in the way they want, and whose price they are willing to pay. The quality and health safety of food is also affected by the packaging in which it is stored and distributed. Well-designed packaging is essential for the proper positioning of products on the market, and well-created packaging is the first step in building a brand.

Keywords: *packaging, brand, food safety, design, law*

INTRODUCTION

Agriculture is a strategic branch of the economy of every society because it supplies the population with food. The path of food from the field to the table can be long, so it is not unusual that certain products lose their quality due to a large number of intermediaries (Zakić and Stojanović, 2008). In order for the product to be recognized on the market for its quality and taste, branding is essential. The world market is increasingly looking for health-safe, biologically more valuable and ecologically clean,

natural food (Vlahović et al., 2010). Customers are increasingly attaching importance to product quality assurance, nutritional value, geographical origin, as well as product safety itself. With the change of lifestyle, consumer demands are increasing, people's taste is changing, and more focus is placed on product quality and safety. So it is in that change that there is a chance to create value-added products for which the consumer is willing to pay a higher price. The process of adding value can include two processes, as follows: 1) Physical transformation of raw materials like cheeses, ajvar, sausages, and other food products of changed shape or 2) Creating an image of added value in the minds of consumers in the form of branding, when sophisticated needs of consumers that the product is environmentally friendly, high quality, specially packaged or, has other values for which the consumer is willing to pay a higher price are creatively met (made in a particular area, according to the original recipe organically, with the welfare of animals in mind, etc.) Certainly, producers who decide to make additional efforts to produce quality products expect the consumer to recognize their efforts. The term brand was taken over from American farmers, who branded cattle mostly with initials, to protect them from theft (Emblem, 2012). It later became synonymous with quality, based on which consumers decide whom to trust. Branding and processing add value to products, and enable customers to consume the product of a particular geographic area, produced in the way they want, and whose price they are willing to pay (Djordjevic et al., 2014). The most common branding in our country is 1) branding of organic products that guarantee healthy, natural, and correct food for modern consumers, food that is produced without or with a minimum of chemicals with optimal use of natural resources. 2) Branding products with protected geographical origin - as a way to preserve and emphasize the uniqueness of these products have.

Branding in agriculture is based on the connection between the consumer's desire for quality guarantee and the desire of producers to get added value for the original product. A successful brand consists of "a recognizable product, service, person or place, whose value is increased in such a way that the customer or user perceives it as relevant, unique, sustainable added value, which meets their needs in the best way" (Chenatony, 2002). The food brand provides consumers with healthy, organic, local food, and the producer itself if they are committed to the brand, recognition, reputation, and exclusivity.

THE ROLE OF PACKAGING IN THE SALE OF CONSUMER GOODS: GOOD PACKAGING – BETTER SALES

The extent to which the brand of agri-food products will be successful depends on how its positioning was performed and, among other things, the possibility of the brand's influence on emotions and senses, adequate choice of visual identity elements, and the like. The packaging is a product whose primary function is to protect packaged contents (Risch, 2009). The packaging is an intermediary between the buyer and the manufacturer. It is the seller of the product and represents advertising, i.e., the primary type of promotion at the place of sale because the first contact between the customer and the product is visual. The Law provides the essential criteria that packaging present

on the territory of the Republic of Serbia must meet on Packaging and Packaging Waste (2009, 2018).

Well-designed packaging is crucial for the appropriate positioning of products on the market, among wholesalers and retailers, and then among consumers, which is the goal. It should be said that design arose from a need to create a visual identity of the product (Spahić 2008, 6–9).

Well-created packaging is the first step in building a brand if the creation of the product itself with the necessary quality features is seen as a starting point in this process. There has never been a more substantial offer of goods in stores in Serbia than today. Among the domestic products, there are those with the packaging of outdated design, but also those whose packaging has a more modern look. Regardless of the overall lag, one gets the impression that producers from Serbia started to pay attention to packaging as well, and not only to product quality and price.

When more and more goods are on the shelves, the priority goal is to separate products from the competition. One of the essential roles of well-designed packaging is precisely to influence the customer to notice, pick up, and then buy precisely that product in the presence of similar and approximately equal products. The design must be visually attractive to potential consumers and add value to the product in the eyes of consumers. The design contributes to increasing the prestige of the product. Good design targets the emotions of a potential buyer, who, in a considerable number of cases, will choose a product whose packaging is more beautiful, unless there is a drastic price difference. The packaging industry is characterized by innovation and a permanent need for the development of new materials and packaging conditions, in order to follow the changes in people's life habits and ensure the production of safe food (Han et al., 2018).

COMMUNICATION OF PACKAGING WITH THE CONSUMER

Communication is a skill that is present exclusively in the interaction of living beings, communication of packaging with the consumer is a personification of the advisory role of packaging material. The product declaration, which is almost exclusively on the surface of the packaging material, is the most descriptive part of the packaging. It must contain the data prescribed by the Rulebook on declaring, labeling, and advertising of food (Official Gazette of RS, 19/2017 and 16/2018).

As consumers have become more health and nutrition awareness, the promotion of nutritional and health benefits as a primary message has become increasingly common. The labeling of nutritional data on product packaging changed significantly in the early 1990s after the entry into force of the NLEA (Nutrition Labeling and Education Act) law in the United States (Balasubramanian et al., 2002.).

According to NLEA, packaged products should emphasize nutritional data in a particular format. Consumers want to be provided with information at the point of purchase to understand how the product affects their diet, understanding certain risks and various diseases, all of which should reduce the risk of product selection. Food

producers are required to clearly state the energy value of the product in order to make it easier for consumers to control their energy intake. The GDA (Guideline Daily Amounts) or Guideline for Daily Calorie Intake labels the nutritional value of a product per serving and is displayed on the product packaging.

In 1990, the Food Association of America, which was eventually accepted in most European countries and present on more than 1.400 types of products, launched the PLU coding system (*Price Look-Up*) which can be used to determine which food group the product belongs to and how the plant from which it was made was grown. The PLU code directly indicates the method of production, whether conventional, organic, or GMO. If the PLU code contains only four digits, it means that the fruit was obtained by conventional production using pesticides. If the PLU code contains five digits and starts with the number 8, it means that the fruit or vegetable is genetically modified. If the PLU code contains five digits and starts with the number 9, it means that it is obtained by organic production. The Clean Label (CL) movement is an organization that is driven by consumer demands for the production of quality and authentic food, which contains easily recognizable natural ingredients, without the use of artificial ingredients or food additives (Go Clean Label, 2018). There is currently a list of over 200 ingredients that should not be present in food if it is declared with the Clean Declaration label. Law on General Use Items "Official Gazette of RS," no. 25/2019 regulates the concept of items of general use, health safety requirements, which must be met by items of general use that are delivered to the market, in order to ensure a high level of protection of life and health of people and the environment, consumer protection and freedom of movement goods. The provisions of this law also apply to raw materials and additives used for the production of general use items, in accordance with this law and regulations governing the said areas. The Law on General Product Safety ("Official Gazette of RS," No. 41/2009 and 77/2019) regulates general product safety, criteria for assessing the conformity of products with the general safety requirement, obligations of manufacturers and distributors, conditions and manner of information and exchanging information regarding the risks that the product poses to the health and safety of consumers and other users, as well as performing supervision to make products placed on the market safe. This law also regulates the prohibition of production, import, export, and trade of deceptive products, which, with their deceptive appearance, endanger consumers' health and safety.

PACKAGING AND HEALTH FOOD SAFETY

Food safety is becoming one of the primary preoccupations of contemporary people. The industrialization of agricultural production and the use of agents such as additives, hormones, pesticides, antibiotics, etc. have led to consumer dissatisfaction and loss of trust in the institutions in charge of controlling food safety in the European Union. Due to that, the high demand for health-safe food is increasing every day. The Law regulates food safety in the Republic of Serbia on Food Safety, and the prescribed international standards are selectively applied. Food safety is becoming increasingly important in all food industries (production, processing, packaging, storage, transport,

and outlets). The path of many food products, from the place of origin to the end-user, in current conditions of purchase, is unthinkable without packaging. The quality and health safety of food is also affected by the packaging in which it is stored and distributed. Food packaging is expected to preserve nutritional properties and protect foods from various mechanical-physical, chemical, and microbiological influences. The packaged product must be in accordance with the declaration written on it and the expiration date. It is crucial that the packaging material, which is in contact with the product (food), ensures the product's health safety. In line with the European Commission (The Framework Regulation, 2004), there are four primary recommendations for packaging materials that ensure food safety (Schöfer, 2010): 1) Packaging materials in contact with food must not endanger human health; 2) Packaging materials in contact with food must not unacceptably change the content of the food; 3) Packaging materials in contact with food must not change the taste, smell, or texture of food; 4) Packaging materials in contact with food must be produced following the principles of good manufacturing practice (GMP).

CONCLUSION

The branding process is a demanding job that requires full commitment and documentation at every stage of food production and processing. Branding of food products and that is the mark of geographic origin, as well as organic certification and application of standards, gives added value to the product, guarantees the quality of the product and its health safety. The brand also reveals that a specific, protected recipe has been applied, and sends a message to the consumer that it is safe, healthy, controlled, and checked. In food products, packaging design has become increasingly important. Contemporary design, along with the quality and price of products, plays a crucial role in placing products on the market and strengthening the competitiveness of companies (Porter 2007, 54). Based on the presented, it can be concluded that the design and quality of product packaging are just as important as the quality of the packaging content, in agriculture and food processing. Before presenting the product to the market, it is necessary to think well about how the product will "reach" consumers. Health and proper nutrition are areas of life in which all of society's subjects are interested, precisely because of the clear awareness that health is an extremely fragile and volatile category. The quality and health safety of food is also affected by the packaging in which it is stored and distributed.

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**Dragana Stanisavljević¹, Violeta Mickovski Stefanović², Predrag Ilić³,
Milić Vojinović¹, Sonja Simić⁴**

¹ Akademija strukovnih studija Južna Srbija, Odsek
za poljoprivredno-prehrambene studije, Prokuplje, Srbija

² Institut "Tamiš", Pančevo, Srbija

³ Filozofski fakultet, Niš, Srbija

⁴ Tehnološki fakultet, Novi Sad, Srbija

E-mail: draganastanisavljevic72@gmail.com

AMBALAŽA U PROIZVODNJI I PRERADI HRANE

Rezime

Poljoprivreda je strateška grana privrede svakog društva jer snabdeva stanovništvo hranom. Kupci sve više pridaju značaja garanciji kvaliteta proizvoda, nutritivnoj vrednosti, geografskom poreklu, kao i samoj bezbednosti proizvoda. Brendiranje poljoprivrednih proizvoda kao i prerada dodaje vrednost proizvodima, a potrošačima obezbeđuje konzumaciju proizvoda određenog geografskog područja, proizvedenog na način koji žele, a čiju su cenu spremni da plate. Na kvalitet i zdravstvenu bezbednost hrane utiče i ambalaža u kojoj se ona čuva i distribuira. Dobro dizajnirana ambalaža ima izuzetno veliki značaj za odgovarajuće pozicioniranje proizvoda na tržištu, a dobro kreirano pakovanje predstavlja prvi korak u izgradnji brenda.

Cljučne reči: *ambalaža, brend, bezbednost hrane, dizajn, zakon*



**Ph. D. Petra Tanović¹, M. Sc. Bratimir Nešić Ph. D. Student²,
Anja Tanović B. Sc. Student³, B. Sc. Nenad Nešić⁴**

¹ Higher Education Technical School of Professional Studies, Novi Sad, Serbia

² Faculty of Occupational Safety, University in Niš, Serbia

³ Faculty of Technical Sciences, University in Novi Sad, Serbia

⁴ City Administration, Kruševac, Serbia

E-mail: stevanovic@vtsns.edu.rs

SAFE FOOD AND THE ROLE OF PACKAGING DURING THE COVID-19 EPIDEMIC

Abstract

The food which is consumed, in addition to good looks and taste, should also be healthy. Most consumers consider the composition, nutritional value, shelf life, storage conditions, content of supplements, etc. before consuming food. However, during the covid-19 epidemic, it is necessary to pay more attention to the hygienic handling of food and drinks, in order to prevent the spread of the virus in the best way. This paper presents the results of research on the behavior of the population when consuming food and beverages during an epidemic.

Key words: *food, packaging, food safety, viruses, hygiene habits*

INTRODUCTION

Nutrition is one of the most important factors that affect on human health, working ability and life expectancy. Possessing modern knowledge about nutrition enables each of us to influence the processes in our own bodies and contribute to the quality of life. According to the Law on Food Safety, food is any substance or product, processed, partially processed or unprocessed, and intended for human consumption. It is forbidden to place food that is not safe on the market. Food is not safe if it is harmful to human health and if it is not suitable for human consumption. Food that is taken into the body should meet three conditions: to be sufficient in quantity to provide the necessary energy for work, growth and renewal of cells and tissues, to be diverse, or to contain in the required amount all the necessary nutrients, and perhaps most impor-

tantly to be health safe. However, in recent months, we have encountered a new virus and preventive measures have been applied on a daily basis in order to prevent infection. There are different ways of transmitting the infection, but there are different opinions about food as a carrier of the infection. The paper presents the results of research on the hygienic habits of people when handling food during an epidemic.

FOOD HANDLING AND HYGIENE HABITS TO PREVENT THE SPREAD OF VIRUSES

The food product is a very sensitive food of organic origin, in which, during storage, physical and chemical processes are presented. They have a consequence to change in the quality, sensory and nutritional values of the packaged product. The collection of these changes that occur in foods after production and during storage define the shelf life of food products.

Food can be: of plant origin (cereals, fruits, vegetables), animal origin (meat, fish, eggs, milk, etc.), mineral origin (kitchen salt), synthetic origin (various additives).



Picture 1. Food in the store

Food safety has become one of the basic interests of modern human. Food safety in the Republic of Serbia is regulated by the Law on Food Safety. Prescribed international standards are also applied. The law is prescribed in order to ensure a high level of protection of human life and health and protection of consumer interests. The Law on Food Safety established a chain of control from producers to consumers, in order to ensure food safety, to make sure that on the market every consumer knows that the food he consumes meets all the requirements of health and hygiene of the prescribed quality. Food control is carried out by means of inspection, supervision, monitoring, sampling, checking the application of regulations. Official control includes hygienic conditions in facilities, devices, equipment and accessories, as well as hygienic handling of food and food storage conditions. Control and hygienic behavior of persons handling food is a very important condition in reducing the risk of contamination. People who handle and come into contact with food must have basic knowledge of food and personal hygiene.

The consequences of consuming contaminated food can be unpleasant at best and quickly curable, but at worst they can even be fatal. The experience of a large number of developed countries in the control and prevention of diseases caused by food indicates the importance of preventive action on the dangers that can cause health problems. Knowledge of food hygiene and safety has advanced significantly, and the result of such knowledge is a reduction in the dangers and diseases caused by food contamination.

Foodborne diseases are a significant public health problem across the region. People around the world get sick from the food they eat every day, and more than 250 diseases are transmitted through food. Foodborne diseases are diseases that occur as a result of consuming contaminated food. Food is contaminated if pathogenic microorganisms and / or their toxins are present. Food contamination comes from several different sources, and this is especially pronounced in urban and industrial environments. Food can also be subsequently contaminated in different ways. However, in the last few months, since the beginning of the covid-19 epidemic, more and more considerations can be heard about the possibilities of transmitting the virus through food.

According to the World Health Organization (WHO) and the European Food Safety Authority (EFSA), food safety is not endangered by the COVID-19 virus, if good hygiene and manufacturing practices are applied. At the moment, there is no evidence that this virus is transmitted through the consumption of contaminated food or through contact with contaminated products – it is stated in the informant of the Ministry of Agriculture. However, all food handlers must meet the requirements in terms of good health, without signs of respiratory or any other disease that can contaminate food. In order to avoid the slightest possibility that infected people who produce and handle food can transmit the virus by coughing, sneezing or touching, it is extremely important to follow strict hygiene rules.

Packaging has an important role in food protection, especially during the epidemic. There is no healthy food without a properly selected and adequately applied combination of packaging materials and packaging, which significantly affects the quality and sustainability of packaged products. On the way from the producer to the consumer, the products are exposed to various influences and stresses that can more or less



Picture 2. Packaged food

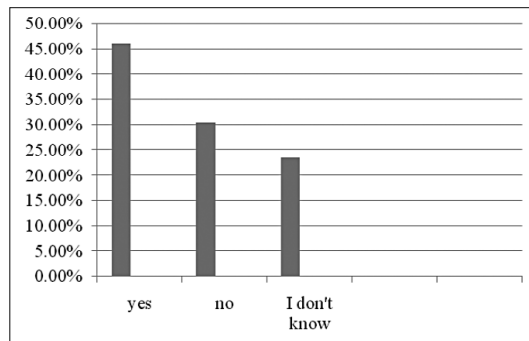
damage or completely destroy them. The task of the packaging is to protect the food on the way as much as possible so that they get into the hands of consumers undamaged. For some products, even that is not enough, but the packaging is required to protect the food for some time with the buyer. The packaging must protect product from various mechanical stresses, atmospheric influences from physical and chemical influences, from the action of microorganisms, insects and rodents. Although it is considered that food is not a way of transmitting the virus, a sick person can infect food in case of coughing or sneezing. During an epidemic, packaging helps prevent the spread of the virus.

According to the WHO, EFSA, the German Institute for Risk Assessment, it is indicated that these viruses survive poorly on surfaces, so there is a very low risk of spreading through food or food packaging, regardless of the temperature at which the food is kept. Research has shown that the virus stays on different materials for different times. It turned out that the virus stays the shortest on cardboard packaging, and a little longer on plastic and metal.

Coronaviruses can generally reach bakery products or fruits and vegetables through an infected person who sneezes or coughs directly at them. Infection of another person is possible if the virus is transmitted soon after by hands or food to the mucous membranes of the mouth, throat or eyes. Bakery products in retail facilities should be protected from sneezing and coughing, as well as touching by customers, which is not provided in most cases. The next chapter presents the hygienic habits of people during the epidemic and their attitudes about food safety.

RESULTS AND DISCUSSION

In order to obtain data on the hygienic habits of people when taking food and their opinion on food safety during the COVID-19 pandemic, a research was done. The research was done in written form. Each of the questions was offered answers that the respondents had to decide on. The aim of the survey is to get an opinion on the possibilities of spreading the virus through food, hygienic habits when handling food, the role of packaging in protecting food from pollution. In the survey participated 115

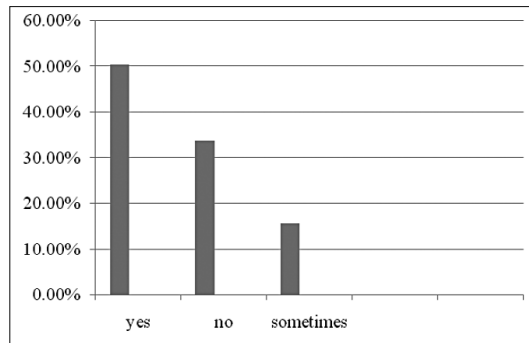


Picture 3. *Opinion on food safety during an epidemic*

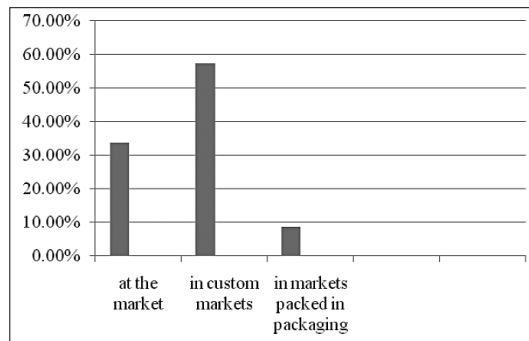
people, of which were 62 female and 53 were male. Respondents were divided into age groups: younger than 18, 18-30, 31-50 and older than 50. The survey was anonymous, which contributed to more realistic answers and thus a better survey result. The questions were compiled by the authors. The questions covered by the survey are shown next to each individual chart. Answers to the question: "Do you think that the COVID-19 epidemic affects food health?" are shown on Picture 3.

The survey results show that 46.1% believe that the covid-19 epidemic can be sustained on food safety. However, 30.4% of respondents think that the epidemic does not make food less safe, while the rest of them do not have an opinion about it. Contrary to the great media attention received by the covid-19 epidemic, more than 50% of respondents are not aware of its impact on food health safety, in everyday life. Answers to the question: "Do you care more about food hygiene at the time of the pandemic than you did at the usual time?" are shown on Picture 4.

In the examined group of people, 50.4% since the beginning of the epidemic have paid more attention to hygienic handling of food than before, while 33.9% think that there is no reason for that. Other respondents only occasionally worry about food hygiene. A slightly higher percentage of respondents pay more attention to hygiene when handling food than before the epidemic. Answers to the question: "Where do you most often buy fruits and vegetables?" are in Picture 5.



Picture 4. Answers about hygiene habits during an epidemic



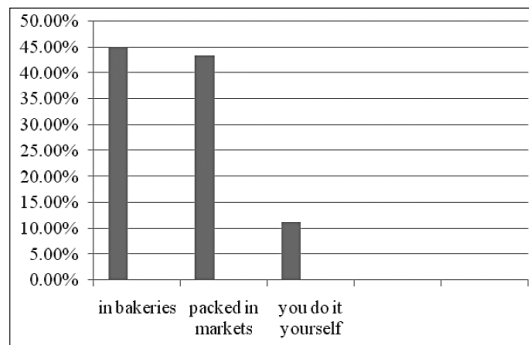
Picture 5. Answers about places of buying fruits and vegetables

More than half (57.4% respondents) buy fruits and vegetables in tailor-made markets, while 33.9% buy these foods at the market. Despite concerns that the virus could be transmitted through food, only 8.7% of respondents buy fruit and vegetables packaged in packaging. They justified the reason for this way of shopping by believing that fruits and vegetables in the tailor-made markets are fresher and it is easier to choose the appropriate product. Answers to the question: "Where do you most often buy bread?" are shown on Picture 6.

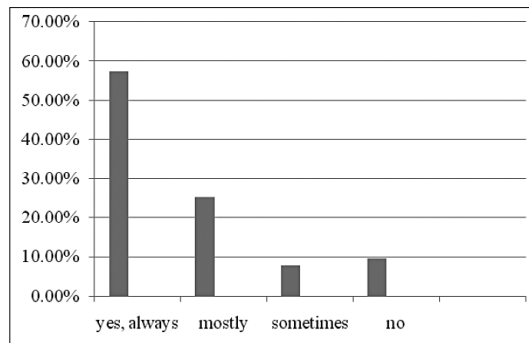
Regarding the purchase of bread, regardless of the fact that bread is on unprotected shelves in bakeries, 45.2% of respondents still buy without thinking about it, while 43.5% buy packed bread. Only a small number of respondents make their own bread.

Answers to the question: "Do you disinfect your hands before consuming food (fruit, fast food, sweets) outside the house (park, beach, restaurant, patisserie) and drinks?" are on Picture 7.

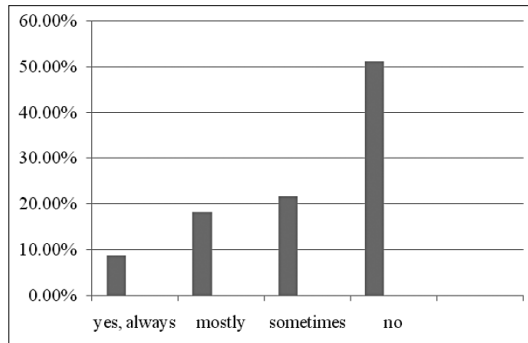
The research shows that the majority of respondents, as many as 57.4%, always disinfect their hands when taking food and / or drinks, 25.2% do it mostly, and the rest sometimes or do not disinfect. These results show that a large percentage of surveyed people care about hygiene when consuming food and drinks, which is important for preventing the spread of the virus. Answers to the question: "Do you disinfect the packaging before opening the food product?" are shown on Picture 8.



Picture 6. Answers about places of buying bread

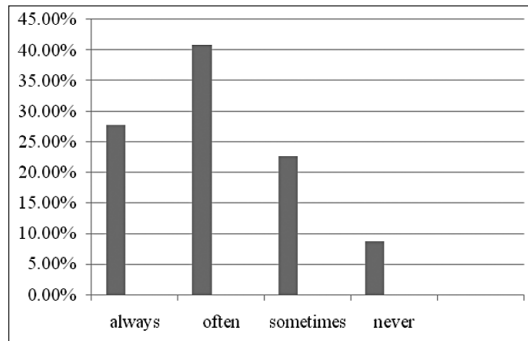


Picture 7. Answers about habits of handling food and drink outside their homes



Picture 8. Answers about handling packaging

The results of the survey show that approximately half of the respondents never disinfect the packaging, 18.3% mostly do so, while only 8.7% always disinfect the packaging before using the food. Answers to the question: "How often do you notice that in grocery stores, employees wearing the same gloves touch both food and money?", are shown on Picture 9.



Picture 9. Answers about the use of gloves in grocery stores

A pronounced problem in smaller stores, where only one employee works, is that the same person adds bread, fruit and other products and also charges for them. About two thirds of respondents noticed that this happens always or often during their shopping.

CONCLUSION

Concern for food became a preoccupation of people during the Covid-19 epidemic. Although the WHO and health institutions say that there is no evidence that the virus is transmitted through food, the results of the research show that about half of the respondents think that the virus can be transmitted through food. Also, approximately half of the respondents care more about food hygiene and wash them in more detail than before. Although they are aware that the packaging protects the product from pol-

lution, most of the respondents buy fruits and vegetables at the market, and bread in bakeries. Only a small number of respondents buy fruits, vegetables and bread in packaging. One third always disinfect their hands when consuming food and drinks when they are in cafes, restaurants or on the beaches. At the end of the survey, many respondents concluded in the comments that more care should be taken about food hygiene and that packaging plays an important role in preventing the spread of infection.

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**Др Петра Тановић¹, Мр Братимир Нешић докторанд²,
Ања Тановић студент³, дипл. инж. Ненад Нешић⁴**

¹ Висока техничка школа струковних студија у Новом Саду, Србија

² Факултет заштите на раду у Нишу, Универзитет у Нишу, Србија

³ Факултет ехничких наука, Универзитет у Новом Саду, Србија

⁴ Градска управа, Крушевац, Србија

Е-пошта: stevanovic@vtsns.edu.rs

ЗДРАВСТВЕНА БЕЗБЕДНОСТ ХРАНЕ И УЛОГА АМБАЛАЖЕ У ВРЕМЕ ЕПИДЕМИЈЕ COVID-19

Абстракт:

Храна која се конзумира, поред лепог изгледа и укуса, треба да буде и здравствено безбедна. Већина потрошача пре конзумирања хране разматра састав, хранљиву вредност, рок трајања, услове чувања, садржај додатака и др. Међутим, у време епидемије covid-19 потребно је посветити више пажње хигијенском руковању са храном и пићима, да би се на најбољи начин спречило ширење вируса. У овом раду дати су резултати истраживања о понашању становништва при конзумирању хране и пића за време епидемије.

Кључне речи: *храна, амбалажа, безбедност хране, вируси, хигијенске навике*



Tanja Žugić-Petrović¹, Katarina Mladenović¹, Mirjana Muruzović¹,
Zorana Žugić², Sunčica Kocić-Tanackov², Vladimir Tomović², Ljiljana Čomić¹

¹ Faculty of Science, University of Kragujevac, Radoja Domanovića 12,
34000 Kragujevac, Serbia;

² Faculty of Technology, University of Novi Sad, Bulevar cara Lazara 1,
21000 Novi Sad, Serbia;

Corresponding author: Tanja Žugić-Petrović,
E-mail: tanja.zugicpetrovic@yahoo.com

EFFECTS OF VACUUM AND MAP PACKAGING ON MICROBIOLOGICAL STATUS AND SENSORY PROPERTIES OF FRESH PORK

Abstract

Improving the process of production and processing, man has continuously improved and packaging technology. Contemporary achievements in technology enable the quality of food produced by various technological processes to be preserved in the chosen packaging. Packaging can significantly affect the shelf life of fresh meat and meat products, and therefore the microbiological status of the packaged product. Vacuum packaging (VP) and modified atmosphere packaging (MAP) are important in ensuring the longer product shelf life without compromising its quality. The aim of the research was to examine the influence of the type of packaging on the speed of on microbiological degradation rate and sensory properties of fresh pork.

Key words: *Fresh pork, MAP packaging, Vacuum packaging, sensory properties*

INTRODUCTION

There is a growing demand on the world market today for fresh, naturally preserved and quality food products that are as little physically and chemically treated as possible during production. This trend imposes a task on manufacturers to pay attention to improving processing methods that extend life and that exclude artificial additives and preservatives. The modern consumer is looking for high-quality food that has retained the sensory characteristics of raw material from which it is produced, and at the same time, it's healthy. In order to preserve the original sensory and nutritional properties of

the raw material in the product, significantly in mild treatments must be applied during its production, especially milder canning procedures. As a rule, commercial sterility is not achieved in such minimally treated food, so, in order to prolong its durability, special attention must be paid to the choice of packaging material (impermeable to gases and moisture) and to the choice of packaging. The most commonly used packaging methods for such products are modified atmosphere packaging, vacuum packaging, and aseptic packaging. In addition to all these precautions and the quality of operations and technological solutions performed in these products, commercial sterility is not achieved, so it is necessary to pay attention to storage conditions, storage temperature, and relative humidity in the warehouse. When it comes to the sustainability of smoked pork, a large number of factors affect the quality and sustainability of this product. The three most important parameters that define sustainability are, the amount of salt and smoke components in the product as well as the way the smoked pork is packaged. Product sustainability depends on initial contamination, production conditions, way of handling the product after the production process, storage temperature, method of packaging. Stopping the growth of bacteria depends on: salt content, temperature, humidity, smoke density, duration of the smoking, the concentration of active substances in the smoke, storage temperature, the method of packaging the finished product (Caglak et al. 2008).

MATERIALS AND METHODS

Preparation and Storage of Samples

The fresh pork-ruža (*m. quadriceps femoris*) were divided into assigned two groups. Approximately 200 g of fresh pork slices were vacuum-packaged or packaged in modified gas conditions. The modified gas mixture was composed of 30% CO₂+70% nitrogen mixture and was produced using a gas mixer (Witt-Gasetechnik GmbH and Co., Witton, Germany). An vacuum packer (Turbovac D40 Vacuum Packing Machine, Orbital Food Machinery Suffolk, UK) was used to seal the pouches. The packaging pouch was made of polyethylene with an oxygen transmission rate (OTR) of 0.5 cm³/m²/atm/24 h at 90% relative humidity. The control consisted of unpackaged fresh pork. All samples were stored in darkness at 7°C, ambient temperature. The samples were opened for subsequent analysis after 1, 7, 14, and 30 days of storage.

Microbiological Analyses

For microbiological analysis, a 25 g sample was aseptically transferred to a 225 mL physiological saline water (0.85 NaCl %, Hemofarm, Vršac, Serbia) in a stomacher (Nasco Whirl-pack; SAD) for 1 min. Serial decimal dilutions using the sterile saline solution were prepared, and duplicated 1 mL samples at appropriate dilution ratio were poured on selective agar plates. Total aerobic bacteria (TAB) were determined on plate Nutrient agar (Torlak, Beograd, Serbia), which was incubated at 30°C for 48 h under aerobic conditions, and Lactic acid bacteria (LAB) on plate de Man Rogosa Sharpe – MRS agar (Torlak, Beograd, Serbia) at 30°C for 48 h under aerobic conditions. *Staphylococcus* spp. were determined on plate Baird Parker – BP (Torlak, Beograd, Serbia), by incubation at 30°C for 48 h. Enterobacteriaceae were determined on *E. coli*

/ Coliform count plate petri-film (3M Health care, St. Paul, MN, USA) at 30°C for 48 h under aerobic conditions. Microbial count determination was performed in triplicate and the experiment was replicated three times.

Sensory Analysis

Two packages of fresh pork-ruža (*m. quadriceps femoris*) and control, per treatment were evaluated for odor and overall appearance by an untrained sensory panel. A group of six evaluator formed a panel to evaluate sensory properties. The panelists were instructed to record the appearance of the sample using a 5-point scale where 5 = extremely desirable, 4 = desirable, 3 = undesirable, 2 = very undesirable, and 1 = extremely undesirable.

RESULTS AND DISCUSSION

Microbiological Analysis

The results of microbiological tests of fresh pork- ruža, and pork packed in VP and MAP are shown in Figures: 1, 2 and 3.

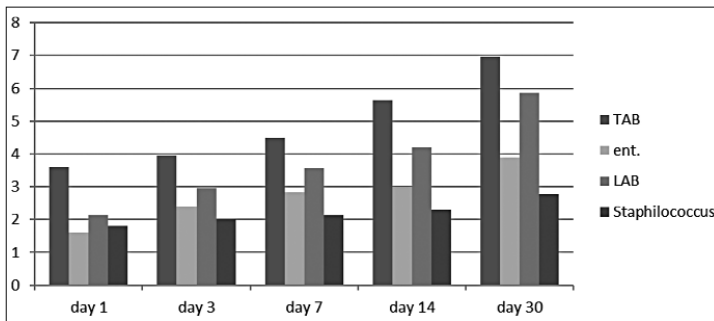


Fig 1. Kinetics of microorganisms in samples of fresh pork tenderloin in VP packaging

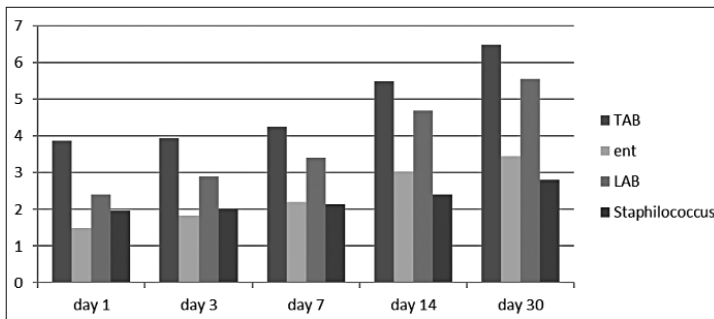


Fig 2. Kinetics of microorganisms in samples of fresh pork tenderloin in MAP packaging

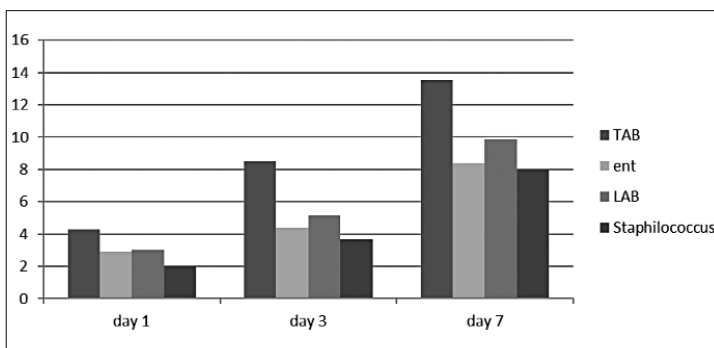


Fig 3. Kinetics of microorganisms in samples of fresh pork tenderloin no packaging

The total number of pork bacteria in the VP on the first day of the study had a value of 3.6 log cfu / g, while the number of Enterobacteriaceae ranged up to 1.6 log cfu / g. The number of LAB on the first day of the study was 2.13 log cfu / g, and the number of *Staphylococcus* spp. was 1.8 log cfu / g. These results indicate good hygienic practice of slaughter and meat processing. The number of bacteria of fresh pork packed in VP increased approximately 3, 7, 14 days of the study the highest value was reached in 30 days of the study, and was for TAB, 6.95 log cfu / g, the number of Enterobacteriaceae had a value of 3.89 log cfu / g, LAB was 5.86 log cfu / g, and the number *Staphylococcus* spp. was 2.78 log cfu / g. LAB represents the dominant microbial population of vacuum-packed meat products (Jones, 2004). Franz and Von Holy (1996) emphasize the dominance of the bacterial population isolated from vacuum-packed Viennese sausages, which were pasteurized and unpasteurized, stored at 8°C for 128 days. The majority (> 52%) of isolates from pasteurized and unpasteurized sausages were first LAB, followed by *Bacillus*, *Staphylococcus* and Enterobacteriaceae. Higher concentrations of CO₂ gave better results, CO₂ prolongs lag phase of bacterial growth and increases generation time (Arashisar et al., 2004). The total number of bacteria in the samples of fresh pork packed in MAP packaging, showed a gradual growth. On the first day of the study, the number of TAB was 3.88 log cfu / g, while the number of Enterobacteriaceae was 1.5 log cfu / g, LAB was 2.4 log cfu / g, and the number of *Staphylococcus* spp. was 1.96 log cfu / g. In the case of MAP packaging as well as in VP packaging, the number of packages increased for 3, 7, 14 days of research. The total number of meat bacteria packed in MAP packaging, as expected, reached the highest value of 30 days of research. For TAB, it ranged up to 6.5 log cfu / g, the number of Enterobacteriaceae to 3.45 log cfu / g, for LAB it was 5.55 log cfu / g, and the number of *Staphylococcus* spp. was 2.8 log cfu / g. Based on the presented results, we can conclude that there are no statistically significant differences in the number of bacteria in the packaging of VP and MAP pork fresh meat-Shola. Irkin et al. (2011) have also emphasized MAP application was more effective in retarding the rate of TVC, psychrotrophs, coliforms, yeast and mold growths on minced beef meat during storage compared with vacuum and air packages.

Uzunlu and Var (2016) reported, MAP affected the growth of bacteria were recorded slightly ($<1 \log \text{CFU} / \text{g}$) until day 5 in all package compositions, which reached to the countable values (approx. $1 \log \text{CFU} / \text{g}$) on day 7. Ozturk et al. (2010) in their paper point out that the total microbial the population of beef packed in different packaging remains unchanged for 7 days, after which the number of bacteria slowly increases. In freshly unpackaged pork, the total number of bacteria or TAB on the first day of the study was $4.30 \log \text{cfu} / \text{g}$, the number of Enterobacteriaceae was $2.90 \text{ cfu} / \text{g}$, and $3.00 \log \text{cfu} / \text{g}$ for LAB and $2 \log \text{cfu} / \text{g}$ for *Staphylococcus* spp. On the third day of the research, the number of bacteria was significantly increased in the samples of unpackaged pork, after 7 days, a defect of pork was detected when the continuous monitoring of the change in the number of investigated bacteria was interrupted.

Sensory Analysis

The results of the sensory analysis of fresh pork packed in VP and Map are shown in Fig 4; 5 and 6. On the first day of testing in VP and MAP, sensory properties inherent were ascertained fresh pork.

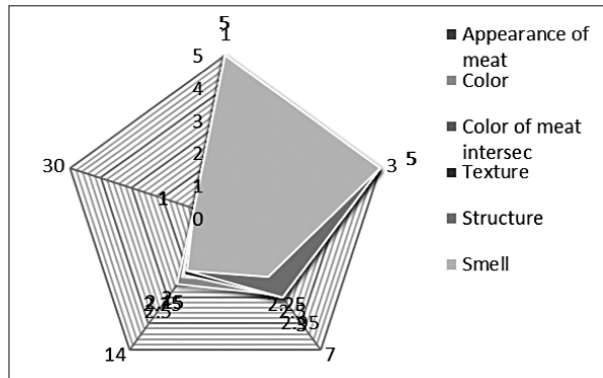


Fig 4. Sensory evaluation of fresh pork tenderloin in VP

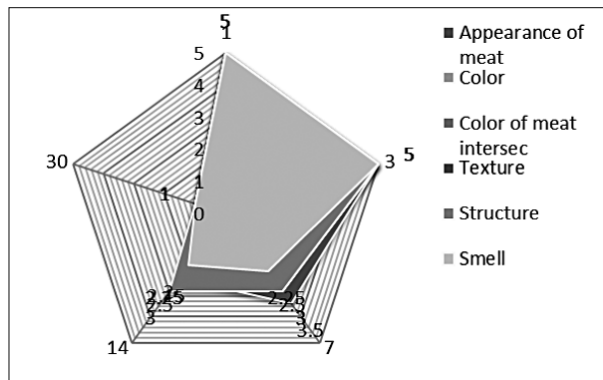


Fig 5. Sensory evaluation of fresh pork tenderloin in MAP

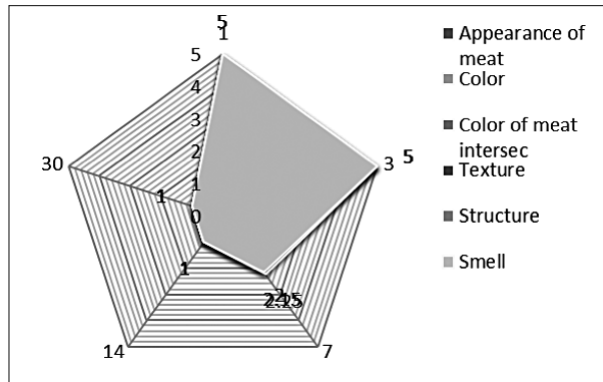


Fig 6. Sensory evaluation of fresh pork tenderloin no packaging

On the surface, as well as in the central parts of the sample, the smell was characteristic of fresh pork, without foreign impurities. The flesh was red-pink in color, and the associated adipose tissue was white. Organoleptic characteristics of pork samples were preserved in VP and MAP packaging for up to 7 days of research, without significant changes in color, consistency, structure and other sensory characteristics, the average score of the sensory examination was 5 (Fig. 4; 5). From 14 to 30 days, there is a change in the organoleptic characteristics of fresh pork, which is reflected in the change in color, smell, structure and consistency. Ratings of fresh pork packed in VP packaging 14 days of testing, the appearance of the meat, the color of the meat on the surface, the color of the meat on the cross-section and the smell of fresh meat, ranged from acceptable and ranged from 2 to 2.25 (Fig. 4). On the thirtieth day of testing, fresh pork packed in VP packaging after opening, the surface was slimy and sticky, with an unpleasant odor and intense discoloration of the meat on the surface and in the cross-section. A visible cloudy turbid liquid with an unpleasant odor was noticed, and on the surface and on the sections of pork, the smell was uncharacteristic and indicated a defect. Fresh pork packed in MAP packaging for 14 days of testing was evaluated with scores ranging from 2.15 to 3 (Fig. 5). On the thirtieth day of testing, fresh pork packed in MAP packaging after opening, changes in color and odor were observed on the surface of the meat, with a less pronounced but slightly unpleasant odor. Based on the organoleptic characteristics, it was concluded that fresh meat packed in MAP packaging started the process of spoilage. Unpackaged pork used as a control retained its own characteristics until the seventh day of the study (Fig. 6). Martinez et al. (2006) conclude that packaging of fresh pork sausages without the presence of oxygen, packaged either in VP or in MAP, has led to an extension of shelf life in terms of color and odor stability as a consequence of low oxidation rate. The results of Kim et al. (2014) indicated that VP preserved the quality of dried pork better than MAP, especially in terms of color change, lipid oxidation, pH, and consistency.

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**Тања Жугић-Петровић¹, Катарина Младеновић¹, Мирјана Мурузовић¹,
Зорана Жугић², Сунчица Коцић-Танацков², Владимир Томовић²,
Љиљана Чомић¹**

¹ Природно-математички факултет, Универзитет у Крагујевцу,
Радоја Домановића 12, 34000 Крагујевац, Србија;

² Технолошки факултет, Универзитет у Новом Саду, Булевар Цара Лазара 1,
21000 Нови Сад, Србија;

Аутор за контакт: Тања Жугић-Петровић,

Е-пошта: tanja.zugicpetrovic@yahoo.com

ЕФЕКТИ ВАКУУМСКЕ И КАРТОНСКЕ АМБАЛАЖЕ НА МИКРОБИОЛОШКИ СТАТУС И СЕНЗОРНА СВОЈСТВА СВЕЖЕ СВИЊЕТИНЕ

Абстракт

Побољшавајући процес производње и прераде, човек је континуирано унапређивао и технологију паковања. Савремена достигнућа у технологији омогућавају очување квалитета хране произведене различитим технолошким процесима у изабраној амбалажи. Паковање може значајно утицати на рок трајања свежег меса и месних производа, а самим тим и на микробиолошки статус пакованог производа. Вакуумско паковање (ВП) и паковање са измењеном атмосфером (МАП) су важни за обезбеђивање дужег рока трајања производа без угрожавања његовог квалитета. Циљ истраживања био је испитати утицај врсте амбалаже на брзину микробиолошке разградње и сензорна својства свеже свињетине.

Кључне речи: *Свежа свињетина, МАП паковање, вакуумско паковање, сензорна својства*

**NUTRITIONAL FOOD VALUE
AND QUALITY NUTRITION**



Agota Vitkay-Kucsera

University of Novi Sad Academy of Arts, 21000 Novi Sad, R. Serbia

E-mail: agowit@hotmail.com

PROPER NUTRITION FOR ELITE VOCAL PROFESSIONALS

Abstrakt

For an elite vocal professional, it is extremely important to understand, comprehend and determine how much effort (vocal and physical) singing requires. In addition to vocal hygiene, voice care and general health, adequate vocal-physical preparation, choosing a good nutrition programme are the key factors for achieving and maintaining optimal results, getting into shape, knowing how to use and distribute strength in accordance with the requirements of the role or recital. This all affects the preservation of vocal and physical condition and general health. If elite vocal professionals are not adequately prepared, fatigue and possible illness can occur.

Key words: *elite vocal professionals, nutrition, hydration*

INTRODUCTION

The vocation of elite vocal professionals (concert and opera singers), although it requires great sacrifices from the individual, such as avoidance of staying in smoky and noisy rooms, enjoyment and consumption of cigarettes, opiates, excessive amounts of alcohol and certain foods, it has positive effects on the development and preservation of psychophysical personality components. To successfully pursue this vocation, it is important to have good vocal and physical predisposition and condition, good health, commitment to vocal art, strong motivation, perseverance, regular vocal trainings (work on mobility, sonority of voice, equalization and expansion of voice range, endurance, etc.) and adequate nutrition, which implies a good fluid balance and energy maintenance.

Due to higher energy consumption, elite vocal professionals, just like athletes, have increased nutritional requirements. In addition to talent and predisposition, it is impor-

tant to have a healthy mental and physical state where one of the important factors is adequate nutrition. The diet of elite vocal professionals must be adapted to body characteristics (height, weight, gender, age), metabolic information, heart rate, tendency to gain or lose weight, frequency, intensity and length of rehearsals and / or performances, whether it is a concert or a play. A well-balanced diet (macro and micronutrients) with adequate hydration can be crucial for good performance and maintaining the health of both the vocal tract and the overall health of elite vocal professionals.

VOCAL "ATHLETES"

Elite vocal professionals (EVP) are like athletes, because they are expected to move on stage, they use a large amount of air and control its release, they sing more intensely to overpower the orchestra, but not so as to damage the voice, they use almost the entire range of their voice, they usually wear heavy costumes and do all this under the hot spotlight and in front of a large audience. Plays (as well as rehearsals) last for several hours, and during those hours no food is ingested, and they rarely take fluid. There is little research on the energy consumption of elite vocal professionals, thus given the difficulty of the job and the growing challenges they face (demanding directions) further research is necessary. According to Vicki L. St. Pierre, professional opera companies such as San Francisco, the Canadian Opera Company and the English National Opera, employ fitness instructors and nutritionists in order to bring opera singers to top physical and, therefore, vocal results in this profession. In addition, attention is paid to maintaining the achieved results. The mentioned author also conducted research upon realising that there are no studies, nor specially designed programmes for calculating the required or consumed calories of opera singers, as is the case with athletes. The question is, therefore, how opera singers can know what food and in what quantity to take, when they do not know how much energy they need and how much energy they expend during a rehearsal or performance (concert or play). Research conducted by Vicki L. St. Pierre was focused on expenditure of energy in the middle of singing an opera aria in the duration of 2:50 minutes during rehearsals and during performances. Although the sample was small, only six people (3 women and 3 men), the study showed that the average heart rate during the rehearsal was 128 bpm (number of heart contractions per minute), and that the average energy consumption was 22,5 calories. During the performance of the same aria in the play, the average heart rate was 138 bpm, and the average energy consumption was 28,5 calories. (<https://tspace.library.utoronto.ca/handle/1807/76555>). The purpose of this research was to discover the most appropriate and accurate way to test the number of calories that a professional classical opera singer burns while singing an aria at rehearsals and as part of a play. The conclusion is that, although the EVP vocation is extremely tiring, not enough attention has been paid to them in the form of measuring the required and consumed energy, and the choice, method and dosage of diet, as is the case with professional athletes.

NUTRITION

The nutritional needs of each person differ in different stages of life and depend on the person's age, gender, health and physical condition, level of physical activity and environmental conditions. Nutrients are divided into two categories: macro and micro nutrients (<https://www.zamrvicubolji.com/ishrana/2018/10/7/makronutrijenti-osnove-ishrane>).

1. Macronutrients are nutrients that are ingested in large quantities, mostly expressed in grams.
2. Micronutrients are nutrients that are ingested in small amounts, mostly expressed in milligrams. These are vitamins and minerals.

Macro and micro nutrients, as well as water, are necessary for the development and regulation of bodily processes (<https://kodren.com/zdrava-ishrana/760-%C5%A1ta-su-to-mikro-i-makro-nutrijenti.html>).

Body needs macronutrients in large quantities, because they provide it with energy. These include carbohydrates, fats and proteins.

The nutrients that should be ingested are as follows:

1. Proteins: meat, fish, eggs, beans, peas, green beans, lentils, pumpkin, hemp seeds, coconut, soy products.
2. Carbohydrates: cereals, legumes, brown rice, vegetables, fruits.
One should limit the intake of sweets, because they contain simple sugars, and very few vitamins, minerals and fibres.
3. Healthy fats: nuts, olive oil, fish, fish oil, avocado.

You should limit the intake of unhealthy fats, that is, avoid fried food, margarine, mayonnaise, various industrial sauces.

It is important to point out the caloric value of certain groups:

- Fats – 9 calories per gram.
- Carbohydrates – 4 calories per gram.
- Protein – 4 calories per gram.
- Alcohol – 7 calories per gram.

MACRONUTRIENTS

The energy needed for cell functions during rest and muscle effort is obtained by the body from carbohydrates, fats and proteins. During muscular effort (whether elite vocal professionals or athletes are in question), the relative share of fuel in energy production depends on the intensity and duration of vocal exercises, as well as nutrition and activity levels during rehearsals, concerts and/or plays.

In order to provide energy elite vocal professionals should consume enough carbohydrates which satisfies most calorie needs and thus achieve optimal performance

and allow muscle recovery after vocal (and physical) activity. In the period of more intense rehearsals and / or performances, carbohydrate intake should be significant, because energy metabolism relies on them as a source of energy muscles need.

If the level of carbohydrates is low during vocal activities (rehearsals, performances), a feeling of exhaustion appears very quickly. Bloating and gases are problems often caused by food with higher amount of fibres, so such food should not be consumed before rehearsals or performances. It is definitely recommended that elite vocal professionals determine for themselves which food they tolerated best.

When it comes to fats, they are more concentrated forms of energy than both carbohydrates and proteins. Elite vocal professionals need less food if they intake food that contains more fat, and at the same time has more energy, and thus improves endurance. Care should be taken not to get more fat than necessary, because that increases the risk of atherosclerotic heart disease.

Milena Tomanić (http://www.adas.org.rs/wp-content/uploads/2016/09/MP_67_Vol_No_2-.pdf#page=23) notes in her research that the intake of omega 3 fatty acids accelerates aerobic metabolic processes, which has a positive effect on an individual's ability to use fat efficiently as an energy fuel. The author points out that the total fat intake should not be increased from what is necessary for the body, but that it would be desirable to include salmon, tuna, herring and other sea fish in the diet, once or twice a week, in order to increase the amount of omega 3 fatty acids.

Proteins are the building blocks necessary for the growth and regeneration of all living cells. More than 50% of each cell consists of proteins that are responsible for the development of muscles, bones and tissues. We distinguish between animal proteins and plant proteins. Products that are the richest source of protein include foods of animal origin and dairy products. The richest, and also the healthiest, sources of protein are lean meat and fish, vegetables, fruits and legumes – they contain less fat, and are therefore healthier. Red meat contains a lot of fat, so it is not recommended in the daily diet (http://www.adas.org.rs/wp-content/uploads/2016/09/MP_67_Vol_No_2-.pdf#page=23).

Although carbohydrates and fatty acids are the sources of energy during vocal training and performance, the more intense (or longer) the rehearsal, concert or play is, the muscle glycogen reserve decreases, and proteins start to be used. EVPs lose a small amount of proteins during rehearsal, performance and / or play – vocal and physical exhaustion, as well as through urine, and need extra amounts to recover from muscle damage that occurs during vocal exhaustion. It should be noted that the consumption of high-protein foods is not recommended before or during vocal use, because they have a low rate of gastric emptying.

MICRONUTRIENTS

Vocal training, as well as the performance itself, causes "depletion" and loss of micronutrients from the body, hence the need for their greater intake due to their role, which is reflected in taking part in building, repairing and maintaining muscle tissue in elite vocal professionals.

The micronutrients include minerals, vitamins and trace elements. They are essential for the functioning of the human organism.

1. Vitamins are categorized by their absorption in the body – they decompose in water (vitamin B1, B2, B5, B6, B 12, vitamin C, folic acid, biotin), or fat (vitamins A, D, E and K).
2. Essential minerals: calcium, potassium, magnesium, sodium, iron, phosphorus, sulphur.
3. Trace elements in our body: chromium, cobalt, selenium, zinc, iodine, fluoride, manganese, silicon, boron, copper.

Micronutrients (vitamins and minerals) are essential nutrients that participate in numerous physiological functions, but also in the synthesis and repair of muscle tissue. Given that the profession of opera singer is stressful and extremely demanding, both physically and mentally, it is necessary to take in several different types of vitamins and minerals.

HYDRATION

"Good hydration enables the maintenance of the balance of intracellular and extracellular fluid in the body and forms the basis for the uninterrupted performance of physical (vocal) activity"
(http://www.adas.org.rs/wp-content/uploads/2016/09/MP_67_Vol_No_2-.pdf#page=23).

During intensive vocal production (rehearsals, concerts, plays), a large amount of sweat is released, which leads to dehydration. Elite vocal professionals should replenish fluid to maintain the state of water in the body. If the fluid is not replenished, premature exhaustion occurs with the possibility of vocal damage, because the moisture of the vocal cords enables their better mobility (the higher the degree of hypohydration, the negative impact is more pronounced). Normal or higher moisture of the vocal cords reduces the possibility of injuries, dilutes thick secretions and enables faster recovery after exhaustion. It is recommended to consume a minimum of eight glasses of water a day. People who are more physically active should drink more water than recommended. Insufficient fluid intake affects the retention of secretions, causes dryness of the throat, pharynx and increases irritation. Instead of carbonated drinks and large amounts of coffee, which should be avoided, hydration of the body should be provided by the intake of plain water (<http://nardus.mpn.gov.rs/bitstream/handle/123456789/11102/Disertacija.pdf?sequence=6&isAllowed=y>: page 73). Water is a very important nutrient, and it is extremely important for every organism. "The human body can survive a few weeks without food, but only a few days without water. Our body consists of 50 to 75 percent of water, it forms the base of blood, digestive juices, urine and sweat, but it is also a part of muscles, fat and bones. We need water to stay healthy and give the bloodstream enough fluid for blood to flow through blood vessels, to eliminate toxins from the body, regulate body temperature through sweating, "lubri-

cate" joints, reduce the risk of cystitis by cleaning the bladder of bacteria, help digestion and prevent constipation, give the face and skin a healthy look and to help transfer nutrients and oxygen to the cells" (<https://kodren.com/zdrava-ishrana/760-%C5%A1ta-su-to-mikro-i-makro-nutrijenti.html>).

Therefore, it is extremely important for EVPs to be in a state of optimal hydration before the start of rehearsals and / or performances.

CONCLUSION

Proper food selection and intake play a significant role in the hygiene of an elite vocal professional. Intake of seasoned, heavy and spicy food, too hot or cold food and strong candies can have negative effect on the vocal apparatus. In addition, special attention should be paid to the time of taking the last meal. It is undesirable to take food before resting or greater physical activity, because it disrupts diaphragm function. It is recommended to have a meal at least two and a half hours before physical activity. What can have even bigger consequences for the speech apparatus is a late meal, that is, a meal after 6 p.m. A late meal causes gastric reflux and laryngopharyngeal reflux, which can cause morning hoarseness. Although the modern pace of life and the chosen profession prevent timely and proper food intake, the task of the vocal professional is to adhere as much as possible to the recommendations (Tepe et al.: 2002) (<http://nardus.mpn.gov.rs/bitstream/handle/123456789/11102/Disertacija.pdf?sequence=6&isAllowed=y>: 73–74).

A good nutrition strategy – proper nutrition is one of the ways to improve the private and professional life of EVPs. In addition to vocal hygiene, voice care, general health and physical fitness, it is extremely important to choose a good diet program, which is designed to provide sufficient energy intake, as well as a good ratio of carbohydrates, fats and proteins to ensure optimal mental health and muscle functions necessary for the profession.

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Agota Vitkai-Kučera
Univerzitet u Novom Sadu Akademija umetnosti, 21000 Novi Sad, Srbija
E-mail: agowit@hotmail.com

PRAVILNA ISHRANA ELITNIH VOKALNIH PROFESIONALACA

Rezime

Za elitnog vokalnog profesionalca je od izuzetne važnosti da shvati, razume i odredi koliko je potrebno uložiti snage (vokalne i fizičke) tokom pevanja. Pored vokalne higijene, brige o glasu i opštem zdravlju, adekvatne vokalno-fizičke pripreme, odabir dobrog programa ishrane jedan je od ključnih faktora za postizanje i održavanje optimalnih rezultata, podizanja kondicije, umeća upotrebe i raspodele snage u skladu sa zahtevima uloge ili resitalala. Na taj način utiče se na očuvanje vokalne i fizičke kondicije i opšteg zdravlja. Ukoliko elitni vokalni profesionalci nisu adekvatno pripremljeni, dolazi do bržeg zamora i mogućeg oboljenja.

Ključne reči: *elitni vokalni profesionalci, ishrana, hidratacija*



Danijela Rajić

University of East Sarajevo, Faculty of Technology Zvornik,
Republic of Srpska, Bosnia and Herzegovina
E-mail: danijelarajic@tfzv.ues.rs.ba

DETERMINATION OF HEAVY METAL CONTENT IN TEAS FROM THE CITY OF ZVORNIK (BIH)

Abstract

Tea has been used in the Balkan mainly for the purpose of improving health since ancient times. Heavy metals are natural ingredients of the Earth's crust, and thus they enter the composition of plants through the soil. Due to their persistence, high toxicity and tendency to accumulate in the ecosystem, heavy metals are dangerous to living organisms. The aim of this paper is to present the importance of tea in human nutrition on the basis of literature references and to experimentally determine and compare with the legally prescribed amounts of heavy metals: copper, zinc, manganese, lead and arsenic in herbal teas collected in the city of Zvornik from beginning of 2020.

Key words: *tea, heavy metals, Zvornik, ICP-OES*

INTRODUCTION

After water, tea is the most commonly consumed drink in the world. Several types of teas are known and the most important are: real tea, herbal, fruit and aromatic (Mađarić, 2014). Tea can contain over 300 ingredients like alkaloids, polyphenols, essential oils, vitamins and minerals. Polyphenols in tea have strong antioxidant properties and, like most other ingredients, also represent a biologically active component and have a beneficial effect on human health (Mađarić, 2014) (Glasnik BAS, 2019). Consumption of herbal teas is most prevalent in our area (Stetoskop, 2019). Herbal teas are low in calories, refreshing drinks that have numerous healing properties. These teas are mixtures of chopped or uncrushed plant parts, and are intended for internal and external use. In its composition, herbal teas have a wide range of vitamins, minerals and phenolic compounds (Mađarić, 2014), but in addition to medicinal ingredients, they also contain ballast substances that are undesirable and can reduce the effect of medicinal

substances (proteins, fats, resins) (Mihajlović, 2015). Herbal parts (herbal drugs) that are most often used for making teas are: flower, leaf and root. One of the parameters that is very often determined in teas is the heavy metal content. Their presence in food is necessary to monitor because some are essential, such as iron, zinc, copper, chromium (III), cobalt and manganese, and some are toxic (lead and mercury) (Randjelovic, 2015), (Nujkic, 2016). However, both deficiency and elevated concentrations of essential elements can have a negative impact on human health (Gibney et al. 2009). The metal content in foods is defined by the maximum permissible concentrations (MAC), which represent the amount of toxic substance that in an adult of 70 kg, consumed throughout life, will not cause toxic effects. Which metals are present in teas usually depends on the type (green, black, fruit or plant) and geological origin (Fernandez-Caceras et al. 2001). Heavy metal contamination of tea can occur during the cultivation of plant species (affects the composition of the soil, nutrients present, artificial fertilizers), as well as during the production and packaging process (Perić-Grujić et al. 2003) (Bjelić, 2012). The market of Republika Srpska is extremely well supplied with all types of teas, and in the sales facilities you can find teas from all domestic producers, but also leading multinational companies, then teas packed in filter bags or in bulk, of different quality and price.

Since the areas of Republika Srpska and Bosnia and Herzegovina in general have an extremely rich flora, we decided to examine the content of teas from the area of the city of Zvornik, which is collected and processed by the company Smrčak d.o.o.

Papers on the content of metals in teas from the territory of B&H have not been published recently, although tests are continuously performed within the institutions responsible for monitoring the quality of food. In this paper, the content of copper, zinc, manganese, cadmium, lead and arsenic in teas that are most often bought in this area was determined. There are several methods and devices for the detection of heavy metals in teas, but due to the high sensitivity and the ability to determine traces of metals in real samples, this analytical technique used in analytical chemistry, ecotoxicology and toxicology of food was used in this paper (Stalović et al. 2013).

The aim of the research was to obtain preliminary data on the content of Cu, Zn, Mn, Pb and As in teas. The obtained results will be used in future tests of teas and infusions by various methods.

EXPERIMENTAL PART

Four samples of tea were taken from a health food store where they are sold in bulk, namely *Matricaria chamomilla*, *Achillea millefolium*, *Hyperici perforatum* L. and *Urtica urens*. The samples were marked respectively as Sample A, B, C, D, each in three harvests.

Samples purchased in bulk were different sizes of plant leaves, so homogenization was performed by grinding all samples individually by electric grinding. Tea samples were prepared in a Milestone ETHOS microwave oven that has HPR1000/10S software according to the standard method DG-FO-47 (Tea leaves) (Milestone, 2018). Samples of 0.5 g each were weighed on an analytical balance in digestion vessels – cuvettes to

which 1 ml of H₂O₂ (30%) and 7 ml of HNO₃ (65%) were added dropwise. The sample was then gently shaken to homogenize the acid and the sample and allowed to stand for some time, until the eventual exothermic reaction subsided completely. After that, the digestion cuvette is closed and transferred to the microwave oven. The time to reach the digestion temperature is 10 min. The digestion temperature is 180 °C for 10 min. Cooling time is 20 min to a temperature below 40 °C.

In a microwave system, the sample is in direct contact with the acid and/or oxidizing agent in a closed vessel and digestion is performed under controlled conditions of high temperature and pressure. The advantages of using microwave systems in sample preparation are: reduced possibility of sample contamination during digestion, minimal loss of easily volatile elements, reduced acid consumption during sample preparation and significantly shorter digestion time compared to traditional methods (Živančev, 2014). The solution obtained by digestion is clear and of approximately the same volume as before digestion. A "blank" sample is prepared in the same way. Samples thus prepared are recorded on ICP-OES (Shimadzu 9820) with prior preparation of standard solutions and formation of calibration curves: copper (0-5.0 mg/l); zinc (0-6.0 mg/l); manganese (0-15 mg/l); lead (0-25 µg/l); arsenic (0-25 µg/l).

Samples of herbal teas were subjected to microwave digestion and then the content of copper, zinc, manganese, lead and arsenic was determined. Comparison of concentrations with those available in the Ordinance on the quantities of pesticides, metals and metalloids and other toxic substances, chemotherapeutics, anabolics and other substances that may be present in food ("Službeni glasnik RS", No. 5/92, 11/92-corr. and 32/2002 and "Official gazette RS", No. 25/2010-other Ordinance and 28/2011-other Ordinance), showed that the content of heavy metals in the samples of tested herbal teas is within the limits that are most often happiness in literature of this type. The paper opens opportunities for further research on this topic, which is relevant due to the high consumption of these types of teas as a means of consumption or funds that have certain medicinal properties.

RESULTS AND DISCUSSION

Table 1 shows the average concentrations of the tested metals in the samples dissolved by microwave digestion.

Table 1. Content of tested metals in tea samples prepared by microwave digestion determined on ICP-OES

Sample	Concentration (mg/kg)				
	Cu	Zn	Mn	Pb	As
A 1	2,68	3,39	ND	3,39	0,69
A 2	2,71	3,78	0,2	3,48	0,78
A 3	2,70	3,65	ND	3,25	0,55

B 1	3,97	4,58	14,76	10,86	0,84
B 2	4,31	4,29	14,28	11,07	ND
B 3	4,25	4,63	14,32	10,87	ND
C 1	1,65	2,42	ND	4,14	0,72
C 2	1,80	2,91	0,25	3,35	0,91
C 3	1,78	2,72	0,89	3,89	0,25
D 1	3,91	3,65	7,10	2,98	1,2
D 2	4,02	3,58	5,69	3,65	ND
D 3	3,89	3,25	6,98	2,87	ND

ND – not detected (A – *Matricaria chamomilla*, B – *Achillea millefolium*, C – *Hyperici perforatum* L., D – *Urtica urens*)

The concentration of copper in all samples varied from 1.65 to 4.31 mg/kg, the concentration of zinc in all samples varied from 2.42 to 4.63 mg/kg. The concentration of manganese in the samples varied from values below the detection limit of the manganese device (0.1 mg/kg) to 14.76 mg/kg. The concentration of lead in the tested samples varied from 2.87 to 11.07 mg/kg per sample and the maximum allowed concentration defined by the ordinance is 5.0 mg / kg, which shows that certain samples exceed the legally prescribed values. The arsenic concentration varied from the impossible to detect (detection limit for arsenic 0.1 mg/kg) to the value of 0.91 mg/kg. The maximum permissible concentration for arsenic is 1.0 mg/kg, and the table shows that only one sample does not meet this recommendation, namely sample D1.

Copper is a naturally occurring ingredient in teas, bound to the polyphenol oxidase enzyme. In the tested samples, the copper concentration was below 5 mg/kg, while in other literature reports for these diseased species, the copper concentration ranged from 2.0 to 20 mg/kg, depending on the place of cultivation of the plant.

Zinc, like copper, is one of the essential elements needed by the human body, but it can also be harmful in excessive amounts. Zinc concentrations ranged from 2.42-4.63 mg/kg. The relevant regulations for food safety and quality in our area do not define the maximum allowed concentration of zinc.

Manganese is one of the essential elements whose concentration ranged below the limit of detection up to 14.76 mg/kg. There is no defined maximum allowed concentration in the regulations, but the literature review showed concentrations ranging from 2.3-25 mg/kg.

Lead in the tested samples is in concentrations of 2.87-11.07 mg/kg, which in some samples exceeds the maximum allowable concentration prescribed by the ordinance of 5.0 mg / kg. Lead can come from mineral fertilizers that contain it as an impurity, zinc sulfate, which is used to provide enough of this micronutrient when growing teas. Also, teas grown near roads are exposed to increased concentrations of lead.

Arsenic is present in the tested samples in concentrations up to 0.91 mg / kg and the ordinance allows a maximum concentration of 1.0 mg / kg.

CONCLUSION

Samples of herbal teas were subjected to microwave digestion and then the content of copper, zinc, manganese, lead and arsenic was determined. Comparison of concentrations with those available in the Ordinance on the quantities of pesticides, metals and metalloids and other toxic substances, chemotherapeutics, anabolics and other substances that may be present in food ("Official gazette RS", No. 5/92, 11/92-corr. and 32/2002 and "Official gazette", No. 25/2010-other Ordinance and 28/2011-other Ordinance), showed that the content of heavy metals in the samples of tested herbal teas is within the limits that are most often happiness in literature of this type. A study of the literature used in the paper identified a lack of legislation in this area. There should be a change in the regulations at the state level to ensure quality cultivation and sale of medicinal herbs for the health of citizens. The paper opens opportunities for further research on this topic, which is relevant due to the high consumption of these types of teas as a means of consumption or funds that have certain medicinal properties.

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Danijela Rajić

Univerzitet u Istočnom Sarajevu, Tehnološki fakultet Zvornik, Republika Srpska,
Bosna i Hercegovina

E-mail: danijelarajic@tfzv.ues.rs.ba

ODREĐIVANJE SADRŽAJA TEŠKIH METALA U ČAJEVIMA SA PROSTORA GRADA ZVORNICA (BIH)

Izvod

Čaj se na prostorima Balkana uglavnom koristi u svrhe poboljšanja zdravstvenog stanja od davnina. Teški metali su prirodni sastojci zemljine kore pa samim tim kroz zemljište ulaze i u sastav biljaka. Zbog svoje postojanosti, visoke otrovnosti i sklonosti da se akumuliraju u ekosistem, teški metali su opasni za žive organizme. Cilj ovog rada je da se na osnovu literaturnih referenci prezentuje značaj čaja u ljudskoj ishrani i da se eksperimentalno odrede i uporede količine teških metala: arsena (As), olova (Pb), žive (Hg) kadmijuma (Cd), kalaja (Sn), cinka (Zn), bakra (Cu), mangana (Mn), barijum (Ba), molibdena (Mo), hroma (Cr) i gvožđa (Fe) u biljnim čajevima koji su sakupljeni na području grada Zvornika od početka 2020. godine.

Ključne reči: čaj, teški metali, Zvornik, ICP-OES



Dragan Dokić¹, Mirna Gavran², Maja Gregić², Vesna Gantner²

¹Erdut Municipality, Bana Josipa Jelačića 4, Dalj, Croatia

²Faculty of Agrobiotechnology Osijek, University of J.J. Strossmayer
in Osijek, Croatia

E-mail: vgantner@fazos.hr

THE ANALYSIS OF FOOD SECURITY IN THE STATE IN CRISIS CONDITIONS

Abstract

The crisis represents a disorder that in contemporary society increasingly occurs. Crises are often the result of some earlier solutions. The situation in agricultural production in Croatia has been negative for years. Inadequate tax and high administrative burdens act to discourage the production process and impede the competitiveness of farmers. Furthermore, the measures taken to create added value are not enough, they can even be said to be wrong. The current crisis Covid-19 caused a disturbance on the market in terms of trends of supply and demand. The crisis period will show whether the country has an adequate strategy to overcome all the economic problems ahead. The aim of this paper was to analyse the readiness of the Republic of Croatia for crisis periods in terms of food security by analysing the volume of agricultural production, the balance of foreign trade of agri-food products as well as the structure of total agri-food product trade. The determined trend of increasing deficits in agri-food products in foreign trade balance, particularly with EU countries implies the state's unenviable position regarding the food security indicating the need for implementation of adequate measures in the direction of the market organization and to facilitate investment in sustainable agriculture production systems.

Key words: *crisis, agricultural production, competitiveness, business efficiency*

INTRODUCTION

Recessions and crises as phases of economic cycles in the real sector are mostly explained by the accumulated imbalances in the underlying macroeconomic aggregates over time, but it does not explain why these imbalances occur at all (Madžar, 2010). The forms of crisis escalation are manifold: the decadence of culture, the stagnation of

economic prosperity, the breaking of trade ties, the collapse of recently stable production systems, the confusion of social order and state, and others (Lardy, 2009). Emerging market economies are facing the outflow of foreign capital, which was especially pronounced at the time of the previous economic crisis. Such countries have experienced a weakening of their currencies, even at double-digit rates. Foreign banks in these countries experienced losses from their claims in local currencies, and experienced difficulties in collecting foreign currency-denominated loans. Madžar (2010) stated that the production decline in most countries is sharp and highly synchronized. Already in scientific circles there is speculation about big losses even though the crisis caused by the Covid-19 virus is only in its initial stage. Precisely because of the threat to the life and health of people, states have adopted measures restricting the movement of people, but in this context, industry is suffering. This prevents the movement of capital, the workforce, the smooth circulation of money and other economic activities that are part of everyday life. The crisis, which threatens to affect not only individual countries but also the world economy due to its complexity, will require a systematic approach to finding a solution (Crotty, 2009). This is an opportunity for transition countries to gain insight into some of the key determinants of current aspirations in the field of institution-building and larger economic policy orientations by looking at the deep determinants that caused the economic crisis. The crisis reveals some aspects of economic trends and social interactions that are not visible in "normal", stable conditions (Stiglic, 2004). The crisis, whether caused by market or state deficiencies, has a negative impact on all economic and financial parameters and has a worrying effect on all market and public sector entities, i.e. all citizens in the state. The crisis is slowing and reducing production, sales and investment, leading to layoffs and rising unemployment, reducing gross domestic product (GDP) and standard and quality of life (Jonung, 2009). For politicians, the crisis is not only the most difficult economic but also a special political problem (Lardy, 2009). Without credit expansion, supply and demand tend to equalize through free adjustment of prices, so there is no opportunity for either cumulative expansion or cumulative depression. What happens if banks opt for credit expansion to stimulate economic activity (investment)? Credit expansion involves the creation of a credit mass that is above the level provided by voluntary savings. It is only an initial impulse which means for the market a "new fact" to which market participants adapt. Thus, the effects of credit expansion are transmitted through the entire economic system (Vujović 2009). The primary cause of cyclical fluctuations lies in changes in the amount of money in circulation, which inevitably leads to a disruption of the price system ("counterfeiting" of price signals) and consequently to misdirection of production. Changing the amount of money in circulation leads to a change in the price level (Hajek, 2002). With the change in the amount of money in circulation, relative prices change, and therefore the structure of production. It is necessary to implement such theoretical thinking into the economic system of the Republic of Croatia, that is, to direct investment funds to the development of those agricultural capacities that produce the highest market yields and from which the wider social community benefits.

The aim of this paper was to analyse the readiness of the Republic of Croatia for crisis periods in terms of food security by analysing the volume of the agricultural

production, the foreign trade of agri-food products as well as the structure of total agri-food product trade.

MATERIAL AND METHODS

For the analysis of agricultural production in the Croatia, the data from the Register of Agricultural holdings (Agency for Payments in Agriculture, Fisheries and Rural Development, APRRR) were used. Accordingly, in year 2018, 167,676 farms were registered, of which 162,248 were family farms (hereinafter referred to as FF) and which make up 96.8% of the total number of farmers. Besides the family farms, agricultural activity performed 2,187 trades, 2,690 companies, 355 cooperatives and 196 legal entities of other organizational forms. Compared to year 2017, the number of farms increased by 3,217 farms or 2%. Farmers used a total of 1,133,851.8 ha of agricultural land, which is an increase of 0.9% over year 2017. The largest number of farmers in year 2017, 119,430 uses areas up to 4.99 ha (accounting for 71.2% of the total number of farmers). In year 2018 the number of these small farmers increased by 4.9%. furthermore, in year 2018, on average, one farmer uses 6.8 ha of farmland. In terms of organizational form, the largest holdings are farms that use an average of 66.7 ha of agricultural land, as follows:

- cooperatives, which use on average 40.1 ha of agricultural land per cooperative
- trades, which on average use 33.8 ha of agricultural land per trade
- other organizational forms of farms use an average of 20 ha of agricultural land and
- FFs, which use an average of 5.3 ha of agricultural land per family farm.

Table 1. Comparative view of agricultural production, import and export (MP, 2019)

Product	Production in 2018, t	Average production in 2013-2018	Export, t	Export in mil Euro	Import, t	Import in mil Euro
Corn	2,147,275.00	1,868,920.00	516,694.00	91.13	41,309.00	26.14
Wheat	738,363.00	809,786.00	506,074.00	89.71	163,254.00	28.53
Sunflower	110,790.00	110,117.00	63,218.00	21.20	3,402.00	5.27
Vegetables	152,899.00	151,336.00	20,221.00	26.14	103,478.00	117.41
Fruit	213,910.00	213,360.00	16,983.00	14.58	204,112.00	187.90
Cattle	414,125.00	413,936.00	43,824.00	45.90	130,636.00	73.10
Pigs	1,049,123.00	1,049,996.00	282,065.00	40.90	485,759.00	23.00
Poultry	11,413,000.00	10,658,366.00	10,087,072.00	6.70	8,998,781.00	5.40
Total				336.26		466.75

The agricultural production accordingly to the products (corn, wheat, sunflower, vegetables, fruit, cattle, pigs, and poultry) in year 2018, as well as import and export are presented in Table 1. In terms of exports, a positive balance is achieved in the production of corn, wheat, sunflower, pigs and poultry. Furthermore, the negative balance is realized in the production of vegetables, fruits and cattle.

RESULTS AND DISCUSSION

International trade flows are of great importance from the standpoint of the development of the domestic economy and the wider environment. Bajec and Joksimovic (2001) state that no economy can base its growth on the self-sufficiency of real and financial resources, and is therefore directed to international trade, whose final balance reflects the degree of growth and macroeconomic variables of a particular economy. Comparison of import and export value in Croatia for year 2018 is presented in the Figure 1. According to the value of export-import ratio, agricultural products were exported in amount of 336.26 million of Euro, while agricultural products were imported in amount of 466.75 million of Euro, which represents a deficit of 130.49 million of Euro.

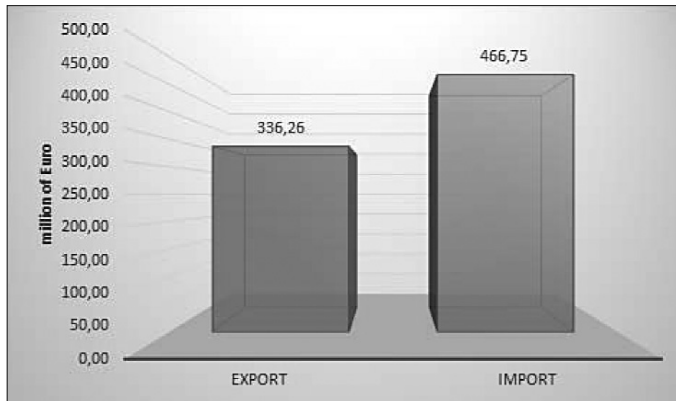


Figure 1. Comparison of import and export value in millions of Euros in Croatia in 2018

In order to obtain a complete picture of the situation in agriculture, it is necessary to coordinate the food industry and the exchange of these products in addition to primary agricultural production. Foreign trade of agricultural and food products on the basis of data from the DZS (2018) in year 2018 shows that agri-food products were imported in amount of 3,094.0 million of Euro, while amount of exported products worth 2,082.4 million of Euros, resulting in a deficit of 1,011.6 million of Euro (Figure 2).

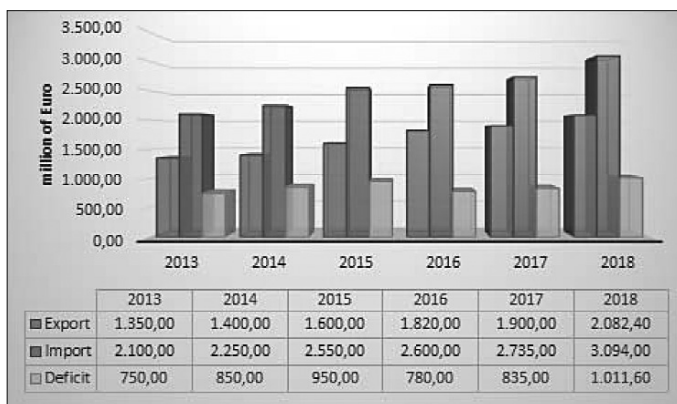


Figure 2. Foreign trade of agri-food products of Croatia in period from 2013–2018

In the period from year 2013 till 2018 the increasing trend of exported and imported agri-food products was determined, with highest values in year 2018. Also, the highest deficit was determined in the same year. Furthermore, in the overall balance of trade of Croatia, the balance of foreign trade in agri-food products in year 2018 was 11%. In year 2018, in the structure of total agri-food product trade, the most traded countries were Member States of the European Union and CEFTA (Figure 3). With the EU Member States, 78.2% of the total value of the agri-food trade was realized, while with the CEFTA countries it was 15.1%. In trade with CEFTA countries, a surplus of 366.2 million of Euros was made, while in trade with EU Member States a deficit of 1,380.8 million of Euros was generated.

The results indicate that Croatia is heavily dependent on import policy. In the event of an economic crisis and adverse economic flows when production is expected to decline and prices increase, the volume of imports will decrease, but it is very likely that the cost of imports will remain at the same level or even increase. In order to avoid deeper negative consequences arising from misguided trade policy, it is necessary to

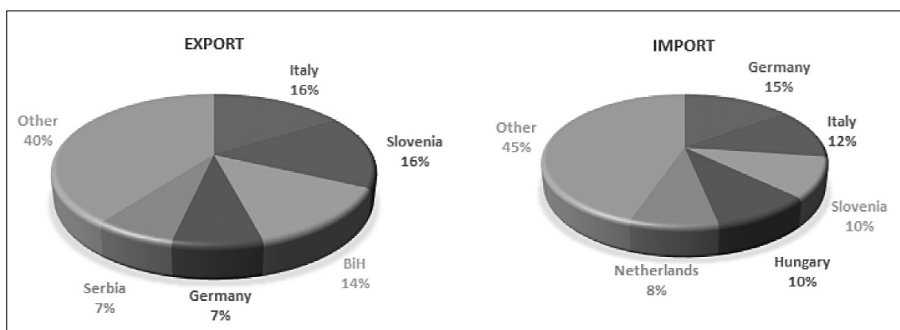


Figure 3. The most important export and import markets of Croatia in agri-food products in year 2018

initially carry out the process of market adjustment. Misdirected allocation in the capital market causes misallocation in the labor market as well. It is necessary to direct the inflow of money into those investments in which a high yield is achieved and a positive change in the structure of employment. The problem lies in the fact that it is a matter of production and export of primary products where the income from production is lower in relation to the processing industry. The chances for the improvement of relations in the trade balance are reflected in the reorientation to the production of industrial products, following the model of developed countries that possess technology and dominate the structure of knowledge. It is therefore necessary to turn to our own capacities. Croatia cannot, by its actions, prevent the global economic crisis, but it can certainly take appropriate measures on a continuous basis to mitigate its impact (Popov, 2007). The process of deindustrialisation must be finally stopped, otherwise Croatia will not solve the issue of unemployment and foreign trade deficit even in the medium term, while in the long term it will be condemned to technological backwardness. Insisting on the development of the service sector is a concept that should not be implemented as primary. Primary production is the real sector (economic activity that results in some material value for which production requires adequate knowledge, industry or agriculture). All this points to the necessity of implementation of industrial policy. The goal of industrial policy is to create conditions for sustained and rapid economic growth, above all industry (Hrustić, 2009), which will contribute to overall economic growth and improve living standards, and in the event of a crisis, strengthen the country. The recapitalization of companies, cooperatives and family farms will strengthen their competitive position. This should be achieved through various measures that increase productivity (Bajec and Joksimovic, 2001). The government is responsible for policies that will encourage the development of domestic companies, improve infrastructure, and in particular knowledge infrastructure, as well as effectively maintain essential non-profit sector activities that provide the basic conditions for attracting desirable foreign investment. All developed countries have full confidence in their own economic science and are developing an original model of industrial policy. With the active role of the state, long-term industrial policy and social consensus, positive economic results can be achieved, as evidenced by the example of Germany and Japan in the post-war period. Another of the state measures is the implementation of expansionary fiscal policy through incentives, reduction of tax pressure, all with the aim of helping the domestic market. The fiscal stimulants that affect the increase in supply through increased demand are: the granting of investment incentives and reduction of tax rates and social security contributions to reduce labour costs; granting consumer loans to citizens and corporate loans; increase social benefits for certain categories of citizens, financial assistance for the unemployed and poor households. The state has also taken over a considerable part of the interest rate management from the market through the reference interest rate, which it uses as a factor in influencing the supply and demand of money and capital in the financial market and as an incentive for investment and employment. An open market policy, in which the government issues securities mainly on the basis of a public loan, affects the amount of money in the market and its price (Mishkin, 2006). After all, it is obvious that an investment climate must be created that

will give an absolute advantage to the real sector of the economy, as it is only one that can provide stability, growth and development.

CONCLUSION

In the event of an economic crisis that seems unavoidable, Croatia will face short- and long-term challenges, the resolution of which will depend on the model of the crisis exit strategy chosen. The speed and extent of state intervention is influenced by a political factor, and each country has to identify the segments it protects through recovery plans. The activities and measures to be implemented by the state need to be directed to the real sector in order to strengthen its own production potential and thus compensate for losses in the medium term due to dependence on agricultural imports. Getting out of the crisis will be neither easy nor quick. The economic slowdown and rising unemployment are problems that will be present. The obtained results in this research show that it is necessary to implement measures that strengthen their own capacities. These measures should reduce the negative balance of imports relative to exports, that is, increase the level of competitiveness for industry. The recovery and continuous strengthening of the real sector also benefits future crises. Economic vibrations should be reduced to minimize damage. In other words, the state must provide stable sources of financing for the domestic economy, as it will thus preserve its companies and labour force, and thereby raise its rating with foreign investors.

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Драган Докић¹, Мирна Гавран², Маја Греггић², Весна Гантнер²

¹Ердут Опћина, Бана Јосипа Јелачића 4, Даљ, Хрватска

²Факултет Агробиотехнологије Осиек, Свеучилиште Ј.Ј. Строссмаиер
у Осиеку, Хрватска
E-mail: vgantner@fazos.hr

АНАЛИЗА БЕЗБЕДНОСТИ ХРАНЕ У ДРЖАВИ У КРИЗНИМ УСЛОВИМА

Извод

Крiza представља поремећај који се све чешће појављује у савременом друштву. Кризе су често резултат неких ранијих решења. Ситуација у пољопривредној производњи у Хрватској већ годинама је негативна. Неодговарајући порез и велика административна оптерећења делују на спречавање процеса производње и ометање конкурентности пољопривредника. Штавише, мере предузете за стварање додате вредности нису довољне, чак се може рећи и да су погрешне. Тренутна криза Цовид-19 изазвала је поремећаје на тржишту у погледу трендова понуде и потражње. Кризни период показаће да ли земља има адекватну стратегију за превазилажење свих економских проблема који предстоје. Циљ овог рада био је да се анализира спремност Републике Хрватске за кризна раздобља у погледу сигурности хране анализом обима пољопривредне производње, биланса цпољне трговине пољопривредно-прехранбених производа, као и структуре укупне трговине пољопривредно-прехранбеним производима. Утврђени тренд повећања дефицита пољопривредно-прехранбених производа у спољнотрговинској равнотежи, посебно са земљама ЕУ, подразумева незавидан положај државе у погледу безбедности хране, што указује на потребу спровођења адекватних мера у правцу тржишне организације и олакшавања улагања у одрживим пољопривредним производним системима.

Кључне речи: *криза, пољопривредна производња, конкурентност, ефикасност пословања*



Ana Jovičić Vuković¹, Aleksandra Terzić²

¹ PhD, lecturer and research associate, Novi Sad Business School, Novi Sad

² PhD, senior research associate, Geographical Institute Jovan Cvijić SASA,
Belgrade

E-mail: dr.ana.jovicic@gmail.com

EATING HABITS OF STUDENT POPULATION: CASE STUDY OF UNIVERSITY OF NOVI SAD

Abstract

The period of acquiring higher education represents one of the most challenging periods for students for creating bad eating habits. The aim of the research is to point out eating habits of students of University of Novi Sad, based on the sample of 108 respondents. The special emphasis was placed on the orientation towards regular and healthy nutrition. The research included creation of the questionnaire involving issues on nutritive quality and food origin, and its importance in food choices, as well as eating habits. Also, data on body weight and height provided the possibility to calculate the body mass index. The results of the study might be used as the base for further research and promotion of proper and healthy nutrition among university students.

Key words: *eating habits, healthy nutrition, student population*

INTRODUCTION

A healthy diet represents one of the most important issues for preserving and enhancing general health. Contemporary society faces the epidemic of bad eating habits that are most often starting even in childhood, and continuing during the lifetime (Turconi et al, 2008), going hand in hand with bad everyday life habits such as lack in physical activities (Musaiger et al, 2016), consumption of alcohol and cigarettes, overuse of mobile phones and computers (Rakić, 2017), followed by an increased stress (Liguori, 2018). Such habits may cause a number of different disorders and diseases (Roger et al, 2012) of which the most common are cardiovascular diseases (Vasiljević-Pantelić, 2013), diabetes, overweight and obesity (NCD Risk Factor Collaboration,

2016). Rašeta et al, 2018 indicate that the specific period starting from the ending of high school and beginning of university education, and the whole studying process, are the most critical times for creating bad eating habits.

A balanced diet is the selection and consumption of nutrient-rich foods, which should provide the body with all nutrients (proteins, fats and carbohydrates) and protective substances (vitamins and minerals) for optimal functioning of all cells and tissues, acting as a protection shield against infections. A healthy diet includes paying special attention to the choice of food and its preparation, but also to the amount and variation of food consumed, i.e. intake of all food groups (Rodić Trmčić et al, 2015), as well as to the regularity in terms of meal consumption. In addition, a healthy diet includes eating habits that are consistent with the improvement, maintenance and strengthening of mental and physical health (Polivy & Herman, 2005; Jovičić, 2015).

So far, in Serbia various research dealing with nutrition from different aspects were conducted (Stojanović et al. 2010; Gagić et al, 2014; Jovičić, 2015), some specifically focusing on student population (Teofilović, 2019; Gazibara et al, 2013; Milošević Georgiev & Krajnović, 2016; Bogdanović Vasić et al, 2019).

A number of changes in the way of life have influenced eating habits to gain more importance. Appropriate, health-safe nutrition today is not applied only for health-related purposes, it becomes the contemporary trend (Jovičić et al, 2012). Its influence is increasingly perceived in Serbian population as well. This is supported by growing orientation towards general health-care even among fast-food chains (Jovičić et al, 2012), that were generally considered for promoters of unhealthy foods and improper nutrition.

Student population is prone to poor eating habits (Driskell et al, 2005), due to numerous reasons: initiating independent living and separation from parents, irregularity in nutrition, lack of free time, insufficient knowledge, consumption of affordable (often cheap) and accessible meals, often overloaded with instant-energizers, but lacking in sufficient amount of nutrients and vitamins.

The results of this study will provide an insight to orientation and motivation of the student population towards proper health-safe and proper nutrition. The results can serve as a basis for future research and act as a promoter of the initiatives in development and adaptation of measures in applying health-safe diet and raising awareness among youth about its necessity.

METHODOLOGY

In order to conduct the research, a research instrument in the form of a questionnaire was developed. It consisted of four parts. First part was made of questions related to standard socio-demographic characteristics of the respondents. The second part included dimensions related to the healthy eating habits and consumption of health-safe food, from the *Food Choice Questionnaire* (FCQ) developed by Steptoe et al. (1995). Although the original questionnaire consists of eight variables: weight control, ethical

principles, practical application, natural origin, health, sensory attraction, availability, knowledge, this particular study involved only the questions related to the food choice dependent on its health-related characteristics (six items) and origin (three items). The respondents were provided responses based on the standard 1-5 Likert scale (1 - not important at all, up to 5 - extremely important). The third part of the questionnaire involved two dichotomous (yes/no) questions related to the issue of being on a special diet regime, as well as on their general need/desire to change their current eating habits. The last part of the survey involved the issues on general body height and weight, providing a possibility to calculate the body mass index – BMI (WHO, see table 4) for each respondent based on the common formula: $BMI=m/h^2$.

The research was conducted using a survey process, in classical paper-pencil form on a random sample. All students involved were notified that the survey was anonymous, as well as introduced to the general goals of the research. As a result, 99% of all questionnaires were properly filled.

The research involved a total of 108 students of University of Novi Sad, the second largest university center in the Republic of Serbia. The respondents were within age range from 20 to 44 years old, of which 34 females and 74 males. The greatest number of students are still living with parents (62%) and in the urban environment (88%). In terms of the income, 61% of respondents do not have personal incomes. A detailed insight to the sociodemographic characteristics of the respondents is shown in Table 1.

Table 1. Sociodemographic Characteristics of the Respondents

Variable	Category	Respondents	Percentage (%)
Gender	male	34	31.5
	female	74	68.5
Habitation	alone	16	14.8
	with friends	15	13.9
	with parents	67	62.0
	with partner	8	7.4
	student's dormitory	2	1.9
Place of habitation	rural	20	18.5
	urban	88	81.5
Incomes	no income	66	61.1
	up to 200 euros	17	15.7
	201–400 euros	14	13.0
	Preko 400 euros	11	10.2

After data collection, the analysis was conducted based on the statistical package of SPSS software with application of standard statistical analytical methods/tools such as descriptives, frequences and cross-tabulation.

RESULTS AND DISCUSSION

In Table 2 and 3 descriptive statistics for the dimensions related to the importance of food characteristics consumed in a function of preserving and enhancing health, along with food origin/composition, is represented.

The results (Table 2) have shown that respondents indicate moderate importance of health-safe nutrition (Mt=3.72). The highest mean value has the statement "It is important that the food that I eat keeps me healthy" (M=4.07), while the lowest mean value has the statement related to the importance of diet fibers in the food (M=3.2) which is the only statement marked as modestly important.

Table 2. Descriptive statistics – health-safety of food products

It is important that the food that I eat:	N	Min.	Max.	Mean	SD
contains vitamins and minerals	108	1	5	3.66	1.312
keeps me healthy	108	1	5	4.07	1.117
to be nutritious	108	1	5	3.94	1.151
to be rich in proteins	108	1	5	3.55	1.335
to be good for my hair, skin and nails	108	1	5	3.87	1.177
to be rich in diet fibers	108	1	5	3.20	1.281
Total	108	1	5	3.72	.935

Table 3. indicates that for the respondents natural food origin is moderately important (Mt=3.63). The least important, according to the results, is the issue of food containing additives (M=3.40).

Table 3. Descriptive statistics – natural origin of the food

It is important that the food that I eat:	N	Min.	Max.	Mean	SD
do not contain additives	108	1	5	3.40	1.215
to be of natural origin	108	1	5	3.94	1.070
do not contain artificial ingredients	108	1	5	3.56	1.314
Total	108	1	5	3.63	.943

From the represented results, it can be seen that students evaluate moderately positively the importance of choosing consumption of healthy food in their everyday habits, that is consistent with previous research of Vukićević (2016) and Teofilović (2019). On the contrary, the research of Bogdanović Vasić et al. (2019), Milošević Georgiev and Krajnović (2016) indicate that healthy habits in student's nutrition are insufficient, outlining the lack of consumption of home-made meals, insufficient consumption of fruits and vegetables, high representation of fast food, snacks and sweets, carbonated and energy drinks, alcohol and coffee. The research conducted on the sample of students of Belgrade University where normal nutritive status of the

respondents was confirmed (Gazibara et al, 2013) are similar to the results of this study. It is interesting that the socio-demographic characteristics reveal that the significant share of respondents still live with their parents, contributing to the positive results, given that being away from home has a negative impact on nutrition (Tomić, 2012), with some exceptions (Gazibara et al, 2013).

Further, when asked if they have ever been on a specific diet, more than a half of respondents give a positive response. Also, 63% of respondents declared a desire to change their eating habits. Examination of the answers and separating respondents according to the gender, using cross-tabulation, clarifies that female population has higher propensity of change in eating habits compared to male respondents. About 62.2% of female respondents were on a diet at some point, and a modest share of males – 29.4% as well. Similar results gave a question related to the change in eating habits, indicating that 70.3% females desire to change their current eating habits, while the same is evident among about 47.1% males. The research confirmed that women care more about health and nutrition compared to men (Đorđević-Pešić et al, 2018). Although the obtained data can be interpreted from the aspect of positive changes in nutrition, similar to the research conducted in Greece (Kyrkou et al, 2018), such results should be taken into consideration from negative aspects as well, associating such behaviour with various eating disorders. Adolescence is the most critical period for the eating disorder development that appears most commonly among the female population. Holding a special diet and other intentional changes in nutrition represent predisposing factors for the appearance of such disorders (Mladenović, 2018).

Based on the analysis we conclude that most respondents moderately care about proper food choice and nutrition, as well as that most respondents are aware of the importance of healthy-food consumption. These results are extended and supported by the information on body mass index. According to provided data on height and weight of the respondents, body mass index was calculated for each respondent and represented in Table 4, allowing to evaluate the quality of student's nutrition quality indirectly. Average BMI of the sample was calculated and amounts 23.21, indicating that in average respondents have an ideal body mass, also supported in previous studies (Vukićević, 2016). With an insight in categories, we perceive that 72.4% respondents have ideal body mass, 20% is overweight, while 2.9% show obesity, and 4.9 underweight, in line with the results of the study conducted in Novi Sad University in 2013 (Grujić-Ridžik et al, 2018).

Table 4. BMI

BMI category according WHO	BMI	Respondents	Percentage (%)
Underweight	<18,5	5	4.8
Ideal normal weight	18,5 – 24,9	76	72.4
Overweight (pre-obesity)	25 – 29,9	21	20.0
Obesity class I – Slight obesity	30 – 34,9	2	1.9
Obesity class II – Serious obesity	35 – 39,9	0	0
Extreme obesity	>40	1	1.0
Total		105	100.0

According to the WHO (2019), obesity represents one of the leading health conditions in the world. Therefore, the results showing that over 22% of the student population in Novi Sad is overweight or fits into obesity rank shouldn't be ignored. As obesity can be prevented, following the recommendations of WHO, physical activity among the student population should be promoted, as well as a decrease in consumption of food rich in fat and sugar and an increase in consumption of fruits and vegetables in nutrition. Teofilović (2019) that conducted a study on a sample of students from Novi Sad outlines that there is a lack of information related to the health-safety of food products among students. Therefore, the promotion and provision of sufficient information on proper nutrition and healthy lifestyles among the student population is extremely important.

CONCLUSIONS

Student population face many challenges in their nutrition habits. Young are often surrounded with unhealthy food and drink choices, commonly consummating the most accessible and most affordable food. Often, young lack awareness about the necessity of proper and health-safe nutrition (Vukićević, 2016). However, the research was conducted to indicate the fact that the student population is actually interested and partly cares for healthy nutrition, natural origin of food products and their nutritive composition. This is supported with the body weight index of the student population data, indicating the greatest share of respondents having an ideal body weight. Additionally, over half of respondents were on a special diet at some point of the time, while over 60% of respondents desired changing their current eating habits.

This study gives a contribution to the existing literature on the student nutrition habits in the Republic of Serbia. Further, it may be used as a basis for further research that should involve greater sample choice and wider geographical scope, allowing generalization of the results that might be perceived as a certain limitation of this study.

Batez et al. (2017) state that average resident of Serbia has some difficulties in reaching reliable information on healthy nutrition, as professional texts dealing with this issue are rare and restricted, while there is an overlay of texts, manuals, advisory related to nutrition in both printed and electronic sources whose source and reputation is questionable. The responsibility over health-safe nutrition habits is individual and personal, but also a result of joint efforts of various governmental measures, health and educational institutions, non-governmental organizations, food producers and suppliers (Mitić & Gligorijević, 2016). All subjects mentioned should find the adequate channel of communication and representation of health-safe nutrition options and contribute to the raise of awareness and providing better eating habits among the student population and general youth.

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Ana Jovičić Vuković¹, Aleksandra Terzić²

¹ PhD, lecturer and research associate, Novi Sad Business School, Novi Sad

² PhD, senior research associate, Geographical Institute Jovan Cvijić SASA, Belgrade

E-mail: dr.ana.jovicic@gmail.com

NAVIKE U ISHRANI STUDENTSKE POPULACIJE: STUDIJA SLUČAJA UNIVERZITETA U NOVOM SADU

Sažetak

Period studiranja predstavlja jedan od najizazovnijih perioda za stvaranje loših navika u ishrani. Cilj istraživanja jeste da ukaže na navike u ishrani studentske populacije Univerziteteta u Novom Sadu na uzorku od 108 ispitanika, sa posebnim akcentom na orijentisanost ka pravilnoj i zdravstveno bezbednoj ishrani. Za potrebe istraživanja kreiran je upitnik koji je sadžao pitanja o kvalitetu nutritivnog sastava i porekla namirnica i značaju istih prilikom izbora, kao i navikama u ishrani, a na osnovu podataka o telesnoj visini i masi izračunat je indeks telesne mase ispitanika. Rezultati mogu poslužiti kao osnova budućih istraživanja i promocije značaja pravilne i zdravstveno bezbedne ishrane među studentima.

Cljučne reči: *navike u ishrani, zdravstveno bezbedna ishrana, studentska populacija*



Jelena Filipović¹, Vladimir Filipović², Milenko Košutić¹, Vesna Vujačić³

¹ University of Novi Sad, Institute for Food Technology, Bul. Cara Lazara 1,
21000 Novi Sad, Serbia

² Faculty of Technology, University of Novi Sad, Bul. Cara Lazara 1,
21000 Novi Sad, Serbia

³ Faculty of Tourism and Hospitality, University of Montenegro, Kotor,
Stari grad 320 Montenegro

E-mail: jelena.filipovic@fins.uns.ac.rs

SPELT BREAD WITH FRESH COMMONNETTLE AS FUNCTIONAL FOOD TO IMPROVE DIET AND MODERN LIFESTYLE

Abstract

Common nettle is a natural medicinal plant rich in minerals and vitamins positively influencing human health. Bread is a food product that occupies a significant role in human diet and it is represented in all diets. Bread is a suitable food that can be enriched with a nettle in order to satisfy the minimal daily intake of mineral matter since it is constantly consumed. The aim of this research was to determine the influence of nettle addition on quality and mineral characteristics of bread. Different shares of nettle (2.55% and 5%) as flour substitution were added in dough formula. Presented data point that investigated bread with nettle is a new product with improved mineral properties due to higher level of mineral content of Zn, Cu, Mg, Ca and Fe, which improves diet and modern lifestyle.

Keywords: *nettle, bread, mineral characteristics, quality*

INTRODUCTION

Spelt cultivation area tends to increase, which is associated with growing interest in healthy lifestyle and healthy food, as well as, the increase in organic farming development. Spelt is valued due to its health-promoting qualities and agronomical advantages, such as high pest resistance and the fact that it can be cultivated on low fertility, poorly drained soils (Koenig, *et al* 2015, Biel, *et al* 2016). The daily intake

of mineral materials in highly industrialized countries is at low level and therefore are usually closely related numerous chronic diseases characteristics for lifestyle habits. Bakery products, particularly bread, are constituent parts of meals in all dietary patterns. By enriching the composition of bread with mineral materials, recognized as, long term health benefits can be easily met (Filipović and Filipović 2010, Filipović 2010).

The nutritional status can be understood as the body condition that results from the process of using the nutrients contained in food, leading to an equilibrium between supply and assimilation of the nutrients and the nutrients consumption of the organism which is influenced by sex and age of the individual (Guardia and Garrigues 2015). The recommended daily intakes according to FAO/WHO (2002) for zinc, copper, magnesium, calcium and iron content are 15, 2, 400, 1000 and 18 mg, respectively for a functioning organism and metabolism. Nettle (*Urticadioica* L.) is a widespread wild plant that is also cultivated for specific uses. This herba ceous perennial belonging to the Urticaceae family is very common in temperate climate regions (Bourgeois, *et all* 2016). Common nettle is a medicinal plant that accelerates the exchange of matter, positively influencing human health (Upton, 2013). It is rich in iron, phosphorus, magnesium, calcium and silicon. In addition, nettle also contains vitamins A, C and K, tannins, numerous and amino acids.

This paper investigates the influence of fresh common nettle on the technological quality and mineral content of bread.

MATERIAL AND METHODS

Bread was baked according to the AACC method (Kaluđerski and Filipović 1998). The composition of bread dough was according to: spelt flour (100%, 97.5% and 95%), common nettle (0%, 2.5% and 5%), salt (2%), and yeast (2.5%). Bread quality was evaluated by volume increase according by Kaluđerski and Filipović 1998, texture and colour attributes.

Texture of bread crumb was analyzed using TA.XT2i (Stable Micro Systems, Surrey, UK) equipped with a 25-kg load cell was used to perform the TPA of crumb. The slices were subjected to a double compression cycle (deformation: 40%, crosshead speed: 0.5 mm/s) with a cylindrical probe (diameter $\frac{1}{4}$ 2.5 cm). Firmness and elasticity were determined. Six replicates were analyzed for each formulation.

The bread color was measured using a tri-stimulus colourimeter type CR-400 (Konica, Minolta, Tokyo, Japan) equipped with D65 illuminant. The results were expressed as per CIELab system in terms of coordinates: L* – lightness (0, black to 100, white), a* – redness (–a*, green to +a*, red), and b* – yellowness (–b*, blue to +b*, yellow). The measurements were observed under constant lighting conditions, at 28 °C, using a colour attributes of white control plate, L* = 98.76, a* = –0.04 and b* = 2.01 (Filipović et all 2015).

The content of calcium, zinc, copper, magnesium and iron was determined by atomic absorption spectroscopy using standard procedure (No. 985.29) given by AOAC (1990).

Descriptive statistical analyses for all the obtained data were expressed as the mean \pm standard deviation (SD). The evaluation of one-way ANOVA analyses of the obtained results was performed using Stat Soft Statistica 10.0® software. Collected data were subjected to one-way analysis of variance (ANOVA) for the comparison of means, and significant differences were calculated according to post-hoc Tukey's HSD (honestly significant differences) test at $p < 0.05$ significant level, 95% confidence. Score analysis utilizes min-max normalisation of bread quality parameter responses and migrate them from their original unit system in new dimensionless system which allows further mathematical calculation of different types of responses. Maximum value of normalised score presents optimum value of all combined analysed responses and indicates on optimum quantity of fresh common nettle in bread formulation (Jayalakshmi and Santhakumaran, 2011).

RESULTS AND DISCUSSION

The technology parameters are the critical point to ensure the acceptance of products by consumers particularly bread volume is highly appreciated. Bread volume is statistically significant decreased (20% and 30%) with the increase fresh common nettle in bread (table 1). ANOVA test showed that the addition of fresh common nettle statistically significantly increases the hardness (2.01 times) and decreased elasticity (about 13%) of the bread as compared to bread without (table 1), fresh common nettle, due to interruption of intra and inter molecular bonds in the dough. In general (Table 2), the high contents of fresh common nettle in bread statistically the decreased bread brightness (L) and yellowness and increased redness ($p < 0.05$).

Table 1. Quality of bread with common nettle

Sample	Bread attributes	Texture attributes	
	VI (ml)	HAR (N)	ELS (%)
1	1446,63 \pm 73,1	2338,9 \pm 279,1	36,6 \pm 1,1
2	0.81	1.05	0.98
3	0.70	2.01	0.87

VI – volume increase, HAR – hardness, ELS – elasticity,
Data are expressed as mean \pm standard deviation (n=6)

Table 2. Colour of bread with common nettle

Sample	Colour attributes		
	L*(D65)	a*(D65)	b*(D65)
1	75,66 \pm 0,26	1,45 \pm 0,20	21,22 \pm 0,57
2	0.78	1.0	0.98
3	0.74	1.41	0.86

L* – brightness, a* – greenness/redness, b* – blueness/yellowness.
Data are expressed as mean \pm standard deviation (n=6).

The effect of fresh common nettle on bread mineral content is shown in Table 3. ANOVA test shows statistically significant differences ($p < 0.05$ level, 95% confidence limit) in zinc, copper, magnesium, calcium and iron content among the values of samples 1 and sample 2 and sample 3 (Table 3). The maximum value of Zn, Cu, Mg, Ca and Fe was measured for sample 3 with maximum fresh common nettle of 5 % in bread. These data indicate that fresh common nettle was good sources of mineral elements. Fresh common nettle in bread are increasing its mineral content. Nutritionists, the World Health Organization, and the Organization for Agriculture and Food recommend a minimum daily intake of mineral matter for a functioning organism and metabolism. In the nutrition, the daily intake of 100 g bread with fresh common nettle is a good opportunity to achieve the recommended daily intake in zinc, copper, magnesium, calcium and iron content necessary for the optimal mineral status and normal body functioning, recommended by FAO/WHO (2003).

Table 3. Mineral content of bread with common nettle

Sample	Zn (mg/kg)	Cu (mg/kg)	Mg (mg/kg)	Ca (mg/kg)	Fe (mg/kg)
1	5,32±0,09	1,83±0,04	243,13±7,93	220,71±8,35	11,80±0,05
2	1.31	1.36	1.77	5.69	1.58
3	3.25	1.66	2.41	8.94	1.92

Zn – zinc, Cu – copper, Mg – magnesium, Ca – calcium, Fe – iron.
Data are expressed as mean standard deviation (n=6).

By using score analysis, 11 different responses of bread quality parameters presented in table 1 and 2 were quantified in dimensionless values that were further calculated in one score value which was comparable between the different bread formulations (Table 4). In that way score values of 3 bread samples allowed the possibility of comparing total quality of the analyzed samples and optimization of their formulation.

Table 4. Score values of bread samples

Sample	Score values
1	0,363636
2	0,461773
3	0,636364

CONCLUSIONS

Based on investigated data, it can be concluded the fresh common nettle adversely affected on technology quality but positively affected on mineral content of bread. By using the standard score analysis sample 3 (bread with 5% fresh common nettle) has

high scores (0.63) while bread without fresh common nettle gained lower scores (0.36). Bread with 5% fresh common has the best content of essential mineral elements, requirements of mineral elements recommended by FAO/WHO. Bread with fresh common nettle could be a valuable source of essential elements in daily diet.

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**Др Јелена Филиповић¹, Др Владимир Филиповић², Др Миленко Кошутић¹,
др Весна Вујачић³**

¹ Универзитет у Новом Саду, Научни институт за прехранбене технологије,
Бул. цара Лазара 1, Нови Сад, Србија

² Универзитет у Новом Саду, Технолошки факултет, Бул. цара Лазара 1,
Нови Сад, Србија

³ Универзитет Црне Горе, Факултет за туризам и хотелијерство, Котор,
Стари град 320, Црна Гора
E-mail: jelena.filipovic@fins.uns.ac.rs

ХЛЕБ СА СВЕЖОМ КОПРИВОМ КАО ФУНКЦИОНАЛНА ХРАНА У ЦИЉУ УНАПРЕЂЕЊА ИСХРАНЕ И МОДЕРНОГ НАЧИНА ЖИВОТА

Сажетак

Свежа коприва је природна лековита биљка богата минералима и витаминима који позитивно утичу на здравље људи. Хлеб је прехранбени производ који има значајну улогу у људској исхрани и заступљен је у свим режимима исхране. Хлеб је погодна намирница која се може обогатити копривом у циљу задовољавања дневног уноса минералних материја, пошто се стално конзумира. Циљ овог истраживања био да се утврди утицај коприве на квалитет и минералне карактеристике хлеба. У састав хлебног теста су додати различити удели коприве (2,55% и 5%) као супституција брашна. Добијени резултати показују да је испитивани хлеб са копривом нови производ са побољшаним минералним својствима захваљујући већем нивоу минералног садржаја Zn, Cu, Mg, Ca и Fe, који побољшавају исхрану у модерном начину живљења.

Кључне речи: *коприва, хлеб, минерални састав, квалитет*



**Predrag Ilić¹, Dragana Stanisavljević², Violeta Mickovski Stefanović³,
Natalija Tošić⁴**

¹ University of Niš, Faculty of Philosophy, Niš, Serbia

² Academy of Vocational Studies Southern Serbia – Department of Agricultural
and Food Technology, Prokuplje, Serbia

³ Institute "Tamiš", Pančevo, Serbia

⁴ University of Niš, Faculty of Medicine-Pharmacy Department,
Niš, Serbia

E-mail: draganastanisavljevic72@gmail.com

BEER AS HIGHLY VALUABLE PRODUCT

Abstract

Beer is a sparkling refreshing drink with a characteristic aroma and a pleasant bitter taste. The basic raw materials for beer production are brewer's malt, brewer's yeast, hops, and water. It has been determined that beer can have a positive effect on the health of the consumer. As a biologically balanced drink, beer is a rich source of nutritionally and pharmacologically active ingredients such as vitamins, minerals, and antioxidants, so it is rightly often called "liquid bread." Before placing on the market, beer is subject to mandatory quality testing in terms of physical, chemical, and microbiological parameters, residues of plant protection products, biocides or contaminants, and sensory evaluation, following applicable regulations. The connection between beer flavonoids and a reduced risk of cardiovascular disease has been discovered.

Keywords: *beer, antioxidant activity, nutritional value, quality*

INTRODUCTION

Beer is one of the most popular alcoholic beverages and is consumed in every country in the world. Globally, it is the most consumed beverage in the world (Halonen et al. 2014). Beer is a fermented beverage obtained by a technological process from barley malt, unsweetened raw materials, hops, water, and brewer's yeast (Official Gazette of RS, 30/2010). Beer barley is first used to make malt, which is used to make wort, which is made by extracting the active ingredients of malt and hops and which is then fermented into beer. The quality of all raw materials used has a decisive

influence, even a crucial one, on the quality of the finished product, i.e., beer (Grujić et al., 2000). Water is the main ingredient of this drink. Hops give the drink a pleasant smell, and bitter taste, brewer's yeast causes alcoholic fermentation, and water serves as a solvent. Also, beer contains carbon dioxide, which gives it a special sharpness. Beer is a completely natural and biologically balanced product and is rightly considered a "liquid food." The energy value of standard beer corresponds to the energy value of a liter of whole milk (Psodorov, Đ. 2012). It is best to drink beer chilled, and it is most convenient to use glasses with thick glass to keep the quality and temperature longer (Psodorov, Đ. 2012). According to the Rulebook on the quality of beer 145/14, beer is categorized and placed on the market under different names. The conditions regarding the quality of beer are given. Beer as a completely natural and biologically balanced product, due to its low alcohol content, present nutrients is an excellent basis for obtaining new products with added value (Leskošek-Čukalović et al. 2007).

BEER AS A PRODUCT

Beer, due to its nature, number, and quality of raw materials and the method of production, is one of the healthiest foods. It is rich in nutrients, carbohydrates, amino acids, minerals, vitamins, and phenolic compounds (Gerhäuser, 2005).

Extensive and very serious research conducted over the years in numerous control laboratories led to the conclusion that beer is an extremely safe food in which the presence of potentially harmful ingredients is far below the permitted limits. According to the German law on the purity of beer from 1516, which is, in fact, a series of regulations that determine the ingredients that may be used in the production of beer, it may also only contain barley malt, hops, and water. According to the definition given by the Bavarian Law on the purity of beer production ("Reinheitsgebot") in 1516, beer is a product that must be obtained only from malted barley, hops and water, by fermentation using brewer's yeast (Grujić and Gaćeša, 1999; Kunze, 1998). However, in countries where the Purity of Production Act ("Reinheitsgebot") does not apply to beer production, unsweetened raw materials may also be used. (Grujić et al., 2001; Grujić, 2002; Pejin et al., 2006).

Later, it was supplemented with brewer's yeast, which people in the 16th century did not know about. Some special beers contain other ingredients added for taste (fruit, cloves, coriander, chocolate). Due to its nutritional value and a characteristic pleasant taste, beer as a beverage is widespread globally. From time immemorial, it has been a means of refreshment and enjoyment, but also food and medicine. Epidemiological studies have shown that moderate beer consumption provides greater protection of the cardiovascular system than strong alcoholic beverages. Scientists attribute this to numerous molecules in beer, especially polyphenols, antioxidants, vitamins, and minerals (Psodorov, Đ. 2012). Beer contains a large number of phenolic components, most of which come from malt and hops. In beer, about 75% of phenol comes from malt and the remaining 25% from hops. Due to their specific characteristics, their presence is interesting from both a technological and a physiological aspect. They are one of the key factors responsible for foam quality, physical and chemical stability, and shelf life

(not biological turbidity of beer). Their presence is also important because of the sensory characteristics that beer can give. Most phenolic compounds and phenolic acids in beer come from barley malt (70-80%), and the rest from hops and unsweetened raw materials (Hardwick, 1995; Garcia et al., 2004; Vanderhaegen et al., 2006).

One of the most important research topics in brewing today is the stability of beer taste. Two-row barley is the most important for the production of beer malt. (Garrett, 2011). By choosing the appropriate barley variety and parameters of the sweetening process, malt of high antioxidant activity can be produced without exogenous antioxidants (Liégeois et al., 2002). If malt with more antioxidant activity is produced, a beer with more antioxidant activity will also be obtained, which has a favorable effect on the stability of the taste. Published results indicate the efficacy and health safety of natural antioxidants isolated from plants, food products, soft and alcoholic beverages (Namiki, 1990; Walker et al., 2001; Zuo et al., 2002). Studies have shown that beer also has antioxidant activity. Bamforth (2004) states that beer has higher antioxidant activity than white wine and orange and apple juices. Research on determining the level of antioxidant activity of beer, to which acceptable sensory amounts of extracts of selected medicinal plants were added, to obtain beer with increased functional and new sensory properties also showed that the content of total phenols is highest in beer to which plant isolates (extracts) were added relative to the starting standard beer. Also, beer enriched with extracts of certain aromatic plants, such as lemon balm, had a pleasing and harmonious taste and aroma. (Đorđević, 2015).

NUTRITIONAL VALUE OF BEER

Beer is a drink with a pleasant taste that primarily quenches thirst. However, beer also has a certain nutritional value because it contains carbohydrates and nitrogenous substances. Beer extract is almost completely used in the body (up to 95%). Beer is a weak solution of alcohol in water. The energy value of a liter of beer is in the range of 1670-3350 kJ. For comparison, the energy value of milk is about 2850 kJ per liter. Beer is not considered a food product since only a part of its substances are used to build the tissues of the human body. About 60% of the energy value of beer is alcohol, which is not a nutrient since it is not used to synthesize new tissues (Malchev, 1967). Beer also contains biologically valuable substances, which are necessary for the good work of the digestive organs, and from a physiological point of view, they play an important role. Besides giving beer the character of a refreshing drink, carbon dioxide has a beneficial effect on the work of the digestive organs. The bitter substances in hops stimulate the secretion of bile and improve the process of digestion. Beer is also a good food emulsifier. Colloids of beer, which emulsify and disperse substances in the digestive organs, increase the areas of enzymatic actions and contact of food with the intestines, which improves digestion and increases the coefficient of food utilization. The substances found in beer are easily assimilated by the human body (Petersen, 2004). Malt and hops are rich sources of many vitamins. Beer also contains vitamins. Among them, thiamine, riboflavin, and nicotinic acids are found in significant quantities. Thiamine is abundant in malt and wort but is absorbed by yeast. There are 1-2

μg of riboflavin in a gram of barley, and its content increases during malt production, and it turns into beer. Vitamin B1 is less common in beer. The richest source of this vitamin is yeast. Therefore, several procedures have been proposed for enriching beer with vitamin B1, obtained from yeast. (Šakić, 2005).

MEDICINAL PROPERTIES OF BEER

In recent decades, numerous studies have been conducted that have addressed the health aspects of beer. Beer has defined therapeutic and dietary properties and, if consumed in moderation, improves the body's general condition. Ingesting in moderation has a beneficial effect in reducing the risk of certain diseases, primarily renal and cardiovascular, and a whole range of others. People who regularly ingest moderate amounts of beer have been shown to have fewer heart problems, high blood pressure problems, and fewer ulcers (Muller-Limmroth and Brauwelt, 1982). Moderate alcohol consumption is considered the intake of alcoholic beverages in an amount that does not cause harmful consequences for the organism and the environment of the individual in the broadest sense. In quantitative terms, it is usually about 1-3 (on average, 2) alcoholic beverages per day, or 10-40 g of absolute alcohol per day. This corresponds to a quantity of 1 to 3 bottles of 0.331 beer with 40g / l, or 50 ml of alcohol (Piendl, 1999).

Beer is a mildly alcoholic beverage and a colloidal solution from which alcohol is slowly distributed and resorbed. As a result, the alcohol content in the blood grows more slowly than in the case of other alcoholic beverages. The maximum value that is reached is lower (Leskošek-Čukalovic, 1998), which is why beer is recommended as an integral part of various therapies. It is successfully used in diets in which sodium, calcium, protein, and lipids are limited. Patients are allowed to drink a moderate amount of alcohol, and non-alcoholic beer is recommended for those who cannot drink alcohol. Numerous studies conducted in recent years show that moderate alcohol has a beneficial effect on reducing the risk of cardiovascular disease. People who consume moderate amounts of alcohol daily suffer from these diseases to a lesser extent than those who do not consume alcohol at all or consume it in excessive amounts. (WHO, 1994). Also, beer contains polyphenols similar to those in red wine. Recent research shows that in terms of antioxidant activity, the effect achieved by consuming wine and beer is practically indistinguishable (Hendrix, 1999). Extensive tests of the effect of beer in the fitness training of top athletes were also performed. It has been shown that in situations when it is necessary to compensate for a large amount of water in the body, beer is an extremely suitable means. The presence of vitamins, minerals, and electrolytes and the fact that the components present are quickly and easily resorbed. The favorable ratio of water content and energy value allows adequate compensation of 3-5% of body weight lost during training. Beer can also be recommended to all healthy individuals who are exposed to great physical effort, and high temperatures, environmentally harmful substances, especially smokers and women during pregnancy and lactation, where it enriches the diet and helps normalize metabolic processes disrupted by proper diets, working conditions, that is bodily conditions.

CONCLUSION

Beer is a weaker alcoholic beverage produced in alcoholic fermentation from malt, hops, water, and brewer's yeast. Beer, as a completely natural product, contains many useful ingredients. It belongs to alcoholic beverages with low alcohol content and rich nutrients, which provides it with well-defined functional properties. It contains carbohydrates, amino acids, vitamins, organic acids, phenolic compounds, and bitter substances of hops, but also specific ingredients with a potentially beneficial effect on the human body, making it unique (if consumed reasonably and moderately). As a biologically balanced drink, it is a rich source of nutritionally and pharmacologically active ingredients such as vitamins, minerals, and antioxidants, so it is rightly often called "liquid bread."

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**Predrag Ilić¹, Dragana Stanisavljević², Violeta Mickovski Stefanović³,
Natalija Tošić⁴**

¹ Univerzitet u Nišu, Filozofski fakultet, Niš, Srbija

² Akademija Južna Srbija, Odsek za poljoprivredno-prehrambene studije,
Prokuplje, Srbija

³ Institut "Tamiš", Pančevo, Srbija

⁴ Univerzitet u Nišu, Medicinski fakultet-Farmacija, Niš, Srbija

E-mail: draganastanisavljevic72@gmail.com

PIVO KAO VISOKO VREDAN PROIZVOD

Abstrakt

Pivo je penušavo osvežavajuće piće sa karakterističnom aromom i sa prijatnim gorkim ukusom. Osnovne sirovine za proizvodnju piva su pivarski slad, pivarski kvasac, hmelj i voda. Utvrđeno je da pivo može pozitivno da utiče na zdravlje konzumenta. Kao biološki uravnoteženo piće, pivo predstavlja bogat izvor nutritivno i farmakološki aktivnih sastojaka poput vitamina, minerala i antioksidanasa, pa se s' pravom često naziva "tečnim hlebom". Pre stavljanja u promet pivo podleže obaveznom ispitivanju kvaliteta u pogledu fizičkih, hemijskih i mikrobioloških parametara, prisustva ostataka sredstava za zaštitu bilja, biocida ili zagađivača i senzornom ocenjivanju, u skladu sa važećim pravilnikom. Otkrivena je povezanost flavonoida piva sa smanjenjem rizika oboljevanja od kardiovaskularnih bolesti.

ključne reči: *pivo, antioksidativnu aktivnost, hranljiva vrednost, kvalitet*



**M. Sc. Nemanja Petrovic¹, M. Sc. Bratimir Nestic², M. Sc. Natalija Totic¹,
B. Sc. Nenad Nestic³, M. Sc. Dusan Stevanovic¹, B. Sc. student Luka Nestic²,
B. Sc. Dusan Milincic¹, B. Sc. Aleksandar Aleksic¹**

¹ Academy of Technical-Educational Vocational Studies - Department, Nis, Serbia

² University in Nis, Occupational Safety Faculty, Nis, Serbia

³ City Administration, Krusevac, Serbia

E-mail: bratimir@gmail.com

FOOD HEALTH RISK AND ISO 22000

Abstract

The paper presents the basics of food safety risk management and the effects of the application of ISO 22000, the international standard for food safety management systems. The biological and chemical agents that cause food poisoning can be very different, but they have in common that they monitor the raw material from its primary production, through processing and distribution, to use. Also, the movement of the product through the production chain provides important information for further handling. For these reasons, there is a need to approach the problem of food safety in a fully integrated way. Procedures in this direction must have a preventive status, and not just the character of testing the final product. Such a principle of control was accepted by veterinary professional and scientific organizations, and they also classified it as the basis of the Law on Food in the EU. Starting from the fact that the risk management process refers to unexpected events, the concept of decision making has a very high level of uncertainty. Therefore, great importance is given to the process of risk identification and assessment.

Key words: *risk, health, safety, food, ISO standard*

INTRODUCTION

Organizations directly involved in food production include, but are not limited to: feed manufacturers, harvesting or harvesting organizations, farmers, ingredient producers, food processors, retailers, food service organizations, service preparation, delivery and serving of food, organizations that provide cleaning and disinfection services, then transport, storage and distribution services. Organizations that are indirectly involved

in the food production chain include: suppliers of equipment, cleaning and disinfecting agents, packaging materials and other materials in contact with food [1].

Each organization must accurately define the scope of the standard. For example, the product health safety management system refers to the production program of fermented milk beverages, from the receipt of raw milk to the transport of the finished product to the customer. Or if the organization does not have its own vehicles to transport the product to customers, the area of application of the system will be from the receipt of raw milk to the storage and delivery of the finished product [2,3].

TERMS AND DEFINITIONS

The basic concept of food health safety is as follows: food will not harm the consumer as long as the instructions regarding food preparation and consumption are followed. In contrast, food is potentially dangerous whenever it is exposed to harmful agents, and when the instructions for its use are not followed.

The food chain represents the sequence of phases and operations involved in the production, processing, distribution, storage and handling of food and its ingredients, from primary production to consumption. The food chain includes both the production of animal feed (does not include pet food) and the production of materials intended to come into contact with food or raw materials. As food safety hazards can occur anywhere in the chain, adequate control at every step is very important. Food safety is the responsibility of all actors in food production and distribution and requires joint efforts to that end.

Food safety hazards are any biological, chemical or physical agents that can cause food to be unhealthy for human consumption. The term "danger" should not be confused with the term "risk" which, in the context of food safety, means a function of the likelihood of adverse health effects (eg illness) and the intensity of such effects (death, hospitalization, absence from work, etc.) when exposure to an identified hazard. Risk is defined as a combination of the probability of the occurrence of a harmful effect and the severity of that harmful effect. Food safety hazards include allergens. In the context of feed and feed ingredients, relevant food safety hazards are those that may be present in and / or on feed and feed ingredients and that can then be transferred to the food by the animals consuming the animal feed, and therefore may have a detrimental effect on human health. In the context of operations, other than those related to the direct handling of feed and for humans (eg manufacturers of packaging materials, cleaning agents, etc.), the relevant food safety hazards are those hazards that can be transmitted directly or indirectly to food due to the intended use of the provided products and / or services, and therefore may have a detrimental effect on human health.

The food health policy statement formally defines the organization's commitment to food health safety. It generally expresses what top management intends to do regarding food health safety, and describes the direction the organization wants to go.

The final product is a product that will not undergo further processing or transformation by the organization. That product may be a raw material for another organization, but it is for the organization that produced it the final product.

The flowchart presents a schematic representation of the stages of the final product production process, the input and output elements of the process, the relationships between the phases (order, consequence, feedback) and food health control.

A control measure is any action or activity that can be applied to prevent or eliminate health hazards to food or reduce it to an acceptable level.

The previously required programs describe the basic conditions and activities that are necessary throughout the food chain to maintain an environmentally friendly hygiene that is suitable for the production, handling and supply of safe final products and safe food for human consumption. These programs represent practically all those activities that do not belong to specific HACCP plans, and which affect food health safety. In other words, these are universal steps or procedures that control the operational activities within the food plant, and which enable the production of a final product that is safe. They depend on the segment of the food chain in which the organization operates and on the type of organization. Examples of equivalent terms are: good agricultural practice, good veterinary practice, good processing practice (good hygiene practice, good production practice, good distribution practice and good trade practice).

Operational pre-required programs are mandatory programs that are necessary because risk analysis has shown that they are necessary to control specific hazards to food safety. They are used to reduce the likelihood that products will be exposed to risks, that they will be contaminated, and that the risks will spread. They are also used to reduce the likelihood that the process environment will be exposed to risks, that it will be contaminated, and that the risks will spread to that environment.

A critical control point is a step that is essential to prevent or eliminate food safety hazards and in which management can be applied to prevent or eliminate food safety hazards, or to reduce them to an acceptable level.

The critical limit represents the maximum or minimum value to which physical, biological or chemical hazards should move, in order to prevent, eliminate or reduce the occurrence of identified hazards to food safety to an acceptable level. The critical limit is the criterion that separates the acceptable from the unacceptable.

Monitoring is the observation or measurement to assess whether control measures at a critical point have been effectively implemented.

Correction represents actions that eliminate the observed discrepancy. It is just a correction of a specific discrepancy, without going into the causes of the given discrepancy. Correction (correction) may, for example, be reprocessing, further processing, and / or elimination of the harmful consequences of non-compliance (such as availability for other use or placing special labels).

A corrective measure is a measure that eliminates the cause of a detected non-compliance or other undesirable situation. There can be more than one cause of non-compliance. A corrective action includes an analysis of the cause and is taken to prevent recurrence. Corrective action should be taken when monitoring results indicate a loss of control.

Validation is the initial phase in which the plan is tested and re-examined. The choices made during the work through the preliminary phases and principles should be re-examined and presented, in order to prevent or control the identified hazards in

practice. At this stage, microbiological or residual, testing can be effectively used as confirmation that the process is under control and that acceptable products are being produced. Such testing provides clear evidence that the techniques and methods adopted by the factory to control risks are not only effective in theory, but will work in that particular factory as well.

Verification is the application of methods, procedures, tests and other evaluations, in addition to monitoring, in order to determine compliance or provide objective evidence that the established requirements are met.

An update is an ongoing and / or planned activity, with the aim of ensuring that the latest information is applied [2,3,4].

APPLICATION OF ISO 22000 AND BENEFITS OF IMPLEMENTATION

ISO 22000: 2005 applies to all organizations regardless of their size and their impact on the food industry. The standard is designed to serve not only the needs of food producers and processors, but virtually all organizations that are part of the food industry. ISO 22000 is written so that its structure is compatible with other standards of system management in the light of ISO 9001: 2008 (applying ISO 15161 as a guideline for work), while applying HACCP [5].

The ISO 22000 standard can be implemented in practically all organizations engaged in food production. These include: primary food producers, food component producers, food producers, food sellers, catering establishments, ready-to-eat food producers, organizations that perform cleaning and sanitation, freight forwarders, warehouses, distributors, etc. The ISO 22000 standard can also be implemented in organizations that do not produce food, such as: manufacturers of equipment, manufacturers of packaging materials, manufacturers of ingredients and additives, and organizations that produce other elements that come into contact with food. The most important benefit of this standard is that it will make it easier for organizations around the world to implement HACCP in a harmonized way, which will not depend on the country or type of food. Adoption of the ISO 22000 standard provides the company with competencies recognized worldwide. The implementation of ISO 22000 standards provides numerous advantages. It is a reliable system that has been validated by the FAO / WHO [6].

Numerous countries have developed national standards related to safe food production, and individual companies and groups in the food sector have developed their own standards for testing their suppliers. This brought confusion in terms of requirements and increased costs because they had to meet multiple programs. ISO 22000 provides for a uniform standard of control that can be applied in all organizations which are related to the food industry. The standard allows the incorporation of legal and regulatory requirements related to food health safety including the HACCP system. ISO 22000 provides an incentive for an organization to continually improve. This includes internal and external communication systems, record keeping, compliance with hygiene regulations and food safety risk control [3].

This standard enables traceability and clear communication within the food industry chain through a system of clear responsibilities and competencies of all employees. The application of the system optimizes the resources of the organization internally and within the food industry chain. Rational communication and cooperation bring faster and better informed decision-making on food safety hazards together with other partners in the supply chain. In this way, the standard strikes a good foundation in the decision-making system and has a positive effect on the work environment, thus increasing both productivity at work and employee satisfaction. Employees are becoming more aware of issues related to food hygiene and health safety. The standard provides a framework for third-party certification, and can be applied without certification [6].

Although ISO 22000 can be implemented separately, it is designed to be fully compatible with ISO 9001: 2008. Organizations that already have ISO 9001 certification will easily extend the certification to ISO 22000. It extends the approach of the ISO 9001: 2008 QMS management system, which is widely accepted and applied in all areas, but is not specifically focused on food safety. Integration speeds up and simplifies processes, increases efficiency and reduces costs without compromising existing or other quality or management systems [3].

ISO 22000 is applicable to all producers and participants in the entire supply chain of the food industry. It can be easily applied in small and medium enterprises. A systematic and proactive approach to identifying food safety risks, developing and implementing control measures and systematic management leads to better planning and thus less verification after the process. Implemented ISO 22000 increases the international acceptance of food products and reduces the risk of product / service liability lawsuits [2,3].

CONCLUSION

The essence of the application of the concept of health safety consists in specific planning activities and constant efforts to position, define and timely eliminate all dangerous situations or phases in the complete production cycle of food products (from primary production of basic and auxiliary raw materials to direct consumption of finished products). The essence is preventive action with the aim of timely elimination, reduction or establishment of an acceptable level of all potential risks to food safety.

Clearly, this concept is essentially a systemic, designed, active and preventive norm for ensuring full toxicological, hygienic-sanitary and other safety of foodstuffs. The success of the system depends on the training and education of employees. It is important that employees understand how the system works. Employees should be familiar with the procedures and work instructions with a description of the work to be performed.

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**M. Sc. Nemanja Petrović¹, M. Sc. Bratimir Nesić², M. Sc. Natalija Tosić¹,
B. Sc. Nenad Nesić³, M. Sc. Dusan Stevanović¹, B. Sc. student Luka Nesić²,
B. Sc. Dusan Milincić¹, B. Sc. Aleksandar Aleksić¹**

¹ Academy of Technical-Educational Vocational Studies - Department, Nis, Serbia

² University in Nis, Occupational Safety Faculty, Nis, Serbia

³ City Administration, Krusevac, Serbia

E-mail: bratimir@gmail.com

РИЗИК ЗДРАВСТВЕНЕ БЕЗБЕДНОСТИ ХРАНЕ И ISO 22000

Абстракт

У раду су приказане основе управљања ризиком здравствене безбедности хране и ефекти примене ISO 22000, међународног стандарда за системе менаџмента здравствене безбедности хране. Биолошки и хемијски агенси који изазивају тровања храном могу да буду веома различити, али им је заједничко да прате сировину од њене примарне производње, преко прераде и дистрибуције, до употребе. Такође, кретање производа кроз ланац производње обезбеђује значајне информације за даље руковање. Из тих разлога, постоји потреба да се проблему здравствене исправности хране приступи на један потпуно интегрисан начин. Поступци у том правцу морају да имају превентивни статус, а не само карактер тестирања крајњег производа. Такав принцип контроле прихватиле су ветеринарске стручне и научне организације, те су га сврстале и у основу Закона о храни у ЕУ. Полазећи од чињенице да се процес управљања ризиком односи на неочекиване догађаје, концепт доношења одлука има веома висок ниво неизвесности. Због тога је веома велики значај дат процесу идентификације и процене ризика.

Кључне речи: *ризик, здравље, безбедност, храна, ISO стандард*



**M. Sc. Natalija Tosic¹, M. Sc. Bratimir Nestic², M. Sc. Nemanja Petrovic¹,
B. Sc. Nenad Nestic³, B. Sc. Dusan Milincic¹, B. Sc. student Luka Nestic²,
B. Sc. Aleksandar Aleksic¹, M. Sc. Dusan Stevanovic¹**

¹ Academy of Technical-Educational Vocational Studies - Department, Nis, Serbia

² University in Nis, Occupational Safety Faculty, Nis, Serbia

³ City Administration, Krusevac, Serbia

E-mail: bratimir@gmail.com

HEALTH SAFETY OF MEDICINAL HERBS

Abstract

The paper presents the basics of health risk management of medicinal plants, as well as determining the degree of change and improvement of business processes by applying ISO 22000, as an international standard for food safety management systems, ie how much greater efficiency and competitiveness of business processes has been achieved.

Key words: *health, safety, medicinal herbs*

INTRODUCTION

In recent years, opinions on the status of food have changed significantly. Originally, food was an imperative for survival. In such circumstances, quality and health were not a priority. Over time, the essence of production changes and it is increasingly directed towards quality and adapted to consumer requirements. The levels presented have the following meanings [1]: A - the goal is existence, B - the goal is quality, C - commitment to quality, D - commitment to sustainable production and the environment.

A number of elements affect the health and quality of the product. Based on them, the main areas that can pose a potential danger have been formed, and they are:

- environmental pollutants (pesticides, heavy metals, etc.),
- contaminants on the farm (animal health status and veterinary drugs ...), and
- pollutants in processing and consumption (from product development to users).

The health system is the transmission of information through the production chain, from the farm to the end user. The flow of information must be two-way. The concept is based on risk analysis, which enables a high level of protection of human health and life. Risk analysis combines three interrelated activities: risk assessment, risk management, and risk information transfer.

In the part of defining environmental pollutants, risk assessment and management are performed by veterinary experts. Based on the primary production, all the way to the final goal of the finished product, the more important aspects are: implementation of general principles of food hygiene and control, assessment and self-checking procedures of various hazards.

An important part of control is risk analysis through control critical points related to production. This area includes determining control points during the production process and defining optimal control parameters for them.

Pollutants in the environment can also define the health and quality of products. Pollution of the human environment is the biggest problem of today. Modern man has negatively influenced nature, water and air, food quality, perfecting his scientific achievements. That is why environmental problems have become dominant, and solving them has become a priority.

Directing development, in a way that production activity is harmonized with the need to preserve the natural environment, has influenced the creation of a new concept of "sustainable development". Sustainable development enables the improvement of the technical and technological basis of work, the increase of social wealth and well-being of people, while preserving the environment. Therefore, sustainable development implies the harmonization of three factors: economic growth, social justice and a healthy environment [1].

PROPER COLLECTION OF MEDICINAL HERBS

During the collection of raw materials, the guidelines on the hygiene of food products and staff must be fully followed. It is necessary to continuously train staff on hygiene rules and responsibilities. A healthy and clean working atmosphere of the staff involved in collection and processing must be ensured. Personnel must be protected from contact with toxic or potentially allergenic plant material by wearing adequate protective clothing. Persons suffering from communicable infectious diseases or who have open wounds must be removed from areas where they may come into contact with plant material. Staff should undergo training before performing tasks that require knowledge in the field [2].

Collectors must have a sufficient level of knowledge about the plant species they need to collect. These include: identification, characteristics and requirements of the habitat such as shading, humidity, soil type, etc. Collectors must be able to distinguish the species collected from botanically related and / or morphologically similar species in order to avoid a risk to public health and to avoid endangering other plants. Collectors should have a sufficient level of knowledge about the appropriate time for harvesting, and about harvesting techniques for individual plants in order to obtain the

best possible quality material. If they do not have a sufficient level of knowledge, education should be necessary. Also, they must be referred to all issues that are important for the protection of the environment and the conservation of plant species, and this includes information on regulations related to protected species [3].

In order to ensure the rational collection of medicinal plants from nature, in addition to the human factor, it is necessary to provide the following [2,3,4]:

- It is necessary to appoint supervisors (within the company) who will identify and verify the collected plant material and who will supervise the work of the collector.
- Collection must be carried out in accordance with existing regulations on the protection and sustainable use of plant species.
- The collection of different types of plants must not adversely affect or damage the environment in which the collection takes place. Optimal conditions for the regeneration of the harvested plant species must be ensured.
- Plant species listed in the endangered species list may not be collected unless authorized by the authorized institution.
- Collection will be carried out only in unpolluted areas or at the minimum allowed distance from the source of potential pollution (roads, industry and settlements).
- Certain plant species can be harvested only when they have the best quality for the intended purpose. Therefore, each collector should wait for the approval of the company before starting the collection season.
- Only the quantity and the part of the plant that has been contracted can be collected.
- Damaged plant material must either be excluded from the plant material supplied to the market or labeled for alternative purposes.
- Plant species must be harvested under the best conditions, avoiding moist soil, dew, rain or extremely high humidity.
- Harvesting tools must be cleaned and prepared between the two harvests to avoid contamination of plant material.
- Harvested plant material should not come into direct contact with the soil. It should be collected immediately and transported in dry and clean conditions.
- During the harvest, no other plant species growing in the collection area may be mixed with the collected plant material.
- All packaging used during the harvest must be clean and free from contamination from (plant) material that was kept in it before.
- In case collectors use bags for collection, the company is obliged to distribute new bags.
- Mechanical damage and compaction of collected fresh plant material, which would result in undesirable quality changes, must be avoided. In this regard, care must be taken not to overfill the bags or to place them on top of each other.
- Freshly harvested plant material must be delivered as soon as possible to the processing facility in order to prevent undesired heating of plant material (inflamed material – quickly turns black), or immediately after collection, spread for drying.

- Harvested plant material must be protected from all pests, mice / rodents, insects and domestic animals.
- In case of collecting roots or bulbs, 80% of the plant population should be left intact. When collecting leaves, 70% of the leaves of the plant should be left. When collecting flowers, 30% of the flowers of each plant and 30% of the plant population should be left intact. If seeds are collected, 30% should be left for regeneration. Only adult plants may be collected during the harvest. Prohibited harvesting methods include hitting plants with sticks, tearing and plucking plants, and cutting branches. Treatment after collection includes: washing, cutting before drying and drying.
- Upon arrival at the processing facility, the collected plant material must be urgently unloaded and unpacked. The material should not be exposed to direct sunlight unless there is a specific need for it. The raw material must be protected from additional moisture or rain.
- In the case of outdoor drying, the plant material must be spread in a thin layer. To ensure air circulation, the drying frames must be placed far enough above the ground.
- Drying on the ground itself or drying in which the material is exposed to direct sunlight should be avoided.
- Plant material needs to be inspected to eliminate unwanted materials and foreign bodies. In order to protect the product and to reduce the risk of pest attacks, it is advisable to pack as soon as possible. Pack the products in clean and dry, at best new bags, sacks or crates. Avoid plastic packaging.
- The label must be clear, permanently affixed. The information on the label must be complete and should include: Product name, gross and net weight, collection time, collector name, any notes. Reusable packaging should be thoroughly cleaned and completely dried before reuse. The reuse of bags must not be allowed to be a source of pollution. Store packaged material in a clean and dry place, free from pesticide pests, inaccessible to livestock or domestic animals. It must be guaranteed that the use of packaging materials will not lead to contamination of plant material, especially in the case of fibrous bags.
- Store packaged dried plant material in dry, well-ventilated rooms, where daily temperature variations are limited and where good ventilation is ensured.
- Storage and transport facilities must be free of pesticides and other toxic materials.

POISONOUS HERBS

In case of the need to collect poisonous plants, additional caution is required in the work [2,4]:

- Multiple species must not be collected at the same time.
- Children and pregnant women must not work with poisonous herbs.
- You must not eat, smoke, etc. during work, and your mouth should be protected with gauze.

- After finishing work, it should be changed and washed.
- Poisonous herbs are dried and stored separately from the rest. At no time should poisonous plants be in the same room as another.
- The type of drug and the skull and the sign POISON should be marked on each package.
- In case of poisoning, it is necessary to have a handy pharmacy.

PLANT ORGANS

Natural medicinal raw materials or drugs by origin can be herbal (vegetable), animal (animal) and mineral. Herbal medicinal raw materials (herbal drugs) are dried plant organs (flower, leaf, herb, root, seed, fruit, etc.) in the narrower sense of the word. In a broader sense, they also represent products that appear as such in plants (fatty oils, essential oils, resins, etc.). When collecting medicinal herbs, ie. herbal drugs, among other things, is extremely important time of picking a particular species, as well as which part is harvested.

Therefore, we list the general regulations that should be followed when picking individual plant parts [2,4]:

1. **Flos (flower)** Harvested during flowering. It is best at the very beginning of flowering, because then it is richest in active ingredients. Overblown and withered flowers should not be picked, because they have no value. Picking is done by hand, making sure that the flower stalks are as short as possible. Drying can be natural or artificial (in dryers). Natural drying is done in a thin layer, in a dry place and on a draft. Drying is done in the shade, and only a small number of flowers can be dried directly in the sun, and not all the time. The drying temperature must not exceed 35-40°C. Unnecessary touching of the drying material should be avoided. From time to time, it is necessary to turn over the material in order to speed up the process. Drying time varies from 3-6 days. Dried flowers are packed in cardboard boxes, without compaction. Large pallets should be avoided, because they cause mechanical damage (shredding), and thus reduce the quality. Storage is mandatory in a dry and dark place.

2. **Folium (leaf)** The most suitable time for picking leaves is the beginning of flowering. Leaf picking should be avoided in very young plants, because then the leaves are full of water and poor in active substances. Also, the leaves are not picked from flowering plants, although there are exceptions to this rule. The same conditions apply to drying as for flowers. Drying time depending on the type and drying conditions is up to eight days. It can be packed in boxes and pallets, nylon bags should be avoided. Herba (above-ground part of a flowering plant) The name herba usually tolerates 25-30 cm of the top parts of a flowering plant. As with flowers, harvesting is done at the beginning of flowering. In cases of distribution on larger areas, it can also be mowed. The same conditions apply to drying and storage as to previous drugs.

3. **Cortex (bark)** It is removed from young branches and trees in early spring before flowering. The bark that is old and cracked is not for use. The bark is cut with

a knife and peeled. If it is not removed in the spring, it can also be removed in late autumn. After removing, for easier drying and storage, we cut the bark into longitudinal strips 2-3 cm wide and 10-30 cm long. Unlike the previously mentioned plant organs, drying of the bark can also be performed in the sun, which means that the drying temperature can be higher, ie. up to 60°C.

4. **Fructus (fruit)** The time of harvesting the fruit varies, so that in some cases the ripe fruit is picked, and in some species it is semi-ripe (unripe). One of the divisions of fruits is into fleshy and dried fruits. For most meaty ones, it is valid to pick the ripe ones, and most of the dry ones are picked before ripening. The fruits can be dried in the sun. Particular attention should be paid to the drying of fleshy fruits (pomegranate) to prevent spoilage and decay of the drug.

5. **Seeds (seeds)** Harvested fully ripe. After drying, special attention should be paid to storing the seeds. It should be packed in coated bags or boxes, because most seeds (the same goes for most fruits) are attractive food for rodents due to the usually high content of fatty oil.

6. **Radix, rhizome, tuber (root, rhizome, tuber)** The root, rhizome and tuber are the underground organs of plants. In the case of perennials, they are dug in early spring and late autumn, and in the case of annuals, during flowering (although there are exceptions). Depending on the time of harvesting, the chemical composition also changes, so that with the same species, the root harvested in the spring and the root harvested in the fall can be significantly different in composition, and thus in quality. After extraction, the root (or rhizome) is cleaned of the remains of the soil, the rotten parts are removed and washed well. In some species, it is necessary to peel the roots. The roots can be dried in the sun, but in order to dry faster, it is necessary to pre-cut the root (rhizome) into longitudinal strips. It should be emphasized that after removing the roots, it is necessary to cut off the root head and return it to the ground in order for a new plant to develop from it.

FOOD SAFETY MANAGEMENT SYSTEM

The food safety management system requires [5]: the establishment, documentation, implementation and maintenance of an effective ISO 22000. This includes the procedures and records required to ensure the effective development, implementation and updating of ISO 22000. The organization should:

- Ensures that health hazards to food, within the subject matter and scope of the system, that may arise in relation to products are identified, assessed and controlled;
- Exchanges relevant information within the food chain;
- Exchanges information related to the development, implementation and updating of ISO 22000 and
- Periodically evaluates and updates ISO 22000.

The implementation of the Food Safety Management System has a number of advantages, among which are the following [6]:

- The system is suitable for all organizations in the food chain (from primary producers, suppliers, processing to service in the food chain)
- It is designed to support communication with all parties related to the food chain in order to increase standards within the food industry.
- It is consistent with the recognizable HACCP principles developed by the Codex Alimentarius Commission.
- Improving food safety,
- Improving product quality,
- Strengthening consumer protection and trust,
- Increasing cost efficiency in the food production and marketing chain,
- Interactive communication,
- Implementation of so-called prerequisite programs (PRP) as the basis of functional HACCP.

Given that HACCP as a system is difficult to apply to large production or sales chains, to be able to function successfully requires the implementation of ISO 9001 and thus additional costs for the company. To avoid these shortcomings in HACCP implementation, there is a strong need in large food companies to create a new standard such as ISO 22000. It integrates not only HACCP and ISO 9001, but also deals with predictions and analysis of a large number of external factors and hazards that, not only can endanger food safety, but can negatively they also affect the production process, company finances and employees.

CONCLUSION

The essence of the concept of health safety is contained in the constant effort and concrete planning activities to position, define and timely eliminate all dangerous phases or situations in the entire cycle of production of agri-food products (from primary production of basic and auxiliary raw materials to direct consumption of finished products).

The essence is in preventive action in order to eliminate, reduce or bring to an acceptable level in time all real potential risks in terms of food safety. It is obvious that this concept represents a systemic, well-designed, active and preventive norm by which it is possible to ensure full hygienic-sanitary, toxicological and any other correctness of food. The success of the system depends on the education and training of employees. It is very important that employees understand what this system is and how it works. They must be familiar with the appropriate procedures and work instructions containing a description of the work to be performed.

Risk assessment indirectly affects the increase of satisfaction with service users because they will get a better and timely service. By assessing the risk and adopting an appropriate document, the employer shows seriousness in its work and its commitment to caring for employees, environment and, finally, compliance with legal regulations.

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**M. Sc. Natalija Tosić¹, M. Sc. Bratimir Nesić², M. Sc. Nemanja Petrović¹,
B. Sc. Nenad Nesić³, B. Sc. Dusan Milincić¹, B. Sc. student Luka Nesić²,
B. Sc. Aleksandar Aleksić¹, M. Sc. Dusan Stevanović¹**

¹ Academy of Technical-Educational Vocational Studies - Department, Nis, Serbia

² University in Nis, Occupational Safety Faculty, Nis, Serbia

³ City Administration, Krusevac, Serbia

E-mail: bratimir@gmail.com

ЗДРАВСТВЕНА БЕЗБЕДНОСТ ЛЕКОВИТОГ БИЉА

Абстракт

У раду су приказане основе управљања ризиком здравствене безбедности лековитог биља, као и утврђивање степена промена и унапређења пословних процеса применом ISO 22000, као међународног стандарда за системе менаџмента здравствене безбедности хране односно како је постигнута знатно већа ефикасност и конкурентност пословних процеса.

Кључне речи: *здравље, безбедност, лековито биље*

**LEGAL ASPECTS OF PROTECTING
BRAND NAMES OF SAFE FOOD**



Professor Dr Vladan Joldžić

Institute for Criminological and Sociological Researchings and Faculty
of Chemistry University of Belgrade
E-mail: vladanj@eunet.rs

ENVIRONMENTAL LAW APPROACH TO HEALTHY FOOD PRODUCTION

Abstract

With our work Environmental law approach to healthy food production, as it can be seen from the title itself, we direct readers to the basic and necessary legal elements through which the production of healthy food is ensured. Of course, in our analysis, we point out both the international legal elements relevant to the subject of our research and those formed at the level of national legislations. At the same time, given that our gathering is being held in the Republic of Serbia, we are doing so by focusing on the efforts expressed in the development of its legislation, not forgetting those shown by other countries.

Key words: *healthy food, consideration of ecological legal approach*

The production of healthy food, if we strive for the sustainable development of society-state, is one of the necessary elements. It must be viewed from several directions. One of the basic ones is the one formed on the basis of legal logic, principles and normative creations, which requires the application of an adequate methodological approach, especially respecting:

- Formal-normative method, in order to determine whether they are: international or original texts of state legislation, and in the latter case, whether they are legal or by-law texts;
- Normative-hierarchical method, through which we determine the mutual hierarchical relationship of valid laws as well as bylaws that supplement them; but also
- Material-normative method, through which we arrange legal norms with regard to their content, primarily within legal works, but also legal-logical units that we form through objective perception and logical connection of norms of numerous regulations located within several valid laws and bylaws, which are important

for adequate treatment of observed values and / or relationships. This is exactly how we create the image of what really exists and is applicable in law.

The approach to methods and their use is also valid when we talk about the subject of our research, the results of which we present to you in this paper.

Approaching to the legal observation of the production of healthy food, we do so starting from recognizing the necessary relationship to the basic ecological values, at the same time mediums, those are: water, air and land, without which this production is impossible. Then we, at the first place, follow a logical sequence that starts from looking at the initial production of everything that enables the production of healthy food, and then we focus on the healthy food production itself, but also its packaging, storage, transport, placement, as well as consumption.

WHAT AND HOW MUST BE PROPERLY TREATED IN ORDER TO PRODUCE HEALTHY FOOD?

The basic condition for the production of healthy food is healthy media, that is, air, water and soil. This means that they must be of certain qualities, protected from various dangers. Let's start by considering air protection.

Protection of the air, which is important for the subject of our interest, was provided on a global level by the Convention on Long-range Transboundary Air Pollution [8], which established: protection of the air from all types of economic pollution [Art. 1. (1) (a)], pollution control measures (Art. 6), the obligation to develop technologies that reduce pollution, hence improve the effects of importance for the preservation of human health but also agriculture (Art. 7). In order to achieve that, a number of accompanying protocols were adopted [1] [2] [34] [35] [59] [60] [61], and then the Convention on Climate Change [6], supplemented by the Kyoto Protocol to the United Nations Framework Convention on Climate Change [20], which provided the air with legislative protection of global significance, which was incorporated into Serbian legislation [19]. This also ensures significant elements of water protection, since their possible pollution, among other things, comes from the air.

Water protection, aimed at stopping various pollutions, was formed on a global and regional level, through the protection of the sea and oceans [5], rivers [7] [9] [13][18] [65] and lakes [3] [10] [11], and even from accidental consequences [12].

The protection of the seas and oceans, also as a source of healthy food, is provided by numerous norms of the Convention on the Law of the Sea [66]. First of all, the norms by which the states are obliged to preserve the living elements of the environment of the seas and oceans (Art. 117, 118, 119), adjusting their activities accordingly (Art. 147), with the application of measures of necessary pollution control (Art. 194, 195), as well as the prohibition of polluting technologies (Art. 196), and especially pollution: from land (Art. 207), the bottom of the sea and ocean (Art. 208), within legally protected areas (Art. 209), by discarding various substances (Art. 210), and from vessels (Art. 211). In doing so, States Parties have a clear obligation to regulate

those obligations more precisely by their legislations (arts. 213, 214, 215 and 216). All the mentioned norms also provide protection to seafood as a source of healthy food. It is obligatory for every state that has a coast, but also one that does not own it but has ships, barges or sea platforms, or the subject of law under its jurisdiction.

Legislative protection is also provided to the soil through numerous texts of regional significance of ecological [32] or exclusively ecological significance [16]. Such protection is also provided by legislative constructions of global importance aimed to prevent from some of the problems. Such a creation is, for example, the Minamata Convention [64]. At the same time, these acts provided protection for the production of healthy food. For example, the Convention on Biodiversity [63], which provides protection and agro-biodiversity, by identifying activities that affect the conditions for the survival of biodiversity, but also land [Art. 7 (c)] and obliges to establish: conservation and protection of space [Art. 8, under (a), (b)], as well as the legal elements that are necessary for this protection [Art. 8, under (k)]. Such protection is also provided by Article 2, para. 2 under (d) of the Alpine Convention, which obliges "to reduce quantitative and qualitative damage to land, by applying (adequate) agricultural and forestry methods (with) erosion control and limiting watering". Clearly, substances that harm it. And these requirements were then elaborated in detail by the norms of the accompanying Protocol for the implementation of the Alpine Convention [33].

Land is also protected by the Convention on Climate Change [62], primarily by Article 4, para. 1, under: (b), (c), (d) and (f), through which the norms oblige the development and implementation of programs, measures but also technologies of importance for the conservation of biodiversity, thus the soil also. And the Convention to Combat Desertification [67], together with its annexes, obliges States Parties to develop legislation to prevent land protection [Art. 10, para.1. and st. 2, under (c)], with a commitment to sustainable agricultural practices (Art. 10, para. 4). To this also should be added the so-called Montevideo programs, starting with the first one, from 1982 [31], which calls for the development of legal norms aimed at environmental and legal protection of land [p. 3, under (III)], hence from its pollution [p. 4, under (VII)], pointing out (on page 7) the problems caused by industrialization, urbanization, excessive exploitation of resources, for that reason and the necessity of a legislative approach to: pollution, forests, land, and agriculture. All this is done by the current IV Montevideo program [17].

Respecting the previously explained and by most states adopted international legislative constructions, States Parties form specialist-oriented laws and bylaws, including those of importance for an adequate attitude towards food, starting from the regulation of actions regarding conditions and ways of its production in the future. The European Union acted in the same way, forming elements of legislation intended for the regulation of relations toward food, going from the most general to the already object-oriented elements. The legislation of the Republic of Serbia is developing in the same way. Let's explain this briefly.

The European Union passed, at the year 2002, the most general legislative act which regulates general principles and requirements regarding food [39]. It prescribed the obligation of: protection of human life and health (Article 5, paragraph 1), analysis of possible risks of them (Article 6, paragraph 1), respecting the principle of prevention

(Article 7, paragraph 1). 1.). Member States are obliged to apply internationally adopted standards (Article 5, paragraph 3 and Article 13). It is clearly prescribed that food that is not safe cannot be placed on the market (Art. 14, para. 1), especially if it harms human health and does not correspond to human consumption [Art. 14, para. 2, under (a) and (b)]. This law also prohibits the placing on the market of unsafe animal feed, ie food that is unsafe for animals and / or humans (Article 15). The act in question also establishes the responsibility of operators involved in the production and marketing of: food, if they violate the requirements of the observed Regulation 178/2002 (Article 19), as well as animal feed (Article 20). In recent years, it has been followed by a number of documents that elaborate on the issues addressed in this text in the most general way, including particularly important regulations and directives on: organic food production [14], packaging of genetically modified food [42], packaging hygiene [43], food contact materials [41], its nutritional and health qualities [40], additives, flavors and enzymes [36] [37] [38].

The Republic of Serbia also acts as the members of the European Union, using some of the legal constructions formed in the time of Yugoslavia and the State Union of Serbia and Montenegro, but also forming new ones. Republic of Serbia possesses number of acts important for safe food, some of general and larger number of specialized significance, both legal and by-law constructions. Hence, the most general protection is provided by the Constitution, then by ratified conventions and annexes, and then by laws that protect water, air and land, as the basis for the production of healthy food, then already specialized in directed laws and bylaws. Given the limited space, let us point out only some of the most important ones.

For our topic, at the first place is important the law intended for food safety [15], text that regulates the general conditions for food safety for humans, but also animals, which, or whose products, are used in human nutrition (Article 1), while obliging to respect the principle of prevention (Article 7) and prohibits the trade in food that is not safe (Article 25), including animal feed (Articles 28 and 29). In order for food to be safe, it regulates the quality of food for humans (Art. 55) and animals (Art. 56). It is clearly stated that the production, import, export and placement of food based on genetically modified organisms is regulated by special regulations (Article 12, paragraph 1) and such a regulation is precisely the Law on Genetically Modified Organisms [21], which clearly prohibits placing in trade genetically modified organisms and products thereof (Article 2) as well as the use of genetically modified organisms for the production of food and feed (Article 5, paragraph 1), punishing the placing on the market of such products as a criminal offense. 45). It should also be borne in mind that the Law on Food Safety clearly prescribes that novel food products do not include those produced on the basis of genetically modified organism or organisms (Article 58, paragraph 3).

For the production of healthy food, it is also important to respect the norms of the Law on Organic Production [22], which regulate: primary agricultural production, processing of agricultural products, production of animal feed, production and treatment of seeds, seedlings and planting materials (Article 2) whole organic production (Article 5) and in accordance with the rules prescribed for that (Article 18), including the rules concerning the processing of these products (Article 26) as well as their

storage (Article 28). At the same time, the rules concerning: the application of plant protection products [23], livestock [24], but also consumer protection, must be observed [4].

And in order for all these legal creations to be truly applied, numerous bylaws have been formed, including regulations of importance for: food production [51], food safety [47] [52] [53], packaging for the same [44] [48], but also the technology of production of various products [25] [26] [45] [46] [57], including food for animals [30], but also meat [28] [29] [55] [56] [58] and milk products [50], as well as mill and bakery products [54], and oil products [49] [27], but also fruits and vegetables.

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Проф. др Владан Јолчић

Институт за криминолошка и социолошка истраживања и Хемијски факултет
Универзитета у Београду

ЕКОЛОШКО ПРАВНИ ПРИСТУП ПРОИЗВОДЊИ ЗДРАВСТВЕНО БЕЗБЕДНЕ ХРАНЕ

Резиме

Нашим радом, Еколошко правни приступ производњи здравствено безбедне хране, како се то види из самог наслова, читаоце упућујемо на основне, а неопходне правне елементе путем којих се обезбеђује производња здравствено безбедне хране. Разуме се, у својој анализи, указујемо како на међународно-правне елементе од значаја за предмет нашег истраживања, тако и на оне формиране на нивоу националних законодавстава. При том, обзиром да се наш скуп одржава у Републици Србији, чинимо то и уз усмеравање пажње на напоре исказане у развоју њеног законодавства, не заборављајући нити оне испољене од стране других држава.

Кључне речи: *здравствено безбедна храна, еколошко правни приступ*

**ECOLOGICAL MODELS AND SOFTWARE
IN SAFE FOOD PRODUCTION**



**B. Sc. Dusan Milincic¹, M. Sc. Bratimir Nestic², M. Sc. Nemanja Petrovic¹,
B. Sc. Nenad Nestic³, M. Sc. Natalija Tosic¹, B. Sc. student Luka Nestic²,
B. Sc. Aleksandar Aleksic¹, M. Sc. Dusan Stevanovic¹**

¹ Academy of Technical-Educational Vocational Studies – Department, Nis, Serbia

² University in Nis, Occupational Safety Faculty, Nis, Serbia

³ City Administration, Krusevac, Serbia

E-mail: bratimir@gmail.com

FOOD WASTE MANAGEMENT AS A GLOBAL PROBLEM

Abstract

The World today is facing the serious issue of widespread human undernourishment and at the same time huge amounts of food are being wasted in all phases of food production and consumption. The aim of this paper is to underline, once more, the important issues that arise from the huge flow of food waste both in high income as well as in low income countries. The focus is on food waste from the perspective of municipal solid waste (MSW) management, and its implication for policy makers as well as on the various treatment schemes. The principal issues were pointed out in order to emphasise the neglected problems worldwide and contribute to an open public discussion on this topic.

Key words: *waste, food, problem, human kind, planet*

INTRODUCTION

Since inappropriate management of MSW in landfills contributes from 4% to 11% of the worlds Greenhouse Gas (GHG) emissions [1], properly managed food waste by means of separate collection and recycling has a positive impact on climate change by transforming food waste into compost by means of a low-cost and immediately available technique [2], the organic matter is stored in soils and not lost into the atmosphere as CO₂ or methane.

In general, most literature refers to "food waste" as the sum of the avoidable (edible) and the unavoidable (non-edible parts), hence it includes both: wasted food originally produced for consumption and residues from food preparation (e.g. peelings). From a

life cycle perspective, the term "food waste" can be used to include large sources of biogenous waste (biowaste) along the food production chain. A tentative list is shown below [3]:

- losses after harvesting;
- losses during transportation to industry;
- losses and surplus from food industry;
- residues from markets;
- residues from restaurants and catering;
- leftover food of different origin;
- household food waste.

In the field of municipal solid waste management (MSW), many authors and experts use the term "biowaste", which can have a wide range of origins, from households and restaurants to canteens, cafes and public parks and gardens. Biowaste produced and collected in municipalities is commonly divided into two main categories [3]: 1) garden waste, generated in gardens and streets from plants and grass and 2) food waste, generated in kitchens.

For the purpose of this document, we define food waste to be wasted food originally produced for consumption and residues from food preparation, originated from households and commercial activities (such as restaurants, canteens, bars, cafes, etc.). The term "biowaste" refers to the common definition used in the field of MSW management, it contains food waste and garden waste. It is important to note that this document considers food waste and biowaste as "clean fractions", suitable to be recycled into compost and biogas, only if source separated and separately collected [3].

FOOD WASTE PROBLEM SCOPE

Wasting food costs: money, environment and it also costs society. With an estimated 925 million people deemed to have been undernourished in 2010, [4] (equivalent to about 13% of the world's population [5]), it also has a profound moral dimension. As the global population continues to increase, the security of our food supply is an issue that challenges governments all over the world. Competition for land, water, energy and fertilisers are all factors in a complex web that affects the amount of food available.

Estimates of how much food is wasted [6], however, vary. The most recent report commissioned by the Food and Agriculture Organization (FAO) of the United Nations indicated that approximately 1,32 billion tonnes of food is lost or wasted annually, equivalent to about one-third of food produced for human consumption [7]. A recent study conducted on behalf of the European Commission's DG Environment estimated that approximately 89 million tonnes of food waste was generated in 2006 within the EU27, equivalent to 179 kg per person. This amount is expected to rise to approximately 126 million tonnes (a 40% increase) by 2020 unless additional preventive measures are taken [8].

Food is wasted at all stages along the supply chain, from primary production, through processing to end use by the consumer. In a comprehensive review of food

waste supply chains, there are eleven identified distinct stages where food waste could arise [9]. This is shown schematically in Figure 1.

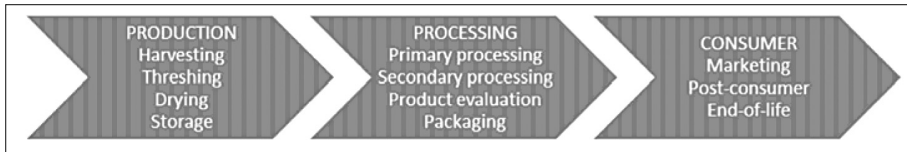


Figure 1. Schematic representation of the food supply chain [9]

The proportion of food waste arising at different stages of the food supply chain (FSC) varies depending upon the level of industrialisation. In general, lower income countries tend to produce proportionally more food waste during production and processing, as these tend to rely on lower-tech production methods, and the supply chains are often fragmented. By contrast, despite the more advanced production and processing technologies in higher income industrialised countries, food is wasted because of the high expectations placed on the supply chain by retailers, consumers and society on the quality and visual appearance of food products. Subsequently, even more food is wasted at the consumption stage than within the food supply chain, particularly by consumers in higher income countries. The FAO estimated that 95 – 115 kg per person is wasted every year by consumers in Europe and North America, compared to 6 – 11 kg per person per year in sub-Saharan Africa and South / South East Asia [3].

IMPACT OF FOOD WASTE TO MUNICIPAL SOLID WASTE

Food wastage by consumers has a direct impact on the quantity and composition of municipal solid waste (MSW). As food waste is readily biodegradable, it has a direct impact on the biodegradability of MSW if mixed with food waste, which in turn affects how MSW is collected, treated and disposed of. The higher the percentage of food waste in MSW, the more crucial the need for source separation of waste. This is because separately collected food waste (together with other biowaste) can be recycled into quality compost and can also be used to produce biogas as a renewable source of energy. When food waste is not source-separated, it can only be partly sorted by mechanical methods, however the quality of recycled materials (particularly the end compost) largely decreases due to source contamination with other substances which might be hazardous. Alternatively, mixed waste could be incinerated, however the high water content from food waste reduces the combustion efficiency and energy recovery efficiency.

In addition, several studies have shown (in Sweden and Italy) that if municipalities introduce source separation of food waste, households are more likely to also sort other recyclable fractions, hence increasing overall recycling amounts. As such, food waste is a considerably important factor in managing MSW.

The treatment of food waste poses a greater challenge to lower income countries, where separate collection at source is usually not in place. The current waste management practise of these countries comprises of basic collection of mixed waste and landfilling (or dumping) of collected mixed waste. The high percentage of biodegradable waste in landfills results in large amounts of leachate and GHG emissions (CO₂ and methane), causing ground water pollution and climate change, if not managed properly [3].

FOOD WASTE PREVENTION INITIATIVES

Over the last few decades, several food waste prevention initiatives have been implemented worldwide, targeting different stakeholders along the food supply chain. These initiatives include those that have been implemented in cooperation with industries or retail businesses with an impact on consumers as well (e.g. Courtauld Commitment [10] in the UK), and those focused on gastronomy (e.g. Green Hospitality Awards programme [11] in Ireland). On the demand side, a lot of effort has been put into direct consumer awareness building campaigns (e.g. "Lebensmittel sind kostbar" in Austria [12], "Zu gut für die Tonne" in Germany [13], and "Love Food Hate Waste" [14] in Australia). These experiences have shown that it is relatively easy to use economic incentives to attract industries and retailers to take food waste prevention measures, while it is more challenging to convince households to prevent food wastage by only highlighting the economic advantages. There are in fact many non-economic barriers which are in conflict with preventing food wastage on the household level, such as time constraints, lack of food handling knowledge, convenience, and the wish to have a broad assortment of food at home.

In 2008, the United Kingdom's Waste and Resources Action Programme (WRAP) engaged in an extensive promotional campaign aimed at reducing food waste generated by households. Called "Love Food, Hate Waste", it set out to inform and educate individuals about the benefits (both economic and environmental) of reducing food wastage. The website <http://www.lovefoodhatewaste.com/> provides an impressive overview of the causes (and mistakes) causing food wastage, the related environmental impact, the economic burden, and possible solutions to capture unused food at various levels, including e.g.: more careful storage at home, better portioning at home and in restaurants, a portioning tool is also provided, better labelling of food in shops and markets and improved comprehension by customers of the meaning of "use by", "best before", "sell by", use of leftovers in innovative and tasty recipes and donations to food recovery programmes. According to the website, one of most comprehensive sources concerning food wastage, almost 50 % of the total amount of food thrown away in the UK is done at home, totalling 7,2 million tonnes of food and drink, and more than half of this could have been used. Wasting this amount of food costs the average household £480 a year, or £680 for a family with children.

With the ever-increasing concern for more appropriate use of resources, food wastage has gained attention in North America, too. Americans waste more than 40 % of food produced for consumption, which corresponds to an annual cost of more than

\$100 billion, while at the same time, food prices and the number of people without enough to eat continues to rise. Subsequently, qualified sources provide insights into the reasons for food wastage, from crops to leftovers after meals, and list the possible approaches to recover food at various stages in the supply chain, starting from capturing food which is not harvested to turning leftovers into new meals. Food rescue programmes are highlighted in order to retrieve edible food that would otherwise go to waste and distribute it to those in need. In most cases, the recovered food is perfectly edible, but not sellable such as day old bread and bagged lettuce past its "sell by" date. The food that food-banks pick up is donated by supermarkets, restaurants and farms. In the case of restaurants and supermarkets, the rescued food is being saved from disposal or processing into compost, whereas food recovered on farms is typically kept from being ploughed under. On farms, the donations often must be harvested, or gleaned, by volunteers [15].

CONCLUSION

Food waste occurs globally and has been growing at a tremendous pace over the last few decades: in high income countries as well as in lower income countries. Large amounts of food are wasted along the production-transportation-retail-consumption chain. Food waste is a severe global problem that has negative moral, environmental and financial implications. Besides international and local initiatives that are raising awareness and taking actions to prevent food waste, the waste management sector has an important role to play in addressing this global issue.

Some initiatives around the world have shown concretely how to prevent food waste through many different ways, such as better planning and storage, being informed about the real meaning of food product labels, and food rescue programmes that have been widely implemented worldwide. From the perspective of municipal solid waste management, food waste management has a profound impact on the whole municipal solid waste management system. It affects the rate of recycling of other recyclable materials, the treatment methods and efficiency of other fractions of municipal solid waste, and the cost of logistics of the overall waste management system.

Currently, the main regulatory approaches, namely bans on landfill, diversion targets and obligation, all show advantages and disadvantages. It is important to ensure a common understanding among stakeholders along the value chain with the overarching aim of reducing food waste, as well as to harmonise with other legislations that may impact on food waste, in particular legislation for soil, agriculture, climate change, and food safety.

Methodologically, biological treatment options to recycle food waste include composting and anaerobic digestion. An integrated concept, combining composting and anaerobic digestion is ideal in order to maximise the recovery of both energy and materials from food waste. In fact, there are a wide range of design varieties for biological treatment of food waste based on different local situations and treatment capacities. Thus the available technologies can support local authorities and decision-makers who wish to reduce and recycle food waste by effectively managing the process of food waste recycling.

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**B. Sc. Dusan Milincic¹, M. Sc. Bratimir Nestic², M. Sc. Nemanja Petrovic¹,
B. Sc. Nenad Nestic³, M. Sc. Natalija Tosic¹, B. Sc. student Luka Nestic²,
B. Sc. Aleksandar Aleksic¹, M. Sc. Dusan Stevanovic¹**

¹ Academy of Technical-Educational Vocational Studies – Department, Nis, Serbia

² University in Nis, Occupational Safety Faculty, Nis, Serbia

³ City Administration, Krusevac, Serbia

E-mail: bratimir@gmail.com

ЗБРИЊАВАЊЕ ОТПАДА ОД ХРАНЕ КАО ГЛОБАЛНИ ПРОБЛЕМ

Абстракт

Данас се свет суочава са озбиљним питањем широко распрострањене људске потхрањености а истовремено се расипају огромне количине у свим фазама производње и потрошње хране. Циљ овог рада је да још једном подвуче важна питања која произилазе из огромног тока отпада од хране како у земљама са високим дохотком, тако и у земљама са ниским примањима. Фокус је на отпаду од хране из перспективе управљања чврстим комуналним отпадом и његовим импликацијама на креаторе политике као и на различитим шемама третмана. Истакнута су главна питања како би се нагласили занемарени проблеми широм света и допринело отвореној јавној расправи на ову тему.

Кључне речи: *отпад, храна, проблем, људска врста, планета*

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