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APPLICATION OF BIOINOCULANTS FOR OPTIMIZING THE USE OF MINERAL FERTILIZERS IN THE PRODUCTION OF SILAGE CORN*

Emina Sijahović^{*1}, Hamdija Čivić¹, Drena Gadžo¹, Almina Kalić¹

Original scientific paper

Abstract

Maize is one of the most important agricultural crops globally and in Bosnia and Herzegovina, where cereals are cultivated on 204,368 ha, of which 57% (116,490 ha) is dedicated to maize production. The application of plant growth-promoting rhizobacteria (PGPR), such as the genera *Pseudomonas* and *Bacillus*, represents a sustainable alternative to mineral fertilizers, particularly in phosphorus-deficient soils commonly found in Bosnia and Herzegovina. A field experiment with ten fertilization treatments, arranged in a randomized block design with three replications, was conducted to evaluate the effects of seed inoculation, organic fertilization, and mineral fertilization on silage maize production. Grain yield, ear characteristics, and nutrient concentrations in maize leaves and grain were determined using standard analytical methods.

The highest grain yield (15.2 t ha⁻¹) was achieved with the combined application of organic fertilization (30 t ha⁻¹) and bacterial inoculation, with a statistically significant difference compared to the control treatment. The applied fertilization treatments improved nutrient uptake and increased the content of protein, nitrogen, phosphorus, and magnesium in the grain, while zinc concentration generally decreased, indicating an antagonistic relationship between phosphorus and zinc.

The obtained results confirm the potential of combining rhizobacterial inoculation and organic fertilization to enhance maize productivity and improve plant nutrient status.

Keywords: *maize, fertilization, plant growth-promoting rhizobacteria (PGPR), bioinoculants, yield*

INTRODUCTION

Maize (*Zea mays* L.) is an annual crop species belonging to the grass family (Poaceae), characterized by the highest genetic yield potential among cereal crops and by its extensive utilization in human and animal nutrition, as well as in the processing industry (Kovačević and Rastija, 2014). Due to its considerable agricultural and economic importance, continuous efforts are being made to improve maize production through the implementation of advanced agronomic practices.

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Maize is characterized by a robust aboveground biomass and a well-developed root system, requiring adequate nutrition and sufficient availability of essential plant nutrients. In particular, nitrogen (N), phosphorus (P), and potassium (K) play a crucial role in achieving optimal growth and yield. The average nutrient requirements for optimum maize production are estimated at 250–300 kg N ha⁻¹, 100–120 kg P₂O₅ ha⁻¹, and 280–300 kg K₂O ha⁻¹ (Marschner, 2012).

Under local production conditions, the majority of these nutrients are supplied through mineral fertilizers. However, the economic crisis caused by the war in Ukraine has resulted in an approximately 100% increase in mineral fertilizer prices, thereby imposing additional challenges on agricultural production and significantly increasing production costs for farmers.

In order to reduce production costs and mitigate the negative environmental impacts associated with the excessive use of mineral fertilizers, increasing attention has been directed toward the application of sustainable technologies, innovative practices, and environmentally friendly approaches. One such approach involves seed inoculation with plant growth-promoting rhizobacteria (PGPR). In particular, bacterial genera such as *Pseudomonas* and *Bacillus* have demonstrated significant potential in enhancing phosphorus solubilization in soil, thereby improving its availability to plants. To reduce dependence on mineral fertilizers, organic fertilizers and plant growth-promoting rhizobacteria (PGPR) can be utilized (Khan, 2005).

These rhizosphere-colonizing microorganisms enhance plant growth and nutrient availability (Kloepper & Schroth, 1978; Gray & Smith, 2005). Important PGPR include nitrogen-fixing genera such as *Rhizobium*, *Azotobacter*, *Bacillus*, and *Azospirillum*, while phosphorus-solubilizing bacteria mainly belong to the genera *Bacillus* and *Paenibacillus* (Brown, 1974). PGPR bacteria contribute to sustainable agricultural production by stimulating plant growth, enhancing nutrient uptake, and protecting plants against diseases (Shippers *et al.*, 1995; Dobbelaere *et al.*, 2003; Cakmakci *et al.*, 2006). They can also improve plant tolerance to abiotic stresses and increase nutrient availability through nitrogen fixation and phosphorus solubilization (Mrkovački & Bjelić, 2011). Several bacterial genera are capable of solubilizing insoluble phosphorus compounds, thereby increasing phosphorus availability to plants (Rodríguez & Fraga, 1999).

Phosphorus availability in many agricultural soils of Bosnia and Herzegovina is generally low and strongly influenced by soil properties and environmental conditions. Moreover, plants utilize only about 20% of phosphorus applied through mineral fertilizers, highlighting the need for alternative strategies to improve phosphorus use efficiency.

According to data provided by the Food and Agriculture Organization (FAO), the production areas and average maize yields in the countries of the region, Europe, and worldwide are presented in Table 1.

Table 1. Maize production areas and average yields in the region, Europe, and worldwide (FAOSTAT)

Country/Region	2023.		2024.	
	ha	t ha ⁻¹	ha	t ha ⁻¹
Bosnia&Herzegovina	102 823	6.97	121 966	6.25
Serbia	922 980	7.18	987 492	5.17
Croatia	269 090	7.40	273 160	7.57
Europe	8 298 960	7.35	8 673 210	6.79
Worldwide	211 099 135	5.87	209 954 361	5.80

In 2024, major cereal crops in Bosnia and Herzegovina were cultivated on a total area of 121 966 ha, with an overall production of 6.25 t ha⁻¹ of grain. Within the total cereal cropping structure, approximately 57% of the cultivated area was occupied by maize. Regarding cereal production, a total of 7 622 875 t of maize grain was produced (FAOSTAT).

According to Lončarić *et al.* (2015), based on wheat production in Croatia, mineral fertilizers account for 18.77–38.66% of the total production costs, depending on soil fertility status.

The aim of this study was to evaluate the effectiveness of bacterial inoculant application in silage maize production at KJP Poljoprivredno dobro Butmir. The use of these bioinoculants is expected to reduce the dependence on mineral fertilizers, increase silage maize yield and quality, and provide significant economic and environmental benefits

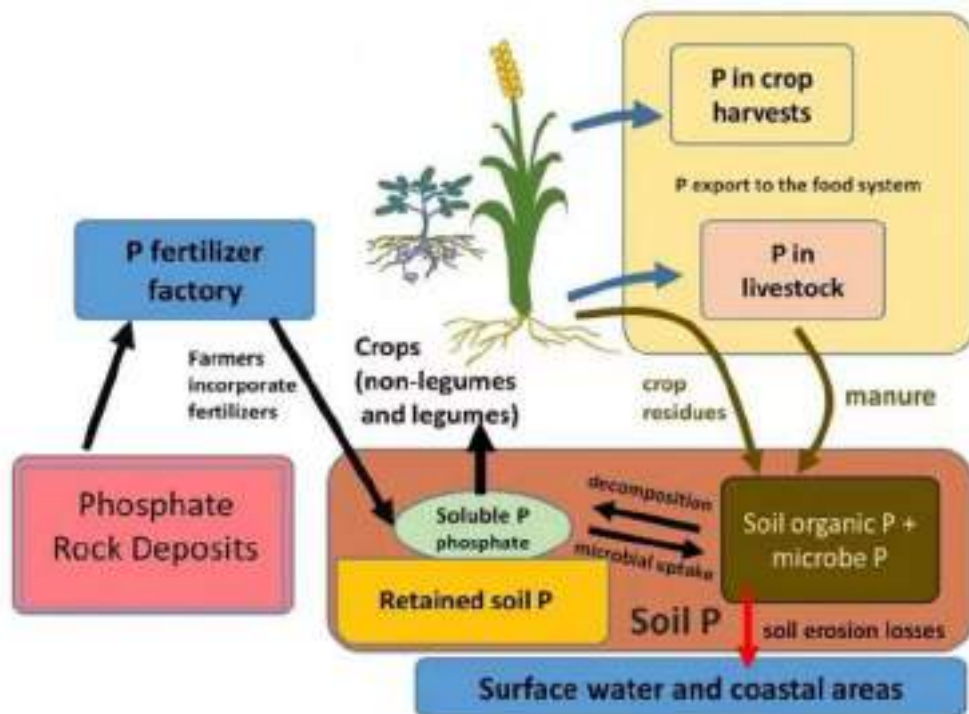


Figure 1. Phosphorus cycling in soil (source: https://serc.carleton.edu/integrate/teaching_materials/food_supply/student_materials/1176)

MATERIALS AND METHODS

The first phase of the study involved the inoculation of maize seeds with bacterial strains belonging to the genera *Pseudomonas* and *Bacillus*. Seed inoculation was performed at University of Sarajevo - The Institute for Genetic Engineering and Biotechnology (INGEB).

The second phase of the study included soil sampling on the production fields of the agricultural farm “PD Butmir”, and based on the agrochemical soil analysis, the most suitable location for the experimental plots was selected. KJP Poljoprivredno dobro Butmir was established in 1893 and is recognized as the oldest agricultural enterprise in Sarajevo. Today, as the Cantonal Public Company “Poljoprivredno dobro Butmir”, it operates a dairy farm with approximately 500 milking cows, for whose feeding nearly 200 ha of silage maize are cultivated annually.

Following soil preparation, the experiment was established according to a randomized block design with three replications. Each treatment was arranged in plots of 10 m² (5 m × 2 m). A total of 70 maize seeds were sown in each plot (7 rows × 10 seeds per row).

The maize hybrid used for sowing was BC 415 (FAO maturity group 400), which is well adapted to the agroecological conditions of the experimental area. Sowing was performed at a spacing of 70 cm × 20 cm. The experimental plots were sown on May 11, 2023. The experiment was established later than the optimal maize sowing period due to continuous rainfall during April and May. Mineral fertilizers (NPK and CAN), organic fertilizer (cattle manure), and bacterial inoculants were used in the experiment. The applied quantities are presented in Table 2.

Table 2. Fertilizer application rates used in the experiment

DOSE	ORGANIC FERTILIZER (t ha ⁻¹)	NPK (kg ha ⁻¹) (7:20:30)	CAN (kg)
I	10	300	367
II	20	450	563
III	30	600	733

The experimental setup included the following treatments:

1. Control treatment without fertilization
2. Organic fertilization treatment (III) + NPK (Dose 1)
3. Organic fertilization treatment (III) + NPK (Dose 2)
4. Organic fertilization treatment (III) + NPK (Dose 3)
5. NPK treatment (Dose 1) + inoculant (*Pseudomonas*, *Bacillus*)
6. NPK treatment (Dose 2) + inoculant (*Pseudomonas*, *Bacillus*)
7. NPK treatment (Dose 3) + inoculant (*Pseudomonas*, *Bacillus*)
8. Organic fertilization treatment (I) + inoculant (*Pseudomonas*, *Bacillus*)
9. Organic fertilization treatment (II) + inoculant (*Pseudomonas*, *Bacillus*)
10. Organic fertilization treatment (III) + inoculant (*Pseudomonas*, *Bacillus*)

During the experiment, standard agronomic practices were applied. Upon completion of the trial, plant material samples were collected, including samples of green silage biomass at the stage of silage maturity, as well as leaf and grain samples at technological maturity.

After sampling, the material was prepared for laboratory analysis through several procedures, including washing leaf samples with deionized water, drying the leaves both in a drying oven and under ambient air conditions, weighing, and preparation for grinding. Plant material analyses included the determination of silage biomass yield and grain yield, while chemical analyses included the determination of nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), zinc (Zn), and protein content.

The following methods were used in this study:

- determination of soil pH using a pH meter (ISO 10390, 1994),
- determination of organic carbon in soil by sulfochromic oxidation (ISO 14235, Geneva, 1998),

- determination of readily available phosphorus and potassium in soil samples using the ammonium lactate (AL) method (Egner *et al.*, 1960),
- determination of total nitrogen content in soil by the Kjeldahl method (Čivić *et al.*, 2004),
- determination of protein content multiplied by a factor of 6.25 (Čivić *et al.*, 2004),
- determination of protein content, calculated by multiplying the total nitrogen content by a factor of 6.25
- extraction of phosphorus and potassium from plant material using nitric and sulfuric acid (2.5:1 ratio), according to the method described by Lisjak *et al.* (2009),
- determination of phosphorus and potassium content in plant material samples, as well as total and available forms of nutrients in soil samples, using flame atomic absorption spectrophotometry on a Shimadzu 7000 AA instrument (ISO 11047, 1998).

RESULTS AND DISCUSSION

In accordance with the research topic, “Application of bioinoculants for optimizing mineral fertilizer use in silage maize“, and the defined objectives, statistical data analysis was performed using the SPSS statistical software package. The results are presented in this chapter.

Based on the physical and chemical characteristics, the soil on which the experiment was established was classified as clay loam of alluvial origin, with nearly equal proportions of sand, silt, and clay. The soil exhibited a slightly acidic reaction (pH 6.6). It was moderately humus-rich (2.9%), with a low content of plant-available phosphorus (12 mg 100 g⁻¹ soil) and a medium content of plant-available potassium (20 mg 100 g⁻¹ soil).

Maize grain yield and ear length

For comparison of the mean values of yield and ear length, Student’s T-test was applied, by which the experimental treatments were compared with the control treatment. The results are presented in Table 3.

Table 3. Average maize grain yield and ear length under different fertilization treatments

Fertilization treatment	Yield (t ha ⁻¹)	Ear length (cm)
Control treatment	9.66	18.53
NPK 1+ Organic	12.18*	19.90*
NPK 2+ Organic	11.43*	18.2
NPK 3+ Organic	13.19**	18.41
NPK 1+ Inoculated	8.69	16.43
NPK 2+ Inoculated	10.97	16.1
NPK 3+ Inoculated	12.83**	22.05*
Organic 1+ Inoculated	11.91*	20.64*
Organic 2+ Inoculated	11.12*	20.48*
Organic 3+ Inoculated	15.21***	21.41*

*Statistically significantly higher maize grain yield and ear length

From the table above, the following conclusions can be drawn. The effects of fertilization and inoculation on maize grain yield were statistically significant compared to the control treatment. The highest grain yield was recorded in treatment 10, where 30 t ha⁻¹ of cattle manure was applied in combination with inoculation, resulting in a yield of 15.2 t ha⁻¹. This treatment showed a highly statistically significant difference compared to the control. This response suggests that the yield increase resulted not only from an additional nutrient supply but also from enhanced biological activity in the rhizosphere, leading to improved nutrient availability and uptake. Similar findings have been reported by Zuluga *et al.* (2024), who emphasized that the integration of organic amendments with PGPR provides more stable field performance than microbial inoculants applied alone.

The lowest grain yields were observed in treatments 5 and 6, which involved the combination of mineral NPK fertilizer and inoculation, specifically at rates of 300 kg NPK + 367 kg CAN and 450 kg NPK + 563 kg CAN, respectively. In these treatments, yield differences compared to the control were not statistically significant. In all other treatments, yield differences relative to control were either statistically significant or highly significant.

Based on these results, it can be concluded that fertilization strategies combining organic fertilizers with inoculation may represent a viable alternative to the combined use of mineral (NPK) and organic fertilizers. Such an approach has the potential to reduce the application of mineral fertilizers, thereby lowering production costs and exerting a positive environmental effect.

Regarding maize ear length, the results presented in Table 3 show that average ear length ranged from 16.1 to 22.05 cm. In the control treatment without fertilization, ear length was 18.53 cm. All fertilization treatments resulted in higher mean ear length compared to the control, except variant 5 and 6. However, statistical analysis indicated significant differences in ear length in five treatments, namely: NPK 1 + organic

fertilization, NPK 3 + inoculation, Organic 1 + inoculation, Organic 2 + inoculation, and Organic 3 + inoculation treatments. Ear length followed the same trend as grain yield, with the greatest values recorded in treatments combining bacterial inoculation with farmyard manure. Since ear length is closely associated with kernel number and final grain yield, these results indicate that improved nutrient availability during vegetative growth positively influenced reproductive development. The enhanced ear development is likely attributable to improved nutrient uptake and PGPR-induced stimulation of plant growth regulators (Kaushal *et al.*, 2023).

Effect of different fertilization treatments on the content of individual elements in maize leaves and grain

Following the measurements of maize grain yield and ear length, the percentage content of individual elements in maize leaves and grain was also determined for each fertilization treatment. The elements analyzed included nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and zinc (Zn), and protein content. For the comparison of mean values, Student's t-test was applied, whereby the experimental treatments were compared with the control treatment. The results are presented in Table 4.

Table 4. Effect of different fertilization treatments on the content of individual elements in maize leaves

Fertilization treatments	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Zn (mg kg ⁻¹)
Control treatment	1.82	0.09	1.52	0.67	0.05	43.32
NPK 1+ Organic	1.73	0.10	1.53	0.69*	0.06	31.35*
NPK 2+ Organic	2.14*	0.13	1.53	0.70*	0.06	30.68*
NPK 3+ Organic	2.24*	0.18*	1.62*	0.76*	0.07	45.47
NPK 1+ Inoculated	2.62*	0.14	1.52	0.64	0.07	36.31*
NPK 2+ Inoculated	2.97*	0.18*	1.58*	0.77*	0.08	31.65*
NPK 3+ Inoculated	2.55*	0.18*	1.62*	0.71*	0.08	30.24*
Organic 1+ Inoculated	2.25*	0.16*	1.57	0.68*	0.08	32.50*
Organic 2+ Inoculated	1.81	0.12	1.55	0.50	0.08	23.87*
Organic 3+ Inoculated	2.32*	0.16*	1.56	0.80*	0.08	30.31*

* Statistically significant difference

After examining the nutrient content in maize leaves, the same elements were also measured in maize grain. In addition to these elements, the protein content was also determined in the maize grain. The results of these measurements are presented in Table 5.

Table 5. Effect of different fertilization treatments on the content of individual elements and protein in maize grain

Fertilizer treatments	Proteins	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Zn (mg kg⁻¹)
Control treatment	6.56	1.05	0.17	0.29	0.02	0.50	54.5
NPK 1+ Organic	7.36*	1.18*	0.21*	0.31	0.02	0.50	56.38
NPK 2+ Organic	8.42*	1.35*	0.23*	0.31	0.02	0.59*	40.69*
NPK 3+ Organic	9.48*	1.52*	0.33*	0.35	0.02	0.60*	51.94
NPK 1+ Inoculated	10.52*	1.68*	0.31*	0.30	0.03	0.59*	40.60*
NPK 2+ Inoculated	7.06*	1.13*	0.23	0.31	0.03	0.64*	53.98
NPK 3+ Inoculated	9.36*	1.54*	0.27*	0.40	0.03	0.68*	56.86
Organic 1+ Inoculated	9.19*	1.47*	0.27*	0.29	0.03	0.50	54.78
Organic 2+ Inoculated	8.04*	1.29*	0.24*	0.30	0.03	0.68*	63.11*
Organic 3+ Inoculated	8.92*	1.43*	0.24*	0.30	0.03	0.68*	46.69*

**Statistically significant difference*

The data indicates that the effect of fertilization on nitrogen content in maize leaves was significant in all treatments compared to the control, except in the NPK1 + organic and Organic2 + inoculation treatments.

Table 5 shows that the effect of fertilization on protein and nitrogen content in maize grain was statistically significantly higher in all treatments compared to the control.

The effect of fertilization on phosphorus content in maize leaves indicates that the NPK3 + organic, NPK2 + inoculation, NPK3 + inoculation, Organic1 + inoculation, and Organic3 + inoculation treatments had a statistically significant effect. The remaining treatments showed higher phosphorus content in leaves compared to the control, but these differences were not statistically significant. It can be concluded that seed inoculation with these bacterial strains had a positive effect on phosphorus uptake, as four out of six inoculated treatments showed a statistically higher phosphorus content in maize leaves. Bioinoculation also increased nitrogen accumulation in both leaves and grain, which was accompanied by higher grain protein content. These results suggest improved nitrogen use efficiency through enhanced root growth and greater microbial activity in the rhizosphere, particularly when bioinoculants were combined with organic fertilization. Similar responses have been reported in previous studies evaluating PGPR-based fertilization strategies.

The effect of fertilization on phosphorus content in maize grain shows that all fertilization treatments resulted in a statistically significantly higher phosphorus content compared to the control treatment without fertilization.

Potassium content in maize leaves was higher in all experimental treatments compared to the control; however, only three treatments showed a statistically significant increase: NPK3 + organic, NPK2 + inoculation, and NPK3 + inoculation.

Potassium content in maize grain ranged from 0.29 to 0.40%, but no statistically significant differences were observed among treatments.

Calcium content in maize leaves was significantly higher in all treatments compared to the control, except in the NPK1 + inoculation and Organic2 + inoculation treatments. Calcium content in maize grain ranged from 0.02 to 0.03, with no statistically significant differences compared to the control. Most inoculated treatments also showed increased phosphorus concentrations in leaves and grain, confirming the ability of *Pseudomonas* and *Bacillus* to improve phosphorus availability through phosphate solubilization. In contrast, potassium concentrations were only slightly affected, indicating that the principal nutritional benefits of the applied bioinoculants were associated with improved nitrogen and phosphorus acquisition rather than potassium uptake. The treatments significantly influenced calcium accumulation in maize leaves but not in grain, whereas the opposite trend was observed for magnesium. Increased magnesium concentration in grain may reflect improved nutrient uptake associated with enhanced root activity and greater mobility of this element within the plant.

Unlike the macronutrients, zinc concentrations tended to decrease in treatments with higher phosphorus accumulation, reflecting the well-known antagonistic interaction between phosphorus and zinc. Although no negative effects on grain yield were observed, these results suggest that zinc nutrition should be monitored when bioinoculants are used to increase phosphorus availability over prolonged periods.

Magnesium content in maize leaves was higher in all treatments compared to the control; however, none of the differences were statistically significant. In maize grain, magnesium content was statistically significantly higher in all treatments compared to the control, except in the NPK1 + organic and Organic1 + inoculation treatments.

Zinc content in maize leaves was statistically significantly lower in all treatments compared to the control, except in the NPK3 + organic treatment, which showed a higher value than the control, although this difference was not statistically significant. Zinc content in maize grain was statistically significantly lower in four treatments compared to the control (NPK1 + organic, NPK1 + inoculation, Organic2 + inoculation, and Organic3 + inoculation).

These results may be explained by the fact that the applied fertilization treatments had a positive effect on phosphorus and calcium uptake, while simultaneously reducing zinc uptake, as these elements are known to exhibit antagonistic interactions with zinc. Considering the importance of zinc in animal nutrition and the observed reduction in its content in both leaves and grain due to the antagonistic effect of phosphorus, it is recommended that additional zinc fertilization be applied in maize production.

CONCLUSION

From the perspective of sustainable agriculture, the results of this study are of particular importance, as they demonstrate that the combined application of farmyard manure and PGPR bacteria can represent an effective strategy for improving nutrient use efficiency and reducing dependence on mineral fertilizers. Such an approach contributes to the preservation of soil fertility, enhances the biological activity of the rhizosphere, and reduces the environmental burden of agricultural production, in line with contemporary concepts of sustainable soil resource management.

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PRIMJENA BIOINOKULANATA ZA OPTIMIZACIJU UPOTREBE MINERALNIH GNOJIVA U PROIZVODNJI SILAŽNOG KUKURUZA

Sažetak

Kukuruz je jedna od najznačajnijih poljoprivrednih kultura u svijetu i Bosni i Hercegovini, gdje se žitarice uzgajaju na površini od 204.368 ha, od čega se 57% (116.490 ha) odnosi na proizvodnju kukuruza. Primjena biljnih rizobakterija koje potiču rast biljaka (PGPR), kao što su rodovi *Pseudomonas* i *Bacillus*, predstavlja održivu alternativu mineralnim gnojivima, posebno na tlima siromašnim fosforom koja su česta u Bosni i Hercegovini. Poljski ogled sa deset varijanti gnojidbe, postavljen prema slučajnom bloknom rasporedu u tri ponavljanja, proveden je s ciljem procjene uticaja inokulacije sjemena, organske i mineralne gnojidbe na proizvodnju silažnog kukuruza. Prinos zrna, karakteristike klipa i koncentracije hraniva u listu i zrnu kukuruza određeni su primjenom standardnih analitičkih metoda.

Najveći prinos zrna (15,2 t ha⁻¹) ostvaren je kombiniranom primjenom organske gnojidbe (30 t ha⁻¹) i bakterijske inokulacije, pri čemu je utvrđena statistički značajna razlika u odnosu na kontrolni tretman. Primijenjeni tretmani gnojidbe poboljšali su usvajanje hraniva i povećali sadržaj proteina, dušika, fosfora i magnezija u zrnu, dok se koncentracija cinka uglavnom smanjila, što ukazuje na antagonistički odnos između fosfora i cinka. Dobiveni rezultati potvrđuju potencijal primjene kombinacije rizobakterijske inokulacije i organske gnojidbe za povećanje produktivnosti kukuruza i poboljšanje statusa hraniva u biljci.

Ključne riječi: kukuruz, gnojidba, bakterije koje potiču rast biljaka (PGPR), bioinokulanti, prinos

ISTRAŽIVANJE ŠTETNOSTI SKAKAVACA I ZRIKAVACA NA POLJOPRIVREDNIM USJEVIMA U HERCEGOVINI

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Izvorni znanstveni rad - *Original scientific paper*

Sažetak

Skakavci i zrikavci (red Orthoptera) ubrajaju se u polifagne štetnike koji u posljednjem desetljeću na području Hercegovine uzrokuju sve izraženije štete na poljoprivrednim kulturama, osobito tijekom ljetnih mjeseci obilježenih sušom i nedostatkom vode. Štete nastaju djelovanjem ličinki i odraslih jedinki, pri čemu su oštećenja od odraslih značajnija. Simptomi se očituju kao grizotine na lišću, plodovima i drugim biljnim organima, a zahvaćene su različite kulture, uključujući lisnato povrće, plodovito povrće i voće, vinova loza, kukuruz, duhan te ukrasno bilje. Istraživanja su provedena tijekom ljeta 2023. i 2024. godine na području Mostara, Čitluka, Ljubuškog i Čapljine, pri čemu je nasumično pregledano po 100 biljaka ili plodova po kulturi radi utvrđivanja prisutnosti oštećenja. Determinirano je ukupno deset vrsta, među kojima su brojnošću dominirali zrikavci, posebice vrste *Tettigonia viridissima*, *Decticus albifrons* i *Ephippiger ephippiger*. Rezultati ukazuju na to da ovi štetnici na pojedinim lokalitetima uzrokuju značajne ekonomske štete, pri čemu su najizraženije zabilježene na lokalitetu Potpolje (Čitluk), osobito na plodovitom povrću, vinovoj lozi i voćkama. Utvrđeno je da zrikavci uzrokuju veće štete u odnosu na skakavce, a među njima se kao najštetnija vrsta ističe zeleni konjic (*Tettigonia viridissima*).

Ključne riječi: skakavci, zrikavci, Orthoptera, štete na biljkama, Hercegovina

UVOD

Problem vezan uz pojavu skakavaca star je gotovo koliko i čovječanstvo. Još u vrijeme dok se čovjek nije ni bavio biljnom proizvodnjom, skakavci su čovjeku bili problem, jer su uništavali biljne vrste od kojih su neke služile i za ishranu ljudi. Taj problem je još više došao do izražaja kada se čovjek počeo baviti uzgojem poljoprivrednih kultura. Podatke o štetnosti skakavaca nalazimo u pisanim izvorima starog Egipta i Izraela (Batinica i Beš, 1988). Skakavci su i danas sinonim za proždrljivost i štetnost. Velike štete od najezde skakavaca nisu svojstvene samo starim, davno proteklim vremenima. Upravo suprotno, skakavci su kao štetnici konstantno prisutni premda ih uočavamo tek kada dođe do njihove masovne pojave.

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Godine 1886. opustošili su Alžir zbog čega je slijedeće godine od gladi u toj zemlji umrlo preko 20.000 ljudi. Godine 1951. i 1952. na području Irana, Iraka, Jordana i u Saudijskoj Arabiji bile su uništene sve biljke na području stotina tisuća četvornih kilometara. Tih pedesetih godina prošlog stoljeća nije ostala pošteđena ni Centralna Afrika. Godine 1977. invazija skakavaca zahvatila je područje Afganistana, Indije, Sjeverne Afrike i Tanzanije ugrožavajući oblasti u kojima je tada obitavalo oko 400 milijuna ljudi. Slično je bilo i 2013. godine kada je zabilježena masovna pojava skakavaca na području Egipta i Sudana koji su obalom Crvenog mora pristigli sve do Izraela. U novije vrijeme, točnije 2020. godine rojevi skakavaca su nakon šteta na području Afrike preletjeli Crveno more te svoj pohod nastavili po Aziji (Rotim, 2025). Skakavci i zrikavci (red Orthoptera) pripadaju skupini polifagnih štetnika. Na području Hercegovine, zadnjih desetak godina, bilježe se veće štete na pojedinim poljoprivrednim kulturama. Iako je na području BiH registrirano preko stotinu vrsta iz reda Orthoptera, desetak vrsta skakavaca i zrikavaca, na ovom području, pričinjava značajnije štete poljoprivrednim kulturama. Štete pričinjavaju ličinke i odrasli mada su štete od odraslih oblika puno veće i značajnije. Prvi pisani zapisi o većoj pojavi skakavaca na području Hercegovine datiraju iz 1863. godine kada se bilježi i njihovo organizirano suzbijanje na Buni (predgrađe Mostara) na način da su kopani kanali iznad kojih su razapeta platna a skakavci su granjem tjerani u kanale a potom zatrpavani zemljom. Sarajevski list (1882) donosi vijest kako su se početkom svibnja 1882. godine u selima mostarskog kotara: Dračevica, Ortiješ, Kosor i Gnojnice pojavila jata skakavaca koja prijete da unište sva polja i njive. Stoga je kotarska oblast u Mostaru objavila poziv pučanstvu u svrhu pokretanja akcije za uništenje skakavaca. Akciji se odazvalo pučanstvo od 15 do 60 godina te su radili svaki dan, njih 500-600 na njihovom suzbijanju. Osobitim naporom pučanstvu je uspjelo da u 5.342 jame zakopa i uništi 1.335 metričkih centi skakavaca, čime je uklonjena prijeteća opasnost (Rotim, 2025). Na području Ljubuškog 1895. i 1914. godine zabilježene su štete od skakavaca. Štete od skakavaca bile su posebno velike u selima Humac, Predgrađe, Stubica i Hardomilje. Štete su zabilježene i u drugim mjestima u Hercegovini. I kasnije su na ovom području zabilježene veće štete od skakavaca i zrikavaca a od vrsta je prednjačio marokanski skakavac *Dociostaurus maroccanus* Thunb. Za vrijeme masovnih pojava marokanskog skakavca koje su zabilježene u više navrata: 1930-1933, 1934-1937, 1945-1948, 1950-1952, do kojih je došlo na raznim područjima bivše države, jaka pojava marokanskog skakavca bila je prisutna i u Hercegovini (Batinica i Beš, 1988). U periodu iza Drugog svjetskog rata, na području Hercegovine, skakavci su pričinjavali iznimno velike štete. Tako je 1946. godine provedena velika akcija suzbijanja skakavaca u kojoj su sudjelovali svi radno sposobni muškarci, uključujući i gimnazijalce. Tijekom 1947. godine, na području Hercegovine, zabilježena su velika jata skakavaca kako se protežu u isprekidanim lancima sve od Stoca i Čapljine pa da sjevernih područja Mostara. Suzbijali su se na način da bi se satjerivali u gomile te potom prskali naftom i voćnim karbolineumima. U kasnijim stadijima razvoja postajali su otporniji na naftu pa bi se hvatali mrežama i mehanički uništavali. Osim toga, kopali bi se i duboki jarci u koja su

se ciljano usmjeravala jata skakavaca a potom zatrpavala zemljom (Rotim, 2019). Brojnija pojava marokanskog skakavca zabilježena je na ovom području i u periodu 1973-1975, 1976-1979, te 1984-1988 (Batinica i Beš, 1988). U pojedinim godinama bilo je pravih invazija skakavaca, npr. krajem osamdesetih godina u Popovu polju u Hercegovini ili okolini Prilepa (Maceljski, 1999). U tom periodu na području Popova polja zabilježena je i veća populacija crne udovice (*Latrodectus tredecimguttatus* Rossi) kao prirodnog regulatora brojnosti skakavaca (Beš i sur., 2000). Vrsta skakavca *Prionotropis hystrix* Ger. , na području Hercegovine, javlja se pojedinačno. Međutim u promijenjenim okolnostima može se javljati i masovno. To je utvrđeno prilikom masovne pojave skakavaca (1947. i 1954. godine) u okolini Mostara (Delić, 1982). Zadnja značajnija pojava skakavaca i zrikavaca na području Hercegovine zabilježena je u periodu 1996-1998 godina. U tom periodu među vrstama su prednjačili zrikavci a posebno vrste *Tettigonia viridisima* L., *Decticus albifrons* F. i *Ephippiger* sp. (Ostojić, 1999). Štete od skakavaca i zrikavaca na području Hercegovine zabilježene su i tijekom 2023. godine (Ostojić i sur., 2023). Najveće štete od skakavaca i zrikavaca, na području Hercegovine, tijekom 2023. i 2024. godine zabilježene su u ljetnim mjesecima na sočnim plodovima i mladim listovima, različitih poljoprivrednih kultura. Osim povrtnih kultura na kojima su zabilježene najveće štete (lisnato povrće, tikvice, tikve, dinje i lubenice), štete su zabilježene i na sočnim plodovima voćnih vrsta (smokva, breskva, nektarina, marelica, maslina), ratarskim kulturama (kukuruz, duhan), vinovoj lozi te cvijeću (krizantema i gerber). Na plodovitim povrtnim kulturama (tikva, tikvica, dinja i lubenica) štete su prisutne na plodovima u obliku grizotina, a pojedini plodovi, primjerice dinje, mogu biti i više od 50% pojedeni. Simptomi oštećenja na voćnim plodovima uočavaju se u obliku površinskih ali i dubinskih grizotina a najčešći su na plodovima smokve, marelice i breskve. Na vinovoj lozi štete su zabilježene na lišću i bobicama grožđa u fazi dozrijevanja u obliku grizotina. Kod kukuruza simptomi oštećenja prisutni su na klipovima u fazi mliječne zriobe u obliku grizotina na vršnom dijelu. Na duhanu su simptomi oštećenja na lišću koje može biti potpuno izgrizišeno. Oštećenja na krizantemama i gerberu zabilježena su na lišću u obliku manjih ili većih grizotina. Prisutnost skakavaca u povećanoj brojnosti normalna je ciklička pojava. Međutim, pojedinih godina dolazi do njihovog pretjeranog razmnožavanja i formiranja velikih rojeva i tada predstavljaju veliki problem za poljoprivredne usjeve. U takvim uvjetima njihovo suzbijanje je otežano iz razloga što zahtijeva primjenu kompleksnih mjera uz velika financijska sredstva, dok pozitivan ishod provedenih mjera nije zagarantiran. Stoga skakavci od ranih vremena predstavljaju predmet izučavanja i stalnu prijetnju uzgajanim usjevima, kao i prirodnoj vegetaciji (Rotim, 2025).

MATERIJAL I METODE RADA

Istraživanje štetnosti skakavaca i zrikavaca, na području Hercegovine, provedeno je tijekom ljetnih mjeseci 2023. i 2024. godine u četiri grada/mjesta (Mostar, Čitluk, Ljubuški i Čapljina). Istraživanje je provedeno na 9 lokaliteta na kojima se uzgajaju različite poljoprivredne kulture (voće, povrće, vinova loza, kukuruz i cvijeće).

U istraživanom periodu vizualno su pregledavani nasadi poljoprivrednih kultura te bilježene štete. Nasumično je pregledavano po 100 biljaka/plodova poljoprivrednih kultura na prisutnost simptoma oštećenja. Kod voćnih vrsta pregledavani su zreli plodovi, kod plodovitog povrća zeleni i zreli plodovi, kod kukuruza šećerca klipovi u fazi mliječne zriobe, kod duhana listovi a kod vinove loze listovi i grozdovi/bobice.

REZULTATI ISTRAŽIVANJA I RASPRAVA

Istraživanje šteta od skakavaca i zrikavaca provedeno je tijekom 2023. i 2024. godine od lipnja pa do kolovoza mjeseca u četiri grada/mjesta odnosno devet lokaliteta. U tablici br.1 i 2 navedeni su lokaliteti i poljoprivredne kulture na kojima je obavljeno istraživanje te postotak oštećenih biljaka/plodova.

Tablica 1. Lokaliteti i poljoprivredne kulture na kojima je obavljeno istraživanje i postotak oštećenih biljaka/plodova od skakavaca i zrikavaca tijekom 2023. godine
Table 1. Locations, agricultural crops, and the percentage of plants/fruits damaged by grasshoppers and bush-crickets during 2023

Općina/ <i>Municipality</i>	Lokalitet/ <i>Locality</i>	Poljoprivredna kultura/ <i>Agricultural crop</i>	% oštećenih biljaka/plodova <i>% of damaged plants/fruits</i>
Mostar	Rodoč	vinova loza	4
		breskva	11
		nektarina	13
		marelica	18
	Jasenica	trešnje	3
		maslina	0
	Buna	vinova loza	1
		maslina	1
		breskva	2
Čitluk	Potpolje	vinova loza	19
		dinja	29
		lubenica	14
		maslina	18
		marelica	14
		kukuruz šećerac	58
	Blizanci	smokva	3
		tikva	17
		dinja	18
		lubenica	13
Ljubuški	Mostarska vrata	vinova loza	3
		duhan	11
	Cerno	vinova loza	0
		kukuruz šećerac	8
		tikva	6

Čapljina	Višići	paprika	0
		krastavac	2
		lubenica	1
		breskva	2
	Gabela	dinja	1
		lubenica	2
		krastavac	0

Tablica 2. Lokaliteti i poljoprivredne kulture na kojima je obavljeno istraživanje i postotak oštećenih biljaka/plodova od skakavaca i zrikavaca tijekom 2024. godine
Table 2. Locations, agricultural crops, and the percentage of plants/fruits damaged by grasshoppers and bush-crickets during 2024

Općina/ <i>Municipality</i>	Lokalitet/ <i>Locality</i>	Poljoprivredna kultura/ <i>Agricultural crop</i>	% oštećenih biljaka/plodova % of damaged plants/fruits
Mostar	Rodoč	vinova loza	2
		breskva	8
		nektarina	9
		marelica	9
	Jasenica	trešnje	0
		maslina	1
	Buna	vinova loza	0
		maslina	0
		breskva	2
Čitluk	Potpolje	vinova loza	15
		dinja	19
		lubenica	14
		maslina	11
		marelica	16
		kukuruz šećerac	46
	Blizanci	smokva	1
		tikva	8
		dinja	12
		lubenica	8
Ljubuški	Mostarska vrata	vinova loza	0
		duhan	10
	Cerno	vinova loza	2
		kukuruz	11
		tikva	4
Čapljina	Višići	paprika	0
		krastavac	1
		lubenica	1
		breskva	2
	Gabela	dinja	1
		lubenica	1
		krastavac	0

Najveće štete od skakavaca i zrikavaca tijekom 2023. i 2024. godine na području Hercegovine zabilježene su na lokalitetu Potpolje (Čitluk). Na svim pregledavanim kulturama zabilježeni su simptomi oštećenja. Naime, pregledavani nasadi i usjevi poljoprivrednih kultura na ovom lokalitetu zasađeni su na plitkim tlima. Tijekom ljetnih mjeseci biljke pate od nedostatka vode isto kao i okolno bilje i raslinje kojim se uglavnom hrane skakavci i zrikavci. U nedostatku „sočne“ hrane, skakavci i zrikavci u potrazi za vodom oštećuju sočne biljne organe, najčešće plodove. Veće štete na ovom lokalitetu zabilježene su na plodovima marelice ali i dinje i lubenice. Simptomi oštećenja na većini plodova dinje i lubenici bili su u obliku plićih ili dubljih grizotina dok je dio plodova, posebice dinje, bio jako oštećen. Posebno velike štete na ovom lokalitetu zabilježene su na klipovima kukuruza šećerca u vrijeme mliječne zriobe. Na velikom broju klipova oštećenja su bila na vrhu klipa u obliku grizotina lišća i zrna kukuruza dok je jedan manji dio klipova pronađen sa istim oštećenjima koja su zahvatila polovinu klipa kukuruza.

Slična oštećenja zabilježena su i na drugim lokalitetima ali sa daleko manjim postotkom oštećenih plodova. Štete od skakavaca i zrikavaca na svim istraživanim lokalitetima bile su veće u 2023. godini u odnosu na 2024. godinu.

Vrste skakavaca i zrikavaca koje su pronađene na oštećenim poljoprivrednim kulturama tijekom istraživanja navedeni su u tablici br. 3.

Tablica 3. Vrste skakavaca i zrikavaca koje su pronađene na istraživanom području
 Table 3. Grasshoppers and bush-crickets found in the research area

Red/Order	Porodica/Family	Vrsta/Species
Orthoptera	Acrididae	<i>Calliptamus italicus</i> (Linnaeus, 1758)
		<i>Anacridium aegyptium</i> (Linnaeus, 1764)
		<i>Dociostaurus maroccanus</i> (Thunberg, 1815)
		<i>Oedipoda caerulescens</i> (Linnaeus, 1758)
		<i>Oedipoda meridionalis</i> (Ramme, 1913)
	Tettigonidae	<i>Tettigonia viridissima</i> (Linnaeus, 1758)
		<i>Decticus albifrons</i> (Fabricius, 1775)
		<i>Eupholidoptera schmidtii</i> (Fieber, 1861)
		<i>Ephippiger ephippiger</i> (Fiebig, 1784)
		<i>Ephippiger discoidalis</i> (Fieber, 1853)

Od navedenih vrsta skakavaca i zrikavaca, u obje godine istraživanja, brojnošću su prednjačili zrikavci i to vrste *T. viridisima*, *D. albifrons* i *E. ephippiger*. Primjerice na jednom klipu kukuruza šećerca pronalazene su često po dvije jedinke kako se hrane dok bi na jednom plodu dinje pronalazili i po tri jedinke zrikavaca.

ZAKLJUČAK

Na osnovu dvogodišnjih istraživanja štetnosti skakavaca i zrikavaca na području Hercegovine mogu se donijeti sljedeći zaključci:

- Istraživanje štetnosti skakavaca i zrikavaca na području Hercegovine provedeno je tijekom 2023. i 2024. godine u dvije županije na devet lokaliteta, a istraživanjima je obuhvaćeno 15 poljoprivrednih kultura.
- Najveći postotak oštećenja, u obje godine istraživanja, zabilježen je na lokalitetu Potpolje (Čitluk) i to na kukuruzu šećercu, dinji i lubenici.
- Na istraživanom području pronađeno je ukupno 10 vrsta iz reda Orthoptera od kojih je 5 iz porodice Acrididae a 5 iz porodice Tettigonidae.
- Najveće štete zabilježene su od zrikavaca i među kojima su prednjačile vrste *Tettigonia viridisima*, *Decticus albifrons* i *Ephippiger ephippiger*.

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DAMAGE CAUSED BY GRASSHOPPERS AND BUSH-CRICKETS TO AGRICULTURAL CROPS IN HERZEGOVINA

Abstract

Grasshoppers and bush-crickets (order Orthoptera) are considered polyphagous pests that have caused increasingly significant damage to agricultural crops in the Herzegovina region over the last decade, particularly during summer months characterized by drought and water scarcity. Damage is caused by both nymphs and adults, although injuries caused by adults are generally more severe. Symptoms manifest as feeding damage on leaves, fruits, and other plant organs, affecting a wide range of crops, including vegetables, fruit crops, grapevine, maize, tobacco, and ornamental plants. The research was conducted during the summer months of 2023 and 2024 in the areas of Mostar, Čitluk, Ljubuški, and Čapljina, where 100 plants or fruits per crop were randomly inspected to determine the presence of damage. A total of ten species were identified, among which bush-crickets were dominant in abundance, particularly *Tettigonia viridissima*, *Decticus albifrons*, and *Ephippiger ephippiger*. The results indicate that these pests cause significant economic damage in certain localities, with the most severe damage recorded at the Potpolje locality (Čitluk), especially on vegetables, grapevine, and fruit crops. It was determined that bush-crickets cause greater damage than grasshoppers, with the great green bush-cricket (*T. viridissima*) identified as the most harmful species.

Keywords: grasshoppers, bush-crickets, Orthoptera, plant damage, Herzegovina

Prilog 1.



Slika 1. Simptomi oštećenja na plodu masline od zrikavaca (foto: I. Ostojić)



Slika 2. Simptomi oštećenja na plodu smokve od zrikavaca (foto: I. Ostojić)



Slika 3. Simptomi oštećenja na plodovima tikava od skakavaca i zrikavaca (foto: I. Ostojić)



Slika 4. Štete od zrikavaca na plodu lubenice (foto: I. Ostojić)



Slika 5. Simptomi oštećenja na bobicama grožđa od skakavaca (foto: I. Ostojić)



Slika 6. Štete na klipu kukuruza od zrikavaca (foto: I. Ostojić)



Slika 7. Simptomi oštećenja na plodu breskve od skakavaca i zrikavaca (foto: I. Ostojić)



Slika 8. Simptomi oštećenja na plodu dinje od skakavaca i zrikavaca (foto: I. Ostojić)



Slika 9. Simptomi oštećenja od skakavaca i zrikavaca na lišću vinove loze (foto: I. Ostojić)



Slika 10. Simptomi oštećenja na lišću duhana od skakavac i zrikavaca (foto: I. Ostojić)

CONSTRUCTION OF TEMPORARY WOODEN AGRICULTURAL STRUCTURES INSPIRED BY THE TRADITIONAL ARCHITECTURE OF BOSNIA AND HERZEGOVINA

Mirza Bašalić*¹

Original scientific paper

Abstract

On agricultural land, construction is permitted only for agricultural purposes, and within a very limited scope - most often as small auxiliary structures used in agriculture (greenhouses, barns, storage facilities for tools and equipment, etc.). To enable the construction of permanent structures on agricultural land, it is necessary to carry out a land-use conversion process, which is quite complex and often results in the permanent and irreversible degradation of this natural resource. Under certain conditions and in accordance with relevant regulations, it is possible to temporarily convert agricultural land for a defined period, thereby allowing the construction of temporary, prefabricated, and demountable structures for agricultural production, provided that after their use, they are removed and the land is restored to its original state.

In Bosnia and Herzegovina, temporary structures have historically been built using natural construction materials available on-site, most commonly in mountainous areas for livestock production.

These structures were mainly used for seasonal habitation, housing animals, supporting agricultural activities, and storing tools and equipment.

They were of a temporary nature and not constructed from permanent materials, primarily because they were usually located on state-owned agricultural land, where the construction of permanent structures was not permitted, and the land was used seasonally, mainly for grazing livestock.

The construction of prefabricated structures primarily made of wood can offer an adequate solution for the use, temporary development, and eventual exploitation of agricultural land in a way that prevents the permanent destruction of this natural resource.

Keywords: *Traditional architecture, wooden structures, agricultural buildings, prefabrication, barn, temporary structures, „torarica“, „povozača“, „koliba“*

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INTRODUCTION

Agricultural buildings used for livestock breeding must be located in close proximity to larger open areas outside urban and residential zones, where it is possible to provide both sufficient food and space for animals, ensuring more humane living conditions and minimal environmental impact. However, in areas where such large open spaces exist, typically classified as agricultural or forest land, the construction of permanent buildings is generally not permitted. On agricultural land, in addition to its primary purpose (agricultural production), other activities are permitted, such as the construction of temporary, prefabricated, and demountable structures, which must be removed after use and the land restored to its original condition. Legislation allows for the temporary change of land use for the construction of modular prefabricated structures of a temporary nature, which are dismantled and removed after use. In this way, the temporarily occupied land is released and can be restored to its original condition without significant difficulty or cost. In the past, in our region, temporary structures were frequently built in various forms and from different materials, such as small shelters, huts, and cabins made of wood or other locally available materials. The construction of modern prefabricated, demountable, modular buildings - primarily made of wood and inspired by traditional temporary structures can offer a solution for the development of temporary (transient) buildings on agricultural land. Agricultural land is a limited and difficult-to-renew natural resource, which represents both natural wealth and a good of general interest, and as such should be subject to special protection. Buildings intended for housing animals on farms must be designed in accordance with regulations governing this field (Pravilnik o uslovima koje moraju da zadovoljavaju farme i uslovima za zaštitu životinja na farmama, 2009).

MATERIAL AND METHODS

Characteristic examples of the earlier construction of temporary agricultural prefabricated structures in the territory of Bosnia and Herzegovina have been analysed, followed by a review of the potential for modern modular construction across various uses. In the past, various simple forms of rural dwellings were used across Bosnia and Herzegovina, most often as seasonal housing or auxiliary economic buildings for the temporary shelter of people, domestic animals, tools, and other production needs. The need for such temporary structures arose when shepherds, due to the lack of their own pastures, especially during periods of drought, moved with their livestock far from their homes into mountainous regions, where they would remain temporarily until returning home. Since these structures were built on land not owned by the shepherds, they had to be temporary and were most often mobile in nature. In the past, construction systems using simple, portable modular elements were frequently used, offering the fastest and simplest solution for creating shelter or auxiliary structures for animals and equipment.

From a functional perspective, these were structures that provided only minimal shelter, ensuring basic conditions necessary for human survival. Many such examples exist, especially among nomadic communities, where entire families travelled with their livestock across different regions, carrying their homes with them in search of better grazing conditions and essential resources. Because these temporary structures were built from perishable materials, they had a limited lifespan and have almost completely disappeared today. “Some of them have already completely disappeared or can very rarely be found in remote areas. Their spatial and structural elements reflect the initial concepts of more advanced developmental types. At the same time, they demonstrate the ability of rural people to improvise and to utilise the basic opportunities offered by nature” (Kadić, 1967). The following section presents examples of structures from our region that were mobile or temporary.

„Savardak“

A round volume, such as the most basic human shelter „Savardak (dubirog, šilja, krivača, busara), found in the border mountainous regions of Bosnia and Herzegovina and Montenegro, represents one of the most elementary, and probably the oldest, human shelters. It is a pointed, conical structure made of roundwood logs joined at the top, about two meters wide, covered with branches, fern, straw, and sometimes turf” (Kadić, 1967).

„Torarica“

Mobile wooden huts, locally known as “kreve”, “pružina”, “kućer”, and most commonly “torarica”, in which shepherds stayed and slept during periods when they needed to remain close to their livestock for safety and protection (Figure 1).



Figure 1. „Torarica - kreve“ at Crepoljsko area, Sarajevo (Kadić, 1967)

In traditional practice, the “torarica” represents “the smallest form of shelter, intended for a single person - a wooden tent placed on sledge-like supports to allow easier movement across grass. The very principle of transport by sliding is reminiscent of the earliest human transport methods before the invention of the wheel” (Kadić, 1967).

This simple portable hut with sledge runners consists of structural elements such as wooden beams, posts, and rafters, with a final cladding of wooden planks on the gable walls and a roof covering made of wooden shingles.

„Povozača or povožnjača“

The *povozača* is a multifunctional hut, most often mobile and temporary in nature, transported from one location to another.

It is a larger hut with a wooden frame filled with wattle, covered with straw, bark, or shingles, and moved on sledges, similar to the „kreve“. It serves as shelter for shepherds, for processing and curdling milk, and as storage for dairy products (Figure 2).

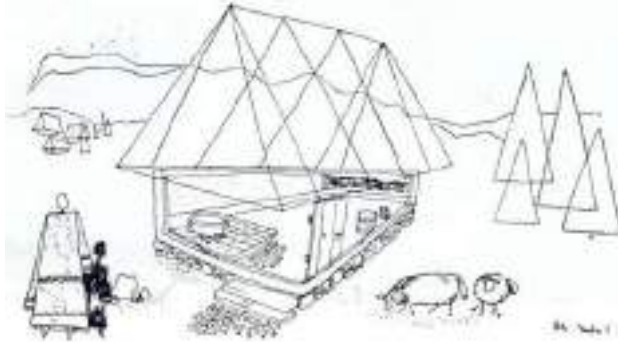


Figure 2. „Podzidna koliba – povozača“ from the Gacko area (Kadić, 1967)

Due to its lightweight structure and mobility, the „*povozača* is considered one of the most ingenious historical constructions, reflecting the builder’s intention to create a mobile dwelling, likely originating from nomadic times“ (Kadić, 1967).

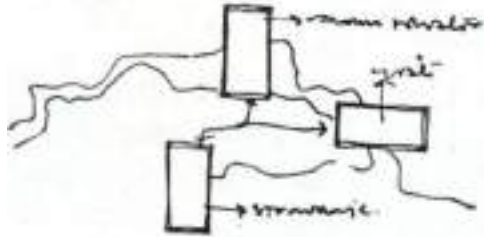


Figure 3. Layout of temporary „podvozača“ (Kadić, 1967)

„In some cases, *povozača* structures are temporarily supported by masonry bases, forming small temporary agglomerations in which each unit has a specific function: work, sleeping, storage, etc.“ (Figure 3, Kadić, 1967).

„Kolibe“

„Kolibe“ In addition to mobile, portable shelters, livestock breeders often constructed simple structures-wooden huts known as “summer huts”—used primarily during the summer months when, due to a lack of grazing space, they were forced to stay for extended periods far from their homes. These huts were used primarily for living, but also for processing and storing milk and dairy products. In terms of layout, the hut typically consisted of a single room without partitions, forming a unified multifunctional space for living, cooking, and working (Figure 4).



Figure 4. Shepherd's cottage „ljetnica“ (Kadić, 1967)

„Shepherds’ huts were built in prominent locations in the mountains. The essential conditions were the presence of pasture, forest, and fresh water“ (Mihić, 1985).

„Stan“ or „kolibe“ huts made of hewn wooden planks

In cases where quality stone was not available for construction, hewn wooden planks and timber were used instead, with structures assembled directly on-site. Wooden elements were often prepared elsewhere, transported, assembled, and, if necessary, dismantled and reused at the same or another location. “In the entire structure, there is neither stone nor iron. The walls are assembled from planks fitted together using grooves. The roof is made of planks arranged so that each board is slightly inclined along its length and supported by wooden beams, resting at the lower end on the ‘žliba’ and at the upper end on the ‘slime’. The structure consists of two parts: one with the hearth (the living space), and the other used for storing milk and dairy products, called the mlikar“ (Figure 5, Mihić, 1985).

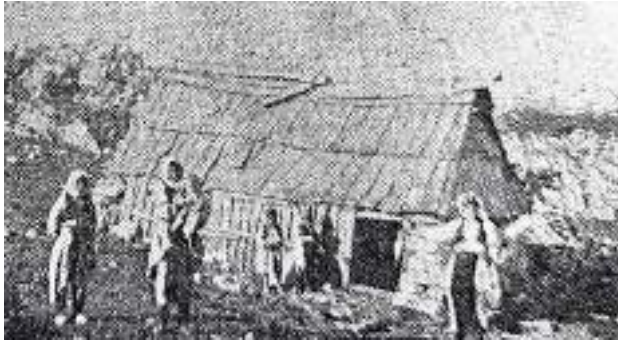


Figure 5. „Stan - koliba“ made of Wood (Mihić, 1985)

„The length of the hut is 4–5 m, and the width is 2 m. The interior height of the rooms is 2 m. The entire structure has no other openings except doors, which are made of wood and always located on the front wall. Neither the hut nor the dairy room has a ceiling. The ground is compacted earth. At the rear wall, in the centre of the hut, there is a fireplace. On both sides of the fireplace, there are sleeping areas made of thick wooden boards. Before leaving the mountain, the shepherds dismantle the dwelling and store the boards. They do this because heavy snow and winds would otherwise collapse and scatter the structure due to its light construction“ (Mihić, 1985). Huts constructed exclusively from wooden elements provided almost the same living and working conditions for shepherds as huts made from more durable and solid materials, such as stone.

„Kolibe“ Huts built from wooden materials, partially embedded in the ground

In addition to stone and above-ground wooden structures, huts were also built partially dug into the ground, with a wooden structure and cladding made of boards and turf. „The side walls of the hut are made of boards only about one meter long. These boards are embedded in the ground and inclined inward. On top of them, beams are placed, and above that, a roof made of boards. The side walls are covered up to the roof with turf, in order to protect the hut from wind and cold. The front and rear sides of the hut are closed with boards. The hut serves only as a shelter from bad weather and as a place for a fireplace“ (Figure 6, Mihić, 1985).



Figure 6. „Stan – koliba“ wooden structure with turf cladding (Mihić, 1985)



Figure 7. „Mlikar“ wooden structure with turf cladding (Mihić, 1985)

„For storing milk and other dairy products, there is a ‘mlikar’ (dairy room), built in the same way as the hut, except that it does not have a fireplace. Milk is processed, and dairy products are stored in the mlikar” (Figure 7, Mihić, 1985).

After seasonal use, the main wooden elements and the structure could be dismantled, stored, and protected from deterioration, and then reassembled later at the same or another location.

„Sojenica – brvnara“

An old pile dwelling, also known as a log cabin or *sohanica*, is a wooden house raised on piles (*sohe*) above flood-prone ground. The earliest findings of pile dwellings date back to prehistoric times, although they were built much later for various purposes (Figure 8).



Figure 8. „Sojenica – brvnara“ (Kadić, 1967)

“In the Sava River valley, pile dwellings appeared as early as prehistoric times, as evidenced by excavations in Donja Dolina“ (Kadić, 1967). They were used by people who lived from the river and its resources, and also served as mills, fulling mills, and stamping devices, but also as very primitive shelters for fugitives who found safety in such structures.

RESULTS ND DISCUSSION

Construction of modern prefabricated–demountable buildings inspired by traditional wooden temporary structures

Prefabricated and demountable wooden structures, inspired by earlier temporary buildings and based on traditional construction materials, can be assembled from individual lightweight modular elements. Such structures can be temporarily built on agricultural land, even on land not owned by the investor, provided that they are temporary in nature and can later be dismantled and removed (Figure 9).

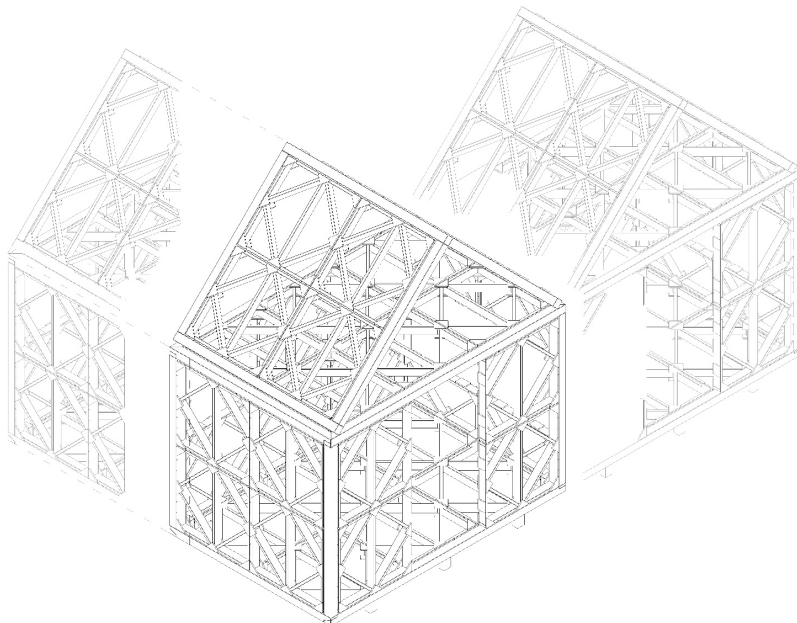


Figure 9. 3D view of the basic module

Different variations of two basic components-one with dimensions 160×160 cm and a smaller derived component of 160×80 cm-can be used in façade, roof, floor, or ceiling configurations to provide multiple design solutions. By combining components in different ways, it is possible to obtain solid planes or surfaces with openings (Figure 10).

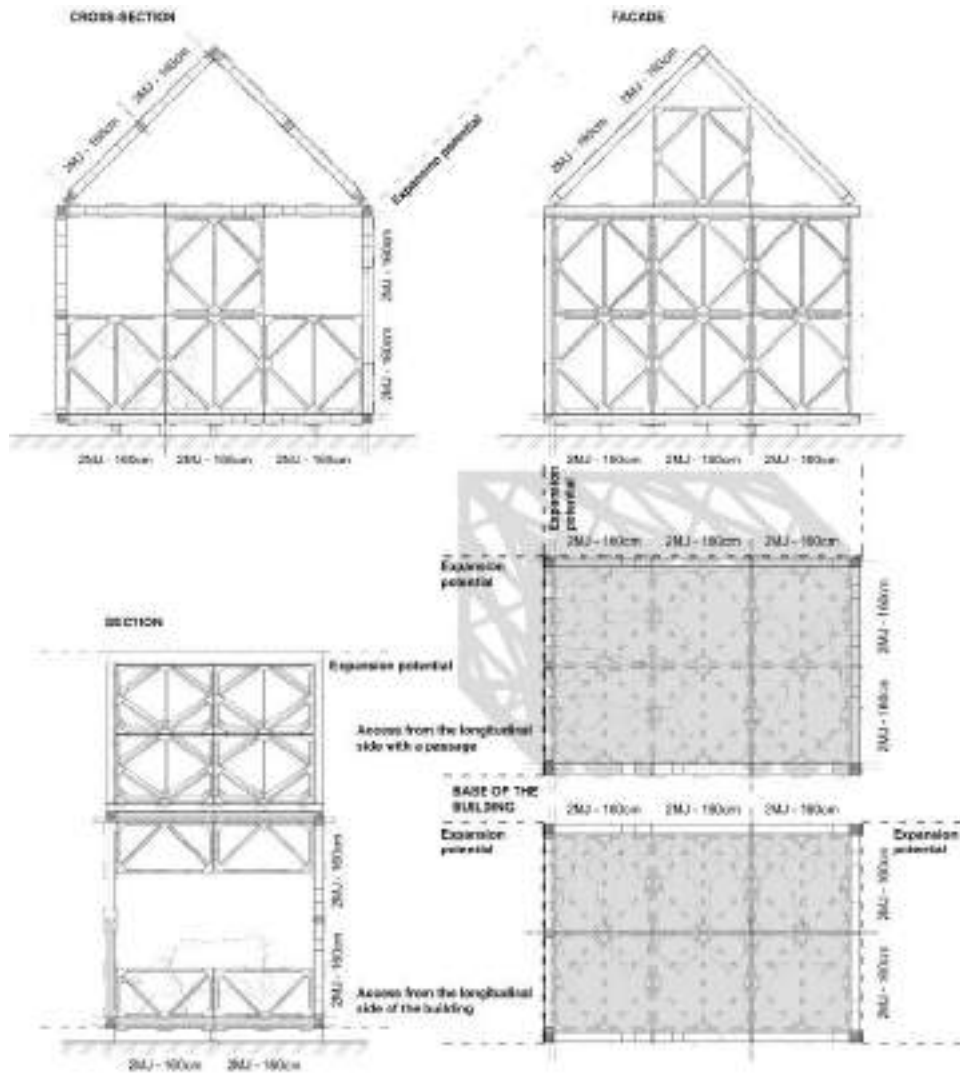


Figure 10. Basic module - plan, sections and facade

By connecting individual components, a module is formed, and by repeating multiple modules, various building sizes for housing animals can be achieved.

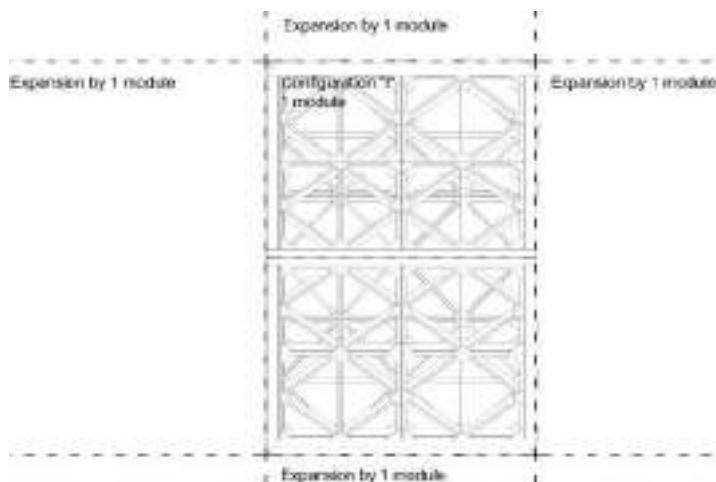


Figure 11. Basic module – expansion potential

Buildings can be easily adapted to actual needs and functions by simply adding or removing modules (Figure 11). These structures can primarily be used for housing and feeding animals, or only for feeding when animals remain outdoors. They can also serve as storage for feed, residential spaces for people, accommodation units in tourism, equipment storage, or combined uses. Modular animal housing structures should be open and adaptable for expansion or reduction of capacity, enabling easy construction and extension of standardised units within a short time frame.

Dimensioning of animal housing structures

The dimensioning of animal housing structures was carried out in accordance with the standards of the International Commission of Agricultural and Biosystems Engineering – CIGR (Commission Internationale du Génie Rural), as well as standards adopted from domestic literature.

According to CIGR (Commission Internationale du Génie Rural) standards for dimensioning parts of a barn for free-stall housing systems:

- Stall length „(Stall length $SL = 0.92 L + 0.3$) (Faba i sar., 2014);
- Individual space required by a standing by a standing cow (feeding area) „Individual space required by a standing cow $1.3 \times W$ “ (Faba i sar., 2014);
- Feeding area surface $Phran = Dh_{ran} \times Sh_{ran} = 1.91 \times 0.78 = 1.49 \text{ m}^2$ (adult cow weighing 650-749 kg $Phran = 1.49 \text{ m}^2$)
- Living area „(Living area $LA = 1.65 \times H \times (0.85 \times (L + H))$ “ (Faba i sar., 2014);

Dimensioning of housing for cows 650-749 kg:

Plež = 6.44 m^2 and feeding area $Phran = 1.49 \text{ m}^2$.

Total area per head is Plež + Phran = 7.93 m²

„living space per animal from 5 to 7 m², total area per cow from 6 to 10 m²“ (Brka i sar., 2015);

Dimension of the facility for goat, average weight of 45-75 kg:

„Single room: 1.3–1.7 m² / head, feeding space width: 0.35–0.4 m'.“ (Brka i sar., 2015);

Total area P = 1.55 – 1.85 m² (Magdić, 2002)

Building dimensions for stable planning 5.2x3.6 m

Configuration I

The building's layout dimensions are 5.2 x 3.6 m. Total net area of Configuration I is 16.0 m², designed to accommodate 2 cows and 9 goats.

Dimensioning of the facility for the 2 cows

The total barn 2 cows (650-749 kg) is 15.86 m² < 15.9 m².

Feed bunk length is 0.78 m' x 2 cows is 1.56 m' < 3.2 m'.

Table 1. Cattle housing dimensioning

	Number of modules	Area	Number of animals feeding + lying area	Number of animals feeding area
Configuration I	1 - MODULE	16 m ²	2	6
Configuration II	2 - MODULES	32 m ²	4	12
Configuration III	3 - MODULES	48 m ²	6	18
Configuration IV	4 - MODULES	64 m ²	8	24

Dimensioning of the facility for goats (9 goats)

Configuration I for 9 goats: floor area per head, lying area + feeding area 1.70 m² (9 x 1.7m² is 15.3 m²).

Feeding space per goat 0.35 m' x 9 goats is 3.15 < 3.2 m'.

The total barn 9 goats is 15.3 m² < 16.0 m².

Table 2. Goat housing dimensioning

	Number of modules	Area	Number of animals feeding + lying area	Number of animals feeding area
Configuration I	1 - MODULE	16 m ²	9	14
Configuration II	2 - MODULES	32 m ²	18	28
Configuration III	3 - MODULES	48 m ²	28	42
Configuration IV	4 - MODULES	64 m ²	37	56

CONCLUSION

Based on the analysis of past construction practices on agricultural land, it is evident that people in this region most often built temporary structures used seasonally for agricultural purposes. They were of temporary transitory character because they were mostly positioned on a location that was not intended for construction and most often on land that did not belong to the builder and that was used exclusively for livestock grazing. Thus, in the past, buildings were built, such as "savardak" made of wooden shapes, mobile "torarice" made of wood placed on sledges, slightly larger and more complex "carriers" which were also most often transported from location to location by cart, various types of huts, etc. Even today, agricultural producers also face the same or very similar problems, and one of the basic ones is how to build buildings on agricultural land that was not originally planned for construction without permanently destroying the natural environment. And because of this, to solve the problem of the construction of buildings on land that is not for construction, it is very important to design or choose the most suitable system for the construction of temporary buildings.

Temporary - temporary buildings made of ready-made prefabricated components offer many advantages over classic construction, but the most important thing is that this construction system ensures simple construction, use, and ultimately the possibility of removing the building without permanently destroying agricultural land.

Configurable modular prefabrication systems based on the principles of traditional Bosnian architecture, basically made of wood, offer an optimal solution for the construction of temporary-transitory buildings built on agricultural land.

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IZGRADNJA PRIVREMENIH POLJOPRIVREDNIH OBJEKATA OD DRVETA PO UZORU NA TRADICIONALNU ARHITEKTURU NA PROSTORU BOSNE I HERCEGOVINE

Sažetak

Na poljoprivrednom zemljištu gradnja je dozvoljena isključivo u poljoprivredne svrhe i to u vrlo ograničenom obimu, najčešće kao manji pomoćni objekti koji služe poljoprivredi (staklenici, štale, spremišta za alat i opremu, itd.).

Kako bi se omogućila gradnja stalnih objekata na poljoprivrednom zemljištu, neophodno je provesti postupak prenamjene zemljišta, koji je prilično složen proces i često rezultira trajnom i nepovratnom degradacijom ovog prirodnog resursa.

Pod određenim uslovima i u skladu s relevantnim propisima, moguće je privremeno prenamijeniti poljoprivredno zemljište na određeni period, čime se omogućava gradnja privremenih, montažnih i demontažnih objekata za poljoprivrednu proizvodnju, uz uslov da se nakon njihovog korištenja oni uklone, a zemljište vrati u prvobitno stanje.

U Bosni i Hercegovini su se privremeni objekti u proteklom periodu gradili od prirodnih građevinskih materijala dostupnih na licu mjesta, najčešće u planinskim predjelima isključivo za potrebe stočarstva. Ovi objekti su se uglavnom koristili za sezonski boravak, smještaj životinja, podršku poljoprivrednim aktivnostima te skladištenje alata i opreme. Bili su privremenog karaktera i nisu građeni od trajnih materijala, prvenstveno zato što su se obično nalazili na državnom poljoprivrednom zemljištu gdje gradnja stalnih objekata nije bila dozvoljena, a zemljište se koristilo najčešće za ispašu stoke.

Gradnja privremenih montažnih objekata izrađenih primarno od drveta može ponuditi adekvatno rješenje za korištenje, privremeno uređenje i eventualnu eksploataciju poljoprivrednog zemljišta, čime se izbjegava trajno uništavanje ovog prirodnog resursa.

Ključne riječi: *Tradicionalna arhitektura, drveni objekti, poljoprivredni objekti, prefabrikacija, privremene građevine, torarica, povozača, koliba*

UTJECAJ ALKOHOLNE BAZE NA SENZORSKA I FIZIKALNO-KEMIJSKA SVOJSTVA LIKERA OD BAZGE

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Sažetak

Cilj ovog istraživanja bio je ispitati utjecaj vrste alkoholne baze na senzorska i fizikalno-kemijska svojstva likera od bazge. Pripremljena su dva uzorka likera: jedan s rakijom komovicom i drugi s rakijom od šljive. Senzorska evaluacija provedena je na skupini potrošača i obučenih senzoričara, dok su fizikalno-kemijske analize obuhvatile određivanje sadržaja etanola, ukupnog ekstrakta, gustoće, kiselina, sumpornih spojeva te hlapljivih aromatskih komponenti.

Rezultati su pokazali da su oba uzorka dobro prihvaćena među potrošačima, bez statistički značajnih razlika u ukupnoj ocjeni i okusu. Međutim, obučeni senzoričari uočili su značajne razlike između uzoraka, pri čemu je liker s rakijom komovicom ostvario više ocjene za miris, okus i ukupnu kvalitetu. Fizikalno-kemijska analiza potvrdila je da se uzorci razlikuju u sastavu hlapljivih spojeva: liker s komovicom sadržavao je više estera, dok je liker sa šljivovicom imao veći udio viših alkohola i kiselina.

Dobiveni rezultati ukazuju da vrsta alkoholne baze značajno utječe na fizikalno-kemijska i senzorska svojstva likera od bazge. Iako su razlike jasno uočljive pri stručnoj evaluaciji, potrošači ih percipiraju kao manje izražene. Zaključno, izbor destilata omogućuje oblikovanje različitih stilova proizvoda, ovisno o ciljanoj skupini i željenim senzorskim karakteristikama.

Ključne riječi: liker od bazge, komovica, šljivovica, senzorska analiza, hlapljivi spojevi, kvaliteta

UVOD

Bazga (*Sambucus nigra* L.) višedesetljetno je prisutna u europskoj tradicionalnoj prehrani i fitoterapiji, pri čemu su njezini cvjetovi i plodovi cijenjeni zbog kompleksne arome i bogatog profila bioaktivnih spojeva. Cvjetovi bazge posebno su zanimljivi prehrambenoj industriji jer sadrže visoke koncentracije fenolnih kiselina, flavonoida te specifičnih hlapljivih spojeva koji doprinose karakterističnoj aromi.

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Brojna recentna istraživanja potvrđuju da sastav ovih spojeva ovisi o genotipu, zrelosti, okolišnim faktorima i načinu obrade sirovine (Qazimi i sur., 2024; Mikulic-Petkovsek i sur., 2015; Uhl i Mitchell, 2022). U proizvodnji alkoholnih napitaka i likera od bazge, tehnološki parametri poput omjera alkohola, vremena maceracije i granulacije sirovine izravno utječu na ekstrakciju bioaktivnih i aromatskih spojeva (Floares i sur., 2025; Dawidowicz i sur., 2006). Alkohol djeluje kao učinkovito ekstrakcijsko sredstvo za flavonoide i terpenoide, dok optimizacija procesa osigurava očuvanje funkcionalnih i senzorskih svojstava finalnog proizvoda (Uzlasir i sur., 2020; Uhl i Mitchell, 2022). Ove funkcionalne karakteristike potaknule su porast interesa za proizvode od bazge u prehrambenoj industriji, uključujući sokove, sirupe, vina i likere. Tradicionalni napitci od cvijeta bazge već su ranije prepoznati kao bogati izvor fenolnih spojeva i antioksidativnih komponenti (Todorović i sur., 2017). No, unatoč kulturološkoj važnosti i komercijalnoj prisutnosti, znanstvena literatura o likerima od bazge, posebice o utjecaju tehnoloških parametara na njihov kemijski i senzorski profil, i dalje je ograničena (Floares i sur., 2023; Szymański i sur., 2020).

Kemijski sastav cvjetova bazge vrlo je raznolik: najčešće se nalaze derivati klorogene kiseline, rutin, kvercetin, kaempferol te niz fenolnih kiselina i flavonol-glikozida (Ferreira-Santos i sur., 2021; Todorović i sur., 2017). Detaljne LC-MS analize potvrđuju da cvjetovi mogu sadržavati više od 40 različitih fenolnih komponenti, a polifenolni profil snažno je povezan s antioksidacijskom aktivnošću (Viapiana i Wesolowski, 2017; Młynarczyk i sur., 2018; Mihaylova i sur., 2023). Uz fenolne spojeve, cvjetovi su bogati hlapivim terpenima i norisoprenoidima poput linalool-oksida, β -damascenona i drugih aromatskih komponenti koje oblikuju senzorsku percepciju napitaka i likera (Uhl i Mitchell, 2022). Fenolni spojevi su ključni za funkcionalne karakteristike napitaka, uključujući antioksidacijsku i antimikrobnu aktivnost, te su osnovna determinanta zdravstvenih prednosti bazge (Przybylska-Balcerek i sur., 2021; Khalil, 2026). Profil hlapivih spojeva oblikuje senzorsku percepciju napitaka, dok se koncentracije i omjeri spojeva razlikuju među različitim genotipovima cvjetova (Christensen, Kaack i Fretté, 2008; Gentscheva i sur., 2022).

Na sastav bioaktivnih i aromatskih spojeva značajno utječu način obrade, sušenje i ekstrakcija cvjetova. Dosadašnje studije pokazuju da način sušenja i ekstrakcije značajno utječe na očuvanje ukupnog sadržaja fenola i antioksidacijskog potencijala cvjetova bazge (Ferreira-Santos i sur., 2021; Tundis i sur., 2019). Različite metode ekstrakcije, uključujući uporabu etanola, metanola ili vode, značajno mijenjaju profil polifenola i antioksidativni potencijal ekstrakta (Uzlasir i sur., 2020; Mihaylova i sur., 2023; Floares i sur., 2023). Liofilizacija se pokazala kao najefikasnija metoda očuvanja ukupnog sadržaja fenola u cvjetovima bazge u usporedbi sa sušenjem na zraku ili smržavanjem (Ferreira-Santos i sur., 2021). Osim toga, izbor otapala pri ekstrakciji (npr. omjer vode i etanola) snažno određuje prinos i profil polifenola, što ima izravnu važnost za formulaciju alkoholnih napitaka, budući da alkohol djeluje kao učinkovito ekstrakcijsko sredstvo za flavonoide i terpenoide (Todorović i sur., 2017).

Ekstrakti bazge pokazuju izraženu antioksidacijsku, antimikrobnu i potencijalnu antiproliferativnu aktivnost, što je potvrđeno u više in vitro studija (Khalil, 2026; Przybylska-Balcerek i sur., 2021; Sánchez-Hernández, 2023). Cvjetovi i njihovi ekstrakti prepoznati su kao prirodni izvori fenolnih spojeva koji pridonose smanjenju oksidativnog stresa i poboljšanju zdravstvenih parametara kod ljudi (Viapiana i Wesolowski, 2017; Młynarczyk i sur., 2018). Zbog sadržaja aromatičnih i bioaktivnih komponenti poput beta-damaskenona, linalil antranilata i linalola, cvjetovi bazge imaju potencijalnu primjenu u kozmetičkoj i prehrambenoj industriji, osobito u proizvodima za mirise, arome i formulacije s prirodnim bioaktivnim tvarima (Vujanović i sur., 2021).

MATERIJAL I METODE RADA

Cilj rada

Cilj ovog istraživanja bio je ispitati utjecaj vrste korištenog destilata na aromatski i senzorski profil likera pripremljenog od sušenih cvjetova bazge (*Sambucus nigra* L.). Poseban naglasak stavljen je na usporedbu dvaju destilata jednake alkoholne jakosti (46,7% v/v): šljivovice (destilat fermentiranih plodova šljive) i komovice (destilat fermentirane komine grožđa).

Istraživanje je usmjereno na procjenu:

- razlika u intenzitetu i kompleksnosti aromatskog profila,
- potencijalnih razlika u stabilnosti i bistrini tijekom skladištenja,
- utjecaja matrice destilata na percepciju slatkoće, punoće i harmonije okusa,
- interakcija između fenolnih i hlapivih spojeva bazge i specifičnih kongenera (viši alkoholi, esteri, aldehidi) prisutnih u pojedinom destilatu.

U eksperimentalnom dijelu rada su se usporedile dvije tradicionalne voćne rakije kao alkoholne matrice za maceraciju bazge, pri čemu je istodobno provedena potrošačka i stručna senzorska evaluacija u korelaciji s detaljnom fizikalno-kemijskom analizom hlapljivih spojeva. Time se omogućuje dublje razumijevanje uloge destilata ne samo kao nositelja alkohola, već i kao čimbenika koji aktivno oblikuje aromatski profil i percepciju kakvoće likera.

Materijali

Sušeni cvjetovi bazge (*Sambucus nigra* L.) korišteni su kao osnovna sirovina za pripravu likera. Kao ekstrakcijsko otapalo upotrijebljena je pitka voda (2 L po uzorku), a za zaslađivanje saharoza (1,5 kg po uzorku). Regulator kiselosti bio je svježe iscijeđeni sok jednog limuna (*Citrus limon* L.).

Kao izvor etanola korištene su dvije vrste domaćih destilata:

- šljivovica (destilat fermentiranih plodova šljive),
- komovica (destilat fermentirane komine grožđa).

Početna alkoholna jakost oba destilata iznosila je 46,7% (v/v) etanola.

Pripremljena su dva uzorka likera u dvije novisne pripreme (tablica 1):

- Uzorak A – liker od bazge s komovicom
- Uzorak B – liker od bazge sa šljivovicom

Tablica 1. Recepture za liker od bazge

Table 1. Recipes for elderflower liqueur

Sastojak	Uzorak A liker od bazge s rakijom komovicom	Uzorak B liker od bazge sa rakijom od šljive
Voda (L)	2	2
Cvjetovi bazge (kom)	30	30
Šećer (kg)	1,5	1,5
Limun (kom)	1	1
Rakija komovica (L)	2,5	0
Rakija šljivovica (L)	0	2,5

Metode

Postupak ekstrakcije

Za svaki uzorak provedena je zasebna maceracija. Prirodno sušeni cvjetovi bazge macerirani su u 2 L vode tijekom 24 h pri sobnoj temperaturi (20 – 22 °C) radi ekstrakcije vodotopivih spojeva (fenolnih spojeva, flavonoida, aromatskih komponenti i peludi).

Nakon 24 h provedena je filtracija kroz sterilnu gazu radi uklanjanja biljnog materijala. Dobiveni vodeni ekstrakt korišten je za daljnju obradu.

Toplinska obrada i priprema sirupa

U svaki filtrirani ekstrakt dodano je 1,5 kg saharoze i svježe iscijeđeni sok jednog limuna. Smjesa je zagrijavana do temperature od 70 °C. Tijekom zagrijavanja formirala se pjena, koja je uklonjena mehanički radi postizanja veće bistrine i stabilnosti proizvoda. Potom je smjesa je ostavljena na hlađenje 30 min pri sobnoj temperaturi.

Alkoholizacija uzoraka

U ohlađenu smjesu dodan je odgovarajući destilat:

- Uzorku A dodana je komovica (46,7% v/v),
- Uzorku B dodana je šljivovica (46,7% v/v).

Dodatak etanola imao je funkciju konzerviranja proizvoda, povećanja ekstrakcije spojeva topivih u alkoholu te formiranja karakterističnog aromatskog profila specifičnog za pojedini destilat. Smjese su homogenizirane miješanjem do postizanja ujednačene tekuće faze.

Punjenje i skladištenje

Oba uzorka pretočena su u prethodno oprane i osušene prozirne staklene boce s debljom stijenkom. Boce su skladištene u hladnom i tamnom prostoru tijekom 3 mjeseca. Tijekom prvih dana skladištenja kod oba uzorka uočena je početna замуćenost, nakon čega je uslijedilo spontano bistrenje. Na dnu boca formirao se talog, vjerojatno sastavljen od peludi i koloidnih biljnih čestica. Uzorci nisu dodatno filtrirani kako bi se očuvala prirodna aroma i punina okusa.

Senzorsko ocjenjivanje

Senzorska analiza likera i voćnih destilata provedena je prema važećim testnim propisima Deutsche Landwirtschafts-Gesellschaft (DLG, 2016). Metodologija se temelji na analitičko - deskriptivnom pristupu uz standardizirane uvjete kušanja i bodovni sustav procjene kakvoće. DLG sustav bodovanja ocjenjuje likere i destilate kroz vizualne, mirisne i okusne karakteristike s maksimalno 24 boda po originalnom standardu. Kako bi se dobila prikladnija apsolutna ocjena do 100 bodova, pojedinačna svojstva se proporcionalno skaliraju tako da ukupni zbroj daje približno 100 bodova (npr. Boja = 15, Bistrina = 15, Miris = 25, Okus = 45). Ovakvo skaliranje omogućava preciznije razlikovanje uzoraka, lakšu vizualizaciju i usporedbu (DLG, 2009; Lehnhardt i sur., 2018).

Ocjenjivanje je provedeno u kontroliranim laboratorijskim uvjetima. Uzorci su bili označeni slučajnim troznamenkastim kodovima (Slika 1). Procjenjivani su sljedeći parametri: izgled (boja i bistrina), miris (čistoća, intenzitet i tipičnost), okus (harmonija, punoća, tipičnost i eventualna odstupanja) te ukupni dojam proizvoda. Svaki parametar je vrednovan, pri čemu se ocjena temeljila na principu odbitaka bodova za utvrđene senzorske nedostatke, sukladno DLG smjernicama.



Slika 1. Priređeni uzorci za senzorsko ocjenjivanje
Figure 1. Prepared samples for sensory evaluation

U istraživanju su sudjelovale dvije skupine ocjenjivača:

- Edukacirana skupina – pet ($n = 5$) senzorički educiranih i treniranih ocjenjivača s iskustvom u analitičkom ocjenjivanju jakih alkoholnih pića

- Potrošačka skupina – deset ($n = 10$) potencijalnih potrošača (starosti 20 do 60 godina) bez formalne senzoričke edukacije.

Svi ocjenjivači procjenjivali su oba uzorka u ponovljenim mjerenjima.

Statistička obrada podataka

Rezultati su izraženi kao srednja vrijednost $\pm$ standardna devijacija ($M \pm SD$). Normalnost distribucije podataka provjerena je Shapiro–Wilkovim testom. Budući da su isti ispitanici ocjenjivali oba uzorka, razlike između uzoraka unutar iste skupine ocjenjivača analizirane su t-testom za zavisne uzorke (paired samples t-test), odnosno Wilcoxonovim testom rangova u slučaju odstupanja od normalne distribucije. Razlike između educirane i potrošačke skupine ocjenjivača, kao i utjecaj tipa uzorka i skupine ocjenjivača na senzorske ocjene, analizirani su primjenom dvosmjerne mješovite analize varijance (two-way mixed ANOVA). Faktor uzorak (A i B) definiran je kao unutar-ispitanika (within-subject factor), dok je faktor skupina ocjenjivača (educirana i potrošačka) definiran kao između-ispitanika (between-subject factor). Ovisne varijable bile su senzorske ocjene (boja, bistrina, miris, okus). Za svaku senzorsku varijablu, učinci uzorka i skupine analizirani su putem mixed ANOVA, dok su t-testovi korišteni kao dodatna analiza parnih usporedbi između uzoraka.

Razina statističke značajnosti postavljena je na $p < 0,05$. Pretpostavke ANOVA analize provjerene su prije provedbe: normalnost distribucije (Shapiro–Wilk test) i homogenost varijanci (Leveneov test). S obzirom na ograničen broj ispitanika u educiranoj skupini, interpretacija rezultata dodatno je temeljena na veličinama učinka (partial eta squared, η^2p), uz p-vrijednosti.

Kemijske metode za analizu likera

Za procjenu kvalitete destilata primijenjene su temeljne analitičke metode koje se koriste u kontroli kvalitete jakih alkoholnih pića. U industrijskim kontrolnim laboratorijima ove metode predstavljaju standardizirani okvir za određivanje ključnih fizikalno-kemijskih parametara. Kemijska analiza destilata obuhvaćala je kvantifikaciju etanola, ukupnog ekstrakta, ukupne kiselosti, ukupnog SO_2 , ukupnih aldehida, ukupnih estera, viših alkohola, furfurala i metanola. Svi parametri određeni su primjenom klasičnih kemijskih metoda prema standardnim postupcima AOAC international (1995), koji se koriste za analizu destilata i jakih alkoholnih pića. Sve analize provedene su u dva ponavljanja ($n = 2$), a rezultati su prikazani kao srednje vrijednosti.

Analize su provedene prema sljedećim postupcima:

Sadržaj etanola (% vol) i gustoća (g/mL) određeni su nakon prethodne destilacije uzorka primjenom alkoholmetra i piknometra. Ukupni ekstrakt izračunat je iz dobivenih fizikalno-kemijskih parametara.

Ukupne kiseline određene su volumetrijskom titracijom s 0,1 mol/L NaOH uz fenolftalein kao indikator, dok je ukupni SO_2 određen jodometrijskom titracijom.

Hlapivi spojevi (aldehidi, esteri, viši alkoholi, metanol i furfural) određeni su nakon destilacije uzorka primjenom klasičnih kemijskih metoda. Aldehidi su određeni metodom vezanja s natrijevim bisulfitom i jodometrijskom titracijom, esteri alkalnom

hidrolizom (saponifikacijom), viši alkoholi oksidacijsko-volumetrijskom metodom, dok je metanol određen oksidacijom u formaldehid i kolorimetrijskom reakcijom s kromotropnom kiselinom. Furfural je određen kolorimetrijskom metodom s anilin-acetatom.

Kod kolorimetrijskih određivanja intenzitet obojenja mjeren je spektrofotometrijski pri odgovarajućim valnim duljinama.

Za kolorimetrijska određivanja izrađene su kalibracijske krivulje pomoću standardnih otopina poznatih koncentracija. Linearnost metoda potvrđena je koeficijentom korelacije $R^2 > 0,995$, dok je preciznost izražena kao standardna devijacija (SD).

Koncentracije hlapivih spojeva izražene su u mg/L apsolutnog alkohola (mg/L a.a.) prema izrazu:

$$C_{a.a.} = \frac{C \times 100}{\% \text{ vol. alkohola}}$$

gdje je C izmjerena koncentracija u mg/L uzorka, a $\%$ vol. udio etanola u uzorku.

REZULTATI I DISKUSIJA

Nakon provedenog senzorskog ocjenjivanja uzoraka likera od bazge, dobiveni rezultati su prikazani kao prosječna vrijednost ocjena potrošačke skupinepanela (Tab. 2) i skupine obučanih ocjenjivača (Tab. 3).

Tablica 2. Rezultati senzorskog ocjenjivanja likera od bazge u potrošačkoj skupini ($n = 10$) uz rezultate t testa za $p < 0,05$

Table 2. Sensory evaluation of elderflower liqueur in the consumer group ($n = 10$) with T -test results for $p < 0.05$

Svojstvo	Uzorak A ($M \pm SD$)	Uzorak B ($M \pm SD$)	t vrijednosti uz vjerovatnoću (p)
Boja	15,00 $\pm$ 0,00	15,00 $\pm$ 0,00	0 $p=$, $p = 1,00$
Bistrina	14 $\pm$ 2,10	12,50 $\pm$ 2,60	1,90, $p = 0,09$
Miris	22,00 $\pm$ 0,00	20,90 $\pm$ 2,30	2,00, $p = 0,07$
Okus	39,56 $\pm$ 3,97	37,84 $\pm$ 5,18	1,50, $p = 0,17$
Ukupno	90,56 $\pm$ 3,97	86,24 $\pm$ 6,43	1,00, $p = 0,34$

M = srednja vrijednost; SD = standardna devijacija

Uočava se da su oba uzorka ocijenjena relativno visoko po boji i bistrini (tablica 2), dok su okus i iris dobili nešto niže ocjene. Uzorak A (bazga s komovicom) imao je nešto višu prosječnu ocjenu okusa (39,56 $\pm$ 3,97) i bistrine (14 $\pm$ 2,10) u odnosu na Uzorak B (bazga sa šljivovicom; okus 37,84 $\pm$ 5,18), bistrina 12,50 $\pm$ 2,60). Miris je također nešto favorizirao Uzorak A (22,00 $\pm$ 0,00), a Uzorak B (20,90 $\pm$ 2,30).

Budući da su svi ocjenjivači ocjenjivali oba uzorka, primijenio se t -test za zavisne uzorke za svaki parametar unutar potrošačke skupine. Kao što se može vidjeti niti jedna vrijednost t nije statistički značajna jer su sve p vrijednosti veće od 0,05.

Ovi rezultati sugeriraju da su obje formulacije općenito dobro prihvaćene među potrošačima. Nepostojanje izraženih razlika između uzoraka unutar potrošačke skupine upućuje na to da neobučeni ispitanici percipiraju senzorske profile likera kao relativno usporedive. Slična zapažanja zabilježena su i u prethodnim istraživanjima voćnih alkoholnih pića, gdje potrošači često vrednuju proizvode prvenstveno prema općem dojmu, a ne prema detaljnim senzorskim atributima (Petrović i sur., 2021; Kaack i sur., 2005).

Tablica 3. Rezultati senzorskog ocjenjivanja likera od bazge obučenih senzoričara (n = 5) uz rezultate *t* testa za $p < 0,05$

Table 3. Sensory evaluation of elderflower liqueur by trained sensorists (n = 5) with T-test results for $p < 0.05$

Svojstvo	Uzorak A (M ± SD)	Uzorak B (M ± SD)	t vrijednosti uz vjerovatnoću (p)
Boja	15,00 ± 0,00	15,00 ± 0,00	0 p=, $p = 1,00$
Bistrina	15,00 ± 0,00	13,20 ± 2,17	2,24, $p = 0,09$
Miris	22,00 ± 4,47	16,00 ± 5,66	4,00, $p = 0,015$
Okus	43,00 ± 2,83	31,80 ± 7,45	6,63, $p = 0,002$
Ukupno	95,00 ± 4,47	62,80 ± 8,34	7,71, $p = 0,001$

M = srednja vrijednost; SD = standardna devijacija

Rezultati senzorske analize obučenih senzoričara (Tablica 3) pokazali su određene razlike između uzorka A i uzorka B u procjenjivanim svojstvima. Boja oba uzorka ocijenjena je maksimalnom ocjenom (15,00 ± 0,00), što ukazuje na potpunu podudarnost u percepciji ovog senzorskog svojstva među ocjenjivačima te sugerira da vizualni izgled nije bio čimbenik koji razlikuje uzorke. Kod svojstva bistrine uzorak A ostvario je višu prosječnu ocjenu (15,00 ± 0,00) u odnosu na uzorak B (13,20 ± 2,17). Međutim, ova razlika nije statistički značajna. Osim niže srednje vrijednosti, kod uzorka B zabilježena je i veća standardna devijacija, što upućuje na veću varijabilnost u ocjenama ocjenjivača i moguće razlike u percepciji stupnja bistrine. Izraženije razlike uočene su kod svojstava mirisa i okusa. Uzorak A postigao je statistički značajnu višu prosječnu ocjenu mirisa (22,00 ± 4,47) u odnosu na uzorak B (16,00 ± 5,66), što može ukazivati na intenzivniji ili ugodniji aromatski profil uzorka A. Sličan trend zabilježen je i kod ocjene okusa, gdje je uzorak A ostvario statistički značajno višu prosječnu ocjenu (43,00 ± 2,83) u usporedbi s uzorkom B (31,80 ± 7,45). Veća standardna devijacija kod uzorka B upućuje na neujednačenost percepcije okusa među ocjenjivačima. Posljedično, ukupna senzorska ocjena bila je znatno viša za uzorak A (95,00 ± 4,47) nego za uzorak B (62,80 ± 8,34). Ovi rezultati sugeriraju da je uzorak A općenito bolje prihvaćen među ocjenjivačima te da posjeduje povoljnija senzorska svojstva u odnosu na uzorak B. Kao što se može vidjeti vrijednosti *t* statistički su značajne za miris, okus i ukupnu ocjenu, jer su njihove *p* vrijednosti veće od 0,05. Ovo ukazuje da su obučeni senzorski ocjenjivači uočili razliku između uzoraka te su uočili razlike osobito po mirisu i okusu.

Mješovita ANOVA (uzorak $\times$ skupina)

Glavni učinak uzorka: $F(1,13) = 58,32, p < .001, \eta^2_p = 0,82 \rightarrow$ značajne razlike između uzoraka

Glavni učinak skupine: $F(1,13) = 27,18, p < .001, \eta^2_p = 0,68 \rightarrow$ značajna razlika između potrošača i senzoričara

Interakcija uzorak $\times$ skupina: $F(1,13) = 16,25, p = .001, \eta^2_p = 0,56 \rightarrow$ obrazac procjene uzorka ovisi o skupini ocjenjivača

Iz ovoga proizlazi da obučeni senzoričari bolje razlikuju oba uzorka nego potrošači, posebno po okusu, što se u konačnici odrazilo i na ukupnu ocjenu.

Senzorska evaluacija likera od bazge otkrila je razlike između formulacija pripremljenih s rakijom komovicom i rakijom od šljive kao alkoholnom bazom. Iako su potrošači percipirali oba uzorka kao jednako prihvatljiva, obučeni senzoričari su uočili jasne senzorske razlike, osobito u mirisu, okusu i ukupnoj kvaliteti što je u skladu s istraživanjima Ares i Varela (2016) i Silva i sur. (2025).

Kod vizualnih svojstava, oba su uzorka dobila maksimalne ocjene za boju ($15,00 \pm 0,00$) u obje skupine ocjenjivača, što upućuje na to da između formulacija nije bilo vizualno uočljivih razlika. Boja likera od bazge prvenstveno ovisi o pigmentima prisutnim u biljnom materijalu te je u ovom slučaju bila jednako prihvatljiva za sve ocjenjivače. Sličan trend uočen je i kod bistrine, gdje je uzorak A dobio nešto više ocjene ($14 \pm 2,10$ kod potrošača i $15,00 \pm 0,00$ kod obučenih senzoričara) u odnosu na uzorak B ($12,50 \pm 2,60$ kod potrošača i $13,20 \pm 2,17$ kod senzoričara). Iako razlike nisu velike, mogu ukazivati na male varijacije u suspendiranim česticama ili koloidnoj stabilnosti tijekom pripreme likera (Kennedy, 2022).

Nasuprot tome, obučeni senzoričari pokazali su veću sposobnost razlikovanja dviju formulacija (Tablica 3). Zabilježene su izraženije razlike u mirisu, okusu i ukupnoj senzorskoj ocjeni, pri čemu je Uzorak A dosljedno dobivao više ocjene. Prosječna ocjena mirisa za Uzorak A iznosila je $22,00 \pm 4,47$, dok je za Uzorak B iznosila $16,00 \pm 5,66$. Još veća razlika zabilježena je kod okusa ($43,00 \pm 2,83$ za Uzorak A naspram $31,80 \pm 7,45$ za Uzorak B), što se odrazilo i na ukupnu ocjenu proizvoda ($95,00 \pm 4,47$ za Uzorak A i $62,80 \pm 8,34$ za Uzorak B). Ovaj rezultat sugerira da vrsta alkoholne baze značajno utječe na senzorske karakteristike voćnih likera, što je u skladu s prethodnim radovima koji pokazuju da vrsta destilata može modulirati aromatski profil voćnih likera (Śliwińska i sur., 2020; Mrvčić i sur., 2015).

Više ocjene za miris i okus Uzorka A mogu biti povezane s kemijskim sastavom rakije komovice. Destilati od grožđa obično sadrže raznoliki profil hlapivih spojeva, uključujući estere, više alkohole i terpene, koji doprinose većoj aromatskoj kompleksnosti i percepciji okusa (Wei i sur., 2018; Oliveira i sur., 2020). Takav aromatski profil može bolje naglasiti cvjetne i voćne note bazge. Nasuprot tome, šljivovica često posjeduje izraženiji karakterističan aromatski profil koji može djelomično maskirati prirodni miris i okus bazge (Balak i sur., 2024). Ova interakcija između aromatskog profila destilata i biljnih ekstrakata vjerojatno je doprinijela nižim ocjenama uzorka B u senzorskoj analizi.

Više ocjene za miris i okus Uzorka A mogu se dovesti u vezu s kemijskim sastavom rakijom komovicom. Destilati grožđa karakterizirani su kompleksnim profilom hlapivih spojeva, uključujući estere, više alkohole i terpene, koji su u literaturi opisani kao čimbenici povezani s većom aromatskom kompleksnošću te percepcijom voćnih i cvjetnih senzacija (Wei i sur., 2018; Oliveira i sur., 2020). U tom smislu, navedeni aromatski profil može potencijalno pridonijeti naglašenijoj percepciji cvjetnih i voćnih nota bazge, pri čemu takva interpretacija ostaje hipotetska u odsutnosti izravnih kemijsko-senzorskih korelacijskih analiza u okviru ovog istraživanja.

S druge strane, šljivovica se odlikuje izraženim i karakterističnim aromatskim profilom, koji je u literaturi opisan kao dominantan i senzorno prepoznatljiv matriks te može utjecati na percepciju dodatnih aromatskih komponenti (Balak i sur., 2024). U tom kontekstu, moguće je pretpostaviti da takav profil može djelomično modulirati ili maskirati percepciju inherentnih mirisnih i okusnih svojstava bazge. Stoga se uočene niže senzorske ocjene Uzorka B mogu razmatrati u okviru potencijalnih interakcija između matriksa destilata i biljnih ekstrakata, uz napomenu da takvi zaključci zahtijevaju potvrdu putem ciljane multivarijatne analize povezanosti kemijskog sastava i senzorskih svojstava.

Mješovita ANOVA analiza dodatno je potvrdila da se obrasci ocjenjivanja razlikuju između potrošača i obučene senzoričke skupine. Značajna interakcija između uzorka i skupine ocjenjivača upućuje na to da su obučeni senzoričari razlikovali formulacije snažnije nego potrošači. Ovaj ishod odgovara poznatoj ulozi obučene senzorske skupine, koja je posebno trenirana za prepoznavanje suptilnih razlika u atributima proizvoda koje opća populacija možda ne primijeti (Stone i Sidel, 2004; Meilgaard, Carr i Civile, 2006). Sveukupno, rezultati sugeriraju da liker od bazge pripremljen s komovicom od grožđa može pružiti povoljniji senzorski profil, osobito u pogledu mirisa i okusa. Međutim, s potrošačke perspektive obje formulacije imaju usporedivu razinu prihvatljivosti, što ukazuje na potencijal za primjenu različitih alkoholnih baza ovisno o ciljanoj skupini potrošača i željenom senzorskom profilu proizvoda. Ova saznanja naglašavaju važnost kombiniranja potrošačkog testiranja s obučenom senzorskom analizom pri evaluaciji novih alkoholnih pića, jer svaka metoda pruža različite, ali komplementarne informacije o kvaliteti i prihvatljivosti proizvoda (Lawless i Heymann, 2010; Śliwińska i sur., 2015).

Tablica 4. Rezultati kemijske analiza likera

Table 4. Results of chemical analysis of elderflower liqueur

Parametar	Uzorak A	Uzorak B
Etanol (% vol)	15,25	15,45
Gustoća (g/ml)	1,14228	1,14485
Ukupni ekstrakt (g/L)	462,65	473,92
Ukupni SO ₂ (mg/L)	0,81	0,71
Ukupne kiseline (mg/L)	150,60	159,82

Parametar	Uzorak A	Uzorak B
Aldehidi (mg/L a.a.)	80,59	75,61
Esteri (mg/L a.a.)	600,23	528,31
Viši alkoholi (mg/L a.a.)	859,31	925,47
Furfural (mg/L a.a.)	0,059	0,046
Metanol (mg/L a.a.)	0,0091	0,0802

Analizirani uzorci likera od bazge pripremljeni s dodatkom komovice i šljivovice (tablica 4) pokazuju razlike u fizikalno-kemijskim svojstvima koje se mogu pripisati različitom sastavu korištenih destilata. Sadržaj etanola u oba uzorka je vrlo sličan (15,25 i 15,45% vol), što odgovara tipičnim vrijednostima za likere i voćna alkoholna pića (Jackson, 2014; Miličević i sur., 2013).

Gustoća i ukupni ekstrakt viši su u uzorku sa šljivovicom (1,14485 g/mL; 473,92 g/L) nego u uzorku s komovicom (1,14228 g/mL; 462,65 g/L), što ukazuje na veću koncentraciju otopljenih tvari. Ovi parametri povezani su s udjelom šećera i drugih ekstraktivnih komponenti, koji značajno utječu na viskoznost i punoću okusa likera (Russell i Stewart, 2014).

Ukupni SO₂ prisutan je u vrlo niskim koncentracijama (0,71–0,81 mg/L), što sugerira da sumporni spojevi nemaju značajan utjecaj na stabilnost ni aromu proizvoda. Takve vrijednosti su znatno niže od onih koje imaju tehnološki učinak u enološkoj praksi (Ribéreau-Gayon i sur., 2006).

Ukupne kiseline su nešto više u liker u sa šljivovicom (159,82 mg/L) u odnosu na komovicu (150,60 mg/L), što može doprinijeti izraženijoj svježini i boljoj ravnoteži okusa. Organske kiseline imaju važnu ulogu u formiranju ukupnog senzornog dojma i stabilnosti alkoholnih pića (Jackson, 2014).

Analiza hlapljivih spojeva ukazuje na razlike u aromatskom potencijalu uzoraka. Viša koncentracija estera u liker u s komovicom (600,23 mg/L a.a.) u odnosu na liker sa šljivovicom (528,31 mg/L a.a.) upućuje na izraženiji voćni i cvjetni aromatski profil, budući da su esteri ključni nositelji tih aroma (Swiegers i sur., 2005; Jurak i sur., 2021). Suprotno tome, viši alkoholi su zastupljeniji u uzorku sa šljivovicom (925,47 mg/L a.a.), što može doprinijeti kompleksnosti, ali i potencijalno negativno utjecati na finoću okusa pri višim koncentracijama (Russell i Stewart, 2015).

Slični rezultati zabilježeni su i u istraživanjima tradicionalnih voćnih rakija, gdje esteri i viši alkoholi predstavljaju dominantne hlapljive komponente koje definiraju aromatski profil proizvoda (Šarolić i sur., 2019).

Sadržaj aldehida viši je u liker u s komovicom (80,59 mg/L a.a.), što može rezultirati izraženijom oštrinom mirisa, dok su koncentracije furfurala u oba uzorka vrlo niske i u granicama koje ne utječu značajno na kvalitetu proizvoda (Ribéreau-Gayon i sur., 2006).

Metanol je detektiran u vrlo niskim koncentracijama u oba uzorka, pri čemu je nešto viši u liker u sa šljivovicom.

Nastaje razgradnjom pektinskih tvari tijekom fermentacije, a njegova koncentracija ovisi o sirovini i tehnologiji proizvodnje (Jackson, 2014; Jurak i sur., 2021). Dobivene vrijednosti su znatno ispod razina koje bi predstavljale zdravstveni rizik.

ZAKLJUČAK

Senzorska evaluacija pokazala je da vrsta alkoholne baze značajno utječe na senzorska svojstva likera od bazge, osobito na miris, okus i ukupnu kvalitetu proizvoda. Iako su potrošači oba uzorka ocijenili kao podjednako prihvatljiva, obučeni senzoričari identificirali su jasne razlike, pri čemu je liker pripremljen s komovicom od grožđa ostvario više ocjene u svim ključnim senzorskim atributima. Nedostatak značajnih razlika u ocjenama potrošača upućuje na to da neobučeni ispitanici proizvode procjenjuju prvenstveno prema općem dojmu, dok suptilne razlike u senzorskim svojstvima ostaju manje zamjetne. Vizualna svojstva (boja i bistrina) nisu pokazala značajne razlike između uzoraka, što ukazuje da alkoholna baza nema izražen utjecaj na ove parametre. Kemijski sastav likera potvrđuje senzorske rezultate, liker s komovicom sadržavao je više estera, što doprinosi izraženijem voćnom i cvjetnom aromatskom profilu, dok je liker sa šljivovicom imao veći udio viših alkohola i kiselina. Veći udio estera u liker s komovicom povezan je s boljom aromatskom kompleksnošću i prihvatljivošću, dok viši alkoholi u liker s šljivovicom mogu doprinijeti kompleksnosti, ali i potencijalno negativno utjecati na finoću okusa. Fizikalno-kemijski parametri (etanol, gustoća, ekstrakt, kiseline) razlikuju se između uzoraka, ali su unutar očekivanih vrijednosti za ovu kategoriju proizvoda te ne predstavljaju ograničenje za kvalitetu ili sigurnost. Niske koncentracije sumpornih spojeva, metanola i furfurala ukazuju na dobru tehnološku kontrolu i sigurnost proizvoda. Kombinacija senzorske i fizikalno-kemijske analize pokazala se ključnom za cjelovitu procjenu kvalitete likera, jer svaka metoda pruža komplementarne informacije. Liker od bazge s komovicom od grožđa pokazao je povoljniji senzorski profil, dok liker sa šljivovicom nudi drugačiji, intenzivniji karakter, što omogućuje prilagodbu proizvoda različitim preferencijama potrošača. Zaključno, rezultati potvrđuju da izbor alkoholne baze značajno utječe na kemijski sastav i potencijalni senzorni profil likera od bazge. Liker s komovicom karakterizira veći udio estera i izraženiji aromatski profil, dok liker sa šljivovicom sadrži više viših alkohola i kiselina, što može rezultirati kompleksnijim, ali i intenzivnijim okusom. Ipak, korištenje samo dviju vrsta voćnih destilata, ograničen broj uzoraka i senzoričara te provođenje ispitivanja u laboratorijskim uvjetima ograničavaju mogućnost šire generalizacije rezultata. Nadalje, kemijska analiza bila je usmjerena na kvantitativne pokazatelje bez detaljne identifikacije i senzorne korelacije pojedinih aromatski aktivnih komponenti. Buduća istraživanja trebala bi uključiti veći broj različitih destilata, proširene senzorske panele te uvjete testiranja bliže stvarnoj konzumaciji, uz naprednu instrumentalnu analitiku usmjerenu na identifikaciju ključnih spojeva odgovornih za senzornu percepciju.

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INFLUENCE OF ALCOHOL BASE ON THE SENSORY AND PHYSICOCHEMICAL PROPERTIES OF ELDERFLOWER LIQUEUR

Abstract

The aim of this study was to investigate the influence of different alcohol bases on the sensory and physicochemical properties of elderflower liqueur. Two liqueur samples were prepared using different distillates: grape marc spirit and plum brandy. Sensory evaluation was conducted by both consumers and trained panelists, while physicochemical analyses included the determination of ethanol content, total extract, density, acidity, sulfur compounds, and volatile aroma compounds.

The results showed that both samples were well accepted by consumers, with no significant differences in overall liking and taste scores. However, trained panelists identified significant differences between the samples, with the liqueur based on grape marc spirit receiving higher scores for aroma, taste, and overall quality. Physicochemical analysis confirmed differences in volatile composition: the grape marc-based liqueur contained higher levels of esters, while the plum brandy-based liqueur had a higher content of higher alcohols and acids.

These findings indicate that the type of alcohol base significantly influences the physicochemical properties and sensory characteristics of elderflower liqueur. Although these differences are clearly perceived by trained assessors, they are less noticeable to consumers. In conclusion, the choice of distillate allows for the development of products with distinct sensory profiles tailored to different consumer preferences.

Keywords: *elderflower liqueur, grape marc spirit, plum brandy, sensory analysis, volatile compounds*

KVALITET PEKMEZA OD ŠEĆERNE REPE PROIZVEDENOG PO TRADICIONALNOJ RECEPTURI U BOSNI I HERCEGOVINI

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Sažetak

Šećerna repa (*Beta vulgaris* ssp. *altissima* var. *saccharifera* Alef) je važna sirovina za proizvodnju šećera, koji se svakodnevno koristi u ishrani.

Upotreba šećerne repe u proizvodnji pekmeza na globalnom nivou nije široko rasprostranjena i uglavnom je ograničena na specifična područja, uključujući i lokalitet Centralne Bosne i Hercegovine. Na ovom području proizvodnja pekmeza od šećerne repe zasniva se na tradicionalnoj recepturi, pri čemu su dostupni podaci o njenoj proizvodnji i kvalitetu i dalje nedovoljni.

Cilj rada je bio definisati tehnološke karakteristike šećerne repe kao sirovine, nutritivne i senzorne karakteristike kvaliteta pekmeza od šećerne repe i uticaj agroekoloških uslova proizvodnje na varijacije u njegovom kvalitetu. Analizirani su mehanički sastav, fizičko-hemijski parametri sirovine i pekmeza te senzorna svojstva finalnog proizvoda proizvedenog u dvije uzastopne sezone (S1 i S2). Šećerna repa ima 17,63% rastvorljive suhe materije, 15,80% ukupnih šećera, a iskorištenost tokom prerade je 68,76%. Randman pekmeza je 4,76%. Uzorci pekmeza (S1) imali su značajno veći ($p < 0,05$) viskozitet, sadržaj ukupnih fenola, rastvorljive suhe materije, ukupnih šećera, saharoze i bolji senzorni kvalitet (boju, okus, konzistenciju), dok je miris bio sličan uzorku S2. Razlika u titracionalnoj kiselosti i direktno redukujućim šećerima nije bila značajna. Navedeni podaci su prvi korak u proceduri standardizacije proizvodnje pekmeza po tradicionalnom postupku.

Ključne riječi: *pekmez od šećerne repe, tehnološki, nutritivni i senzorni kvalitet*

UVOD

Šećerna repa, prvenstveno, predstavlja sirovinu za proizvodnju kristalnog šećera odnosno saharoze koja se svakodnevno koristi u ishrani, ali i u prehrambenoj industriji, dok se lišće i glava šećerne repe (oko 30-80% od ukupnog prinosa) upotrebljavaju kao viskokvalitetna hrana za ishranu stoke (Gadžo i sar., 2011). S druge strane, šećerna repa i njeni nusproizvodi mogu se koristiti za proizvodnju biogoriva, biohemikalija i farmaceutski vrijednih proizvoda (Finkenstadt, 2014; Usmani i sar., 2022; Čirić i sar.,

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2024). U tradicionalnoj medicini Irana ekstrakt repe se koristi u liječenju psiholoških problema i jačanju imuniteta (El-Gendy i sar., 2022).

Malo je poznato da se od ove sirovine proizvodi i viskovrijedna poslastica poput pekmeza, koji je posebno cijenjen proizvod u Turskoj (Karababa i Develi Isikli, 2005), ali i u centralnom području Bosne i Hercegovine. Pekmez napravljen po tradicionalnoj recepturi u nekim područjima B&H proizvodi se ukuhavanjem soka bez dodatka šećera. Tehnološke karakteristike korijena šećerne repe variraju i zavise od kultivara (Studnicki i sar., 2019), ekoloških uslova (Hoffman i sar., 2009), uslova uzgoja (Ebmeyer i Hoffmann, 2020; Michalska-Klimczak i sar., 2024), vremena vađenja (Hemayati i sar., 2024; Nowicki i sar., 2025) ali i uslova skladištenja (Kenter i Hoffman, 2009; Hoffman, 2018; English i Larsson Jönsson, 2023). Sadržaj suhe materije iznosi oko 25% sa dominantnim udjelom saharoze (14-20%) dok nešećerne komponente čine samo 7-9% (Pastović, 2017). Stoga ne iznenađuje činjenica da se ova vrijedna sirovina koristi za proizvodnju pekmeza, koji je kao energetski gusta hrana namijenjen sportistima, mladim ali i starijim osobama. Pekmez se odlikuje specifičnim okusom i vrijedan je izvor minerala i biološki aktivnih komponenti poput fenola, koji ispoljavaju niz povoljnih efekata na humano zdravlje (Chen i sar., 2015; Arjeh i sar., 2022). Zbog toga je izuzetno cijenjen proizvod u narodnoj medicini bosanskohercegovačkih potrošača, gdje se koristi kao nutritivna podrška kod malokrvnosti, kašalja, malaksalosti te kao stimulans za jačanje imuniteta. Proizvodnja pekmeza uslovljena je podnebljem sa kojeg sirovina potječe, a bazirana je na ukuhavanju soka šećerne repe. Budući da se proizvodnja pekmeza od šećerne repe u Bosni i Hercegovini zasniva na zanatskoj proizvodnji, gdje se kvalitet sirovine, ali i gotovog proizvoda, procjenjuje empirijski, to je i kvalitet ovog proizvoda varijabilan.

Stoga je cilj rada bio da se definišu tehnološke karakteristike šećerne repe kao sirovine, nutritivne i senzorne karakteristike kvaliteta pekmeza od šećerne repe i uticaj agroekoloških uslova proizvodnje sirovine na varijacije u kvalitetu pekmeza, kao finalnog proizvoda.

MATERIJAL I METOD RADA

Kao materijal za istraživanje korišten je korijen svježe šećerne repe uzgojene na tradicionalan način bez upotrebe mineralnih đubriva i pesticida u domaćinstvu porodice Begić u Brezi. Vađenje korijena je obavljeno u tehnološkoj zriobi, što je utvrđenom vizuelnim pregledom tj. u momentu sušenja vanjskih listova repe.

Tehnološke karakteristike šećerne repe ispitivane su na uzorcima proizvedenim tokom vegetacione sezone 2020. godine (S1). Pekmez je proizveden po tradicionalnoj recepturi u tri ponavljanja, pri čemu su korišteni uzorci iz vegetacijskih sezona 2019 (S2) i 2020 (S1).

Zbog nedostupnosti meteoroloških podataka za područje Breze, za procjenu klimatskih uslova korišteni su podaci Federalnog hidrometeorološkog zavoda za Sarajevo, jer se odlikuje sličnim nadmorskim visinama i agroekološkim uslovima, te se može smatrati reprezentativnom za posmatrano područje.

Nakon vađenja korijena šećerne repe, ostrim nožem se uklonjaju glave sa listovima (slika 1a). Slijedi temeljito pranje pod mlazom vode, zatim uklanjanje kore i vrha korijena (slika 1b). Tako pripremljena repa se sječe na tanke rezance (slika 1c), te pomiješa sa vodom u omjeru 55:45. Dobijena masa kuha se 180 minuta na otvorenom uz povremeno ručno miješanje (slika 1d). Nakon kuhanja, masa se ručno cjedi u drvenoj presi (torkulji, slika 1e), a za dalju preradu se koristi dobijeni vodeni ekstrakt (randman 58,47%), koji se dalje ukuhava uz povremeno uklanjanje pjene i kontinuirano miješanje. Kraj ukuhavanja se određuje empirijski, na osnovu vizuelno ocjenjenog viskoziteta ukuhane mase, povlačenjem linije kroz sredinu pekmeza. Ukoliko se masa razdvaja i duže vrijeme linija ostane razdvojena, ukuhavanje je završeno. Ukuhan pekmez se vruć puni u prethodno oprane i sterilisane tegle i hermetički zatvara odgovarajućim metalnim poklopcima i skladišti na tamnom i hladnom i mjestu. Randman pekmeza iznosio je 4,76%.

Mehanički sastav sirovine tj. randman i neiskoristivi dio/otpad (listovi sa glavom, rep korijena i kora) određeni su vaganjem na tehničkoj vagi (Akagić i Vranac, 2016). Analize fizičko-hemijskih svojstava sirovine i gotovih proizvoda provedene su prema važećem Pravilniku (Sl. list SFRJ 29/83 – preuzeto Sl. list RBiH 2/92¹) i to: sadržaj rastvorljive suhe materije određen je digitalnim refraktometrom (0-45 °Brix, Alla, France); titraciona kiselost određena je titracijom 0,1M NaOH uz odgovarajući indikator i izražena na limunsku kiselinu; redujući i ukupni šećeri određeni su metodom po Luff-Schoorl-u, a saharoza je izračunata računskim putem.

Sadržaj ukupnih fenola određen je spektrofotometrijskom metodom Folin-Ciocalteu reagensom na talasnoj dužini 765nm i izražen u g galne kiseline (GAE) na 100 g uzorka (Ough i Amerine, 1988). Viskozitet uzoraka pekmeza mjren je rotacionim viskozimetrom (Myr model VR 3000, Viscotech Hispania, S.L. Španija) i izražen u mPas.

Senzornu evaluaciju proveo je panel od pet obučanih ocjenjivača, koji su prethodno obučeni i odabrani, prema smjernicama ISO standarda (8586:2023). Prosorija za ocjenjivanje je bila izolavana od buke i imala je ujednačeno bijelo osvjetljenje. Uzorci su ocjenjivačima servirani istovremeno u identičnim bijelim plastičnim čašama i označeni nasumičnim oznakama. Svakom ocjenjivaču dostavljeno je približno 20-30g uzorka. Uzorci su ocjenjeni na sobnoj temperaturi a ocjenjivači su između uzoraka koristili pitku vodu za ispiranje usta, kao i bijele papirne salvete. Za ocjenjivanje uzoraka bilo je potrebno približno 10-15 minuta po ocjenjivaču. Boja, miris, okus i konzistencija uzoraka pekmeza ocjenjivani su na skali od 1 do 5, pri čemu 1 označava najnižu ocjenu i neodgovarajući kvalitet, a 5 najvišu, odnosno odgovarajući kvalitet.

¹ Zakon o primjenjivanju i preuzimanju saveznih propisa (Sl. list RBiH br. 2/92), primjenjuje se kao republički propis



Slika 1(a-e). Neke faze proizvodnje pekmeza od šećerne repe po tradicionalnoj recepturi

Figures 1 (a-e). Some stages of sugar beet pekmez production according to the traditional recipe

Tradicionalno proizveden pekmez od šećerne repe odlikuje se smeđom do tamno smeđom bojom, sa izraženim notama karamela, intenzivno slatkog okusa te guste i homogene konzistencije. Dobijeni rezultati statistički su obrađeni metodama deskriptivne statistike (srednja vrijednost i standardna devijacija) i jednofaktorijskom analizom varijanse (ANOVA) ($p < 0,05$) korištenjem programa IBM SPSS Statistics 23.

REZULTATI ISTRAŽIVANJA I DISKUSIJA

U ovom poglavlju su prikazani i diskutovani rezultati tehnoloških karakteristika korijena šećerne repe, te fizičko-hemijskih i senzornih karakteristika pekmeza proizvedenog od navedene sirovine. Budući da je sirovina proizvedena na području Breze za koje nisu dostupni meteorološki podaci, zbog sličnih klimatskih uslova korišteni su podaci Federalnog hidrometeorološkog zavoda za Sarajevo. Analiza meteoroloških podataka pokazala je da su vegetacione sezone 2019. i 2020. godine bile relativno ujednačene u pogledu temperature i rasporeda padavina, te se klimatski uslovi ne mogu smatrati dominantnim uzrokom uočenih razlika u kvalitetu pekmeza. Tehnološke karakteristike šećerne repe za proizvodnju pekmeza prikazane su u tabeli 1. Randman šećerne repe, određen deveti dan nakon vađenja, iznosi 68,76%, a udio otpada 31,24%. Prema istraživanju Nedomová i sar. (2017) promjene mehaničkih parametara šećerne repe dešavaju tokom vremena skladištenja.

U pomenutom istraživanju, tokom skladištenja repe uzgajane u blizini Jiříkovic u Češkoj Republici tokom 2015. godine postepeno se smanjivala čvrstoća korijena mjerena penetrometrom.

Tabela 1. Fizičko-hemijski parametri šećerne repe

Table 1. Physico-chemical parameters of sugar beet

Parametri kvaliteta/Quality parameters	Vrijednost±SD/Value±SD
Randman/Yield (%)	68,76 ± 3,80
Otpad/Waste (%)	31,24 ± 3,80
Redukujući šećeri/Reducing sugars (g/100g)	0,30 ± 0,10
Ukupni šećeri/Total sugars (g/100g)	15,80 ± 0,10
Saharoza/Sucrose (g/100g)	14,70 ± 0,10
Rastvorljiva suha materija/Total soluble solids (°Brix)	17,63 ± 0,06
Titraciona kiselost/Titratable acidity (g/100g)	0,07 ± 0,02
Ukupni fenoli/Total phenols (g GAE/100 g)	0,30 ± 0,03

SD- standardna devijacija

Takve promjene mogu biti povezane sa gubitkom vlage u korijenu, zavisno od uslova skladištenja (temperatura, rel. vlažnost, strujanje vazduha...) što može uticati na smanjenje udjela iskoristivog dijela sirovine.

Sadržaj rastvorljive suhe materije iznosio je 17,63°Brix što je u skladu sa rezultatima Swicka (2014) koji navodi vrijednost od 17,80%.

Al-Jbawi i sar. (2015) su istraživali kvalitet korijena šećerne repe i na osnovu dvogodišnjih ispitivanja četiri različita kultivara, zaključili su da je skladištenje sirovine odnosno postupanje sa korijenom šećerne repe nakon vađenja, jedan od važnih faktora koji utiču na kvalitet. Osim vegetacione sezone, na kvalitet je uticao period skladištenja, koji je trajao jedan do deset dana. Sadržaj rastvorljive suhe materije se povećavao od prvog do posljednjeg dana skladištenja (20,72-39,93°Brix u sezoni 2007. odnosno 18,28-36,70°Brix u sezoni 2008.) i prosječno za sve sorte ustanovljen je procenat povećanja 42,98%.

Nešto viša vrijednost rastvorljive suhe materije (18,28°Brix) utvrđena je za genotip Rizor u istraživanju Al-Jbawi i sar. (2015). Isti autori su utvrdili da prolongirano skladištenje šećerne repe utječe na postepeno povećanje sadržaja rastvorljive suhe materije, te je za genotip Hospoly prvog dana nakon vađenja sadržaj iznosio 20,52°Brix a već deveti dan 35,90°Brix.

Kenter i Hoffman (2009) utvrdili su da skladištenje repe ima negativan utjecaj na akumulaciju nešećernih komponenti. U uzorcima šećerne repe uzgajane na području Isfahana i Karaja (Iran) sadržaj rastvorljive suhe materije se kretao u rasponu 19,10-26,20 °Brix (Babae i sar., 2013) a više vrijednosti (19,94-25%) zabilježene su u istraživanjima provedenim u Poljskoj (Buraczyńska, 2005; Zimny i sar., 2010; Stochalska i sar., 2014). Literaturni podaci nedvojbeno ukazuju da je sadržaj suhe materije u korijenu šećerne repe varijabilna tehnološka karakteristika i pod utjecajem je genotipa, primijenjenih agrotehničkih mjera kao i agroekoloških uslova uzgoja.

Sadržaj kiselina u uzorku šećerne repe iznosi 0,07% što je značajno niže u poređenju sa vrijednostima 0,20-0,30 % koje je detektovao Pastorović (2017). Evidentno variranje u sadržaju kiselina može biti i posljedica razlika u pH vrijednosti zemljišta, te zemljišnih i klimatskih uslova Bertić (2017). Tehnološka pogodnost šećerne repe zavisi od sadržaja šećera, i u provedenom istraživanju ove vrijednosti iznose: ukupni šećeri 15,80%, direktno redukujući šećeri 0,30% i saharoza 14,70% (tab. 1). Vrijednosti su u skladu sa istraživanjima provedenim u Iranu, gdje je zabilježena vrijednost ukupnog šećera u rasponu od 14,95 do 16,67% (Mohammadnezhad i sar., 2013). Nešto veće vrijednosti saharoze (15,90-21,40%) detektovali su Babaee i saradnici (2013), te Wójcik (2006) i Szulc i sar. (2008), a nađene razlike u sadržaju među analiziranim genotipovima šećerne repe posljedica su uslova uzgoja (hemijskog sastava zemljišta i nivoa đubrenja). Prosječan sadržaj ukupnih fenola u uzorcima šećerne repe iznosi 0,30 g GAE/100 g što je znatno više (0,18 g GAE/100g) u odnosu na uzorke uzgojene u Egiptu (Mohdaly i sar., 2013).

Međutim, u navedenom istraživanju korišten je uzorak nakon ekstrakcije šećera, u kojem je usljed oksidacije došlo do značajnog enzimskog posmeđenja, što je dovelo do snižavanja ukupnih polifenola. Prema Manach i saradnicima (2004) ljuštenje biljnih tkiva može utjecati na gubitak polifenola jer su u vanjskim dijelovima ova jedinjenja prisutna u većim koncentracijama u odnosu na unutrašnje dijelove. Navedeno je potvrđeno i u uzorcima šećerne repe gdje je u ekstraktu kore korijena detektovan značajno veći sadržaj u odnosu na mezokarp (Kujala i sar., 2000). S druge strane na sadržaj ukupnih fenola značajan utjecaj ima i ekstrakciono sredstvo tako su autori Alara i sar. (2021) detektovali veće vrijednosti u mezokarpu korijena ekstrahovanom metanolom u odnosu na etanol (8,3 odnosno 5,6 mg/g sm).

Fizičko-hemijski sastav pekmeza od šećerne repe proizvedenih u dvije vegetacione sezone je značajno varirao (tabela 2).

Sadržaj rastvorljive suhe materije u uzorku S1 (73,66°Brix) je statistički značajno veći u odnosu na S2 (61,53°Brix). Velika varijabilnost u sadržaju rastvorljive suhe materije među uzorcima je posljedica empirijskog određivanja kraja ukuhavanja, za koju se na osnovu rezultata ispitivanja kvaliteta pekmeza može zaključiti da nije pouzdana i prihvatljiva metoda posebno ukoliko se želi standardizirati kvalitet ovog vrijednog proizvoda. Bez obzira na evidentna variranja u sadržaju rastvorljive suhe materije ispitivanih uzoraka pekmeza od šećerne repe, sadržaj je bio iznad 60% što je u skladu sa odredbama važećeg Pravilnika (Službeni list BiH br.85/ 2012). Među analiziranim uzorcima pekmeza nisu utvrđene signifikantne razlike u kiselosti (0,46 g/100g odnosno 0,54 g/100g), kao što je prikazano u tabeli 2. Veću titracionu kiselost (0,67%) u uzorcima pekmeza detektovali su Yildiz i saradnici (2015) dok je u istraživanju autora Karababa i Isikli (2005) iznosila 0,45% što je u skladu sa rezultatima provedenog oglada za uzorak S1. Prema istim autorima sadržaj kiselina u pekmezu zavisi od sadržaja kiselina u sirovini, kao i dužini i uslovima skladištenja pekmeza.

Tabela 2. Fizičko-hemijske karakteristike pekmeza od šećerne repe
Table 2. Physico-chemical characteristics of sugar beet pekmez

Parametar/Parameter	Uzorci pekmeza /Pekmez samples	
	S1	S2
RSM/TSS °Brix	73,67 ± 0,056 ^a	61,533 ± 0,145 ^b
Titraciona kiselost/Titratable acidity g/100g	0,461 ± 0,111 ^a	0,536 ± 0,027 ^a
Redukujući šećeri/Reducing sugars g/100g	2,50 ± 0,300 ^a	2,30 ± 0,289 ^a
Ukupni šećeri/Total Sugars g/100g	54,07 ± 0,833 ^a	41,67 ± 2,081 ^b
Saharoza/Sucrose g/100g	49,00 ± 0,600 ^a	37,40 ± 2,261 ^b
Ukupni fenoli/Total phenols gGAE/100g	6,33 ± 0,153 ^a	3,89 ± 0,079 ^b
Viskozitet/Viscosity mPas	2710,00 ± 51,962 ^a	170,00 ± 0,00 ^b

RSM – Rastvorljiva suha materija; TSS – Total soluble solids

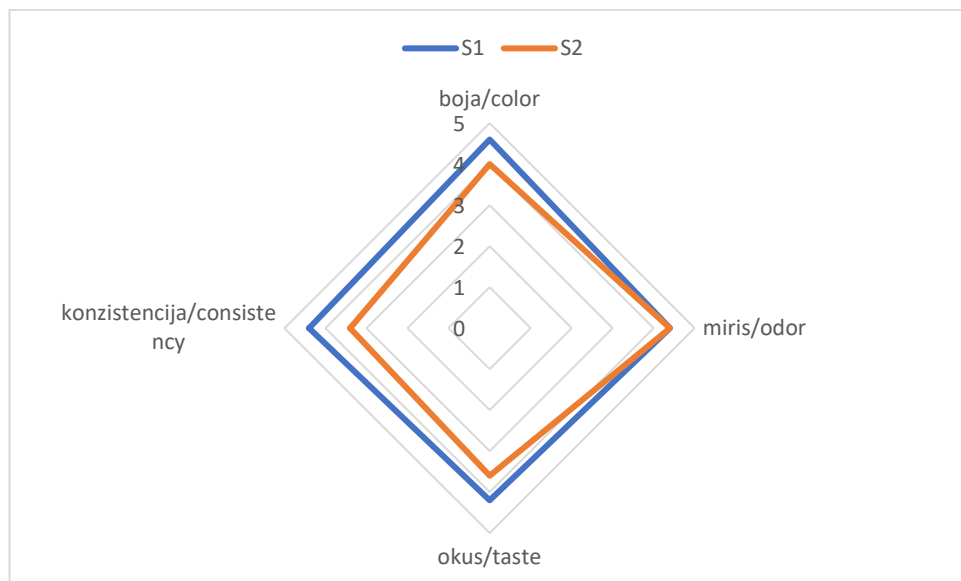
Različita slova 'a-b' unutar redova označavaju statički značajne razlike između uzoraka pekmeza ($p < 0,05$, ANOVA)

Statističkom analizom rezultata ispitivanja kvaliteta uzoraka pekmeza, nisu utvrđene značajne razlike u sadržaju direktno redukujućih šećera, ali su se uzorci statistički značajno ($p < 0,05$) razlikovali u pogledu sadržaja ukupnih šećera i saharoze (S1 2,50; 54,07; 49,00 odnosno S2 2,30; 41,67 i 37,40 g/100g). Prema rezultatima Karababa i Isikli (2005) sadržaj ukupnih šećera u pekmezu od šećerne repe iznosio je 49,90%, a nešto niži sadržaj (44,80%) ustanovljen je u istraživanju Yildiz i saradnika (2015).

Budući da je pekmez u provedenom istraživanju proizveden po tradicionalnoj recepturi, bez preciznog uređaja kojim bi se odredio kraj ukuhavanja, varijabilan sadržaj šećera je očekivan i prati sadržaj rastvorljive suhe materije u uzorcima. Sadržaj fenola se značajno razlikovao među uzorcima pekmeza (S1 6,33 g GAE/100g odnosno, S2 3,89 g GAE/100g) i bio je veći u odnosu na uzorke proizvedene u Turskoj – područje Širan (Yildiz i sar., 2015). Prema istom istraživanju, HPLC tehnikom detektovano je 11 fenolnih spojeva, a među najdominantnijim su: kumarinska kiselina (126,29 mg/kg), rutin (89,89 mg/kg), kvercetin (75 mg/kg) i katehin (66,57 mg/kg). Utvrđene razlike u sadržaju fenola su vjerovatno posljedica upotrijebljenog genotipa, uslova uzgoja, manipulacije sa sirovinom od berbe do prerade, načina proizvodnje, kao i metode određivanja sadržaja fenola. Ispitivanjem kvaliteta uzoraka pekmeza utvrđene su statistički značajne razlike ($p < 0,05$) u viskozitetu među uzorcima (S1 2710 mPas odnosno, S2 170 mPas), što je bilo i za očekivati na osnovu ustanovljene razlike u sadržaju rastvorljive suhe materije (tabela 2). Naime, pozitivna korelacija između sadržaja rastvorljive suhe materije i viskoziteta može se objasniti činjenicom da veća koncentracija rastvorenih komponenti ograničava mobilnost vode, što povećava otpor pri tečenju, i daje veći viskozitet (Juszczak i sar., 2010). Yildiz i saradnici (2015) pokazali su da se viskozitet pekmeza smanjuje s porastom temperature, što se može isključiti kao parametar varijabilnosti viskoziteta među uzorcima provedenog oglada budući da je temperatura pekmeza tokom određivanja viskoziteta bila u rasponu 22,7 °C i 23,3 °C, što su zanemarive razlike. Očigledno je da je empirijsko određivanje kraja ukuhavanja pekmeza, po tradicionalnoj recepturi, rezultiralo razlikama u viskozitetu,

što dodatno ukazuje na potrebu standardizacije procesa proizvodnje, kao i definisanje objektivnih metoda i identifikovanje parametara kvaliteta koji bi se koristili za njegovo praćenje.

Statističkom analizom senzornih atributa nisu utvrđene signifikantne razlike među uzorcima pekmeza (slika 2).



Slika 2. Senzorna analiza pekmeza od šećerne repe
Fig. 2. Sensory evaluation of the analyzed sugar beet pekmez

Uzorak S1 dobio je više ocjene za sve analizirane senzorne parametre (boja, okus, konzistencija), izuzev mirisa, pri čemu su miris oba uzoraka panelisti podjednako ocijenili (4,40). Boja uzorka S1 bila je tamno smeđa bez sjaja, okus izrazito sladak sa tonovima karamela, guste i glatke konzistencije. Najveće razlike u ocjeni među uzorcima primijećene su kod konzistencije, gdje je uzorak S1 dobio ocjenu 4,40, a S2 3,40, zbog tečnije konzistencije koja nije uobičajena za ovaj tip pekmeza. U procjeni kvaliteta hrane konzistencija je potrošačima vrlo važan pokazatelj, te se često viskozija hrana smatra kvalitetnijom u poređenju sa tečnijom (Szczesniak, 2002). Veći viskozitet (2710 mPas) uzorka pekmeza (S1), i veći sadržaj rastvornjive suhe materije (73,67°Brix), uticao je na to da dobije veće ocjene za konzistenciju, u odnosu na uzorak S2.

ZAKLJUČAK

Dobijeni rezultati istraživanja ukazuju na signifikantnu varijabilnost ($p < 0,05$) određenih fizičko-hemijskih parametara kvaliteta pekmeza od šećerne repe proizvedenog po tradicionalnoj recepturi tokom različitih proizvodnih sezona. Naime, između uzoraka S1 i S2 utvrđene su značajne razlike u viskozitetu, sadržaju rastvorljive suhe materije, ukupnih šećera, saharoze te ukupnih fenola.

Uočene razlike u vrijednostima ispitivanih parametara kvaliteta proizvoda mogu se pripisati razlikama u kvalitetu polazne sirovine, ali i empirijskom determinisanju stepena ukuhanja koje predstavlja ključnu fazu u proizvodnji ovog visokovrijednog proizvoda.

Navedeni rezultati ukazuju na potrebu standardizacije proizvodnje pekmeza po tradicionalnoj recepturi kroz definisanje objektivnih i mjerljivih kriterija za određene faze prerade (npr. završetka ukuhanja). Ujednačavanje kvaliteta proizvoda moglo bi značajno unaprijediti njegov tržišni potencijal, povećati njegovu konkurentnost i olakšati plasman na zahtjevnom inostranom tržištu, uz mogućnost razvoja proizvoda sa dodanom vrijednošću.

S druge strane, pekmez od šećerne repe proizveden prema tradicionalnoj recepturi u Bosni i Hercegovini je izuzetno vrijedan prehrambeni proizvod sa potencijalom primjene u kreiranju novih i obogaćivanju postojećih prehrambenih proizvoda.

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THE QUALITY OF SUGAR BEET PEKMEZ MADE IN BOSNIA AND HERZEGOVINA USING TRADITIONAL RECIPES

Abstract

Sugar beet (*Beta vulgaris* ssp. *altissima* var. *saccharifera* Alef.) is an important raw material for sugar production and is widely used in human nutrition. The use of sugar beet in pekmez production is not widely distributed on a global scale and is generally limited to specific geographical and agroecological regions, including Central Bosnia and Herzegovina. In this region, the production of sugar beet pekmez is based on traditional methods, and data regarding its production and quality remain scarce.

The objective of this study was to evaluate the technological characteristics of sugar beet as a raw material, determine the nutritional and sensory properties of sugar beet pekmez, and assess the influence of agroecological growing conditions on variations in its quality.

The mechanical composition, physicochemical parameters of both the raw material and pekmez, as well as the sensory properties of pekmez produced during two consecutive production seasons (S1 and S2) were investigated.

Sugar beet contained 17.63°Brix soluble solids and 15.80% total sugars, while the processing recovery reached 68.76%. The pekmez yield was 4.76%. Pekmez samples produced in season S1 showed significantly higher ($p < 0.05$) viscosity, total phenolic content, soluble solids, total sugars, and sucrose content, as well as superior sensory quality in terms of color, taste, and consistency, whereas odor was evaluated equally for both samples. No significant differences were observed in titratable acidity and directly reducing sugar content between the two seasons. The obtained data represent the first step toward standardizing sugar beet pekmez production using traditional methods.

Keywords: *sugar beet pekmez, technological, nutritional, sensory quality*

INCIDENCE OF LACTOSE INTOLERANCE AMONG THE POPULATION OF BOSNIA AND HERZEGOVINA

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Original scientific paper

Abstract

Lactose is a carbohydrate only found in the milk of mammals and it is one of the most important components of milk. Upon consumption by humans, the enzyme β -galactosidase (lactase) breaks down lactose into glucose and galactose with the help of water in the small intestine, but its activity decreases or disappears completely when growing up, and consumption of lactose in adulthood can cause indigestion. In this research, based on literature data, it is explained why certain group of people in the world can digest lactose regardless of age, and some others cannot. It is also explained which products can potentially replace milk and milk products. However, the primary goal of this paper is to show the prevalence of lactose intolerance among the population of Bosnia and Herzegovina, and which dairy products cause them the most problems. Most of the previously conducted research showed that the phenomenon of lactase persistence is genetically determined. It occurs in Europeans in whom the activity of β -galactosidase is constantly maintained and the European population is able to digest large amounts of lactose regardless of age. On the basis of the conducted survey on the occurrence of milk lactose intolerance among different groups of people in Bosnia and Herzegovina, it can be concluded that the number of people who are lactose intolerant is significantly low. The results show that more than half, i.e. 58 out of 100 subjects tolerate lactose well, while only 20 respondents do not tolerate lactose. The latter answered that among milk and dairy products milk causes them the greatest digestive and other disturbances due to the highest lactose content, while dairy products, primarily fermented milks such as kefir, ayran and yogurt, cause significantly fewer problems.

Keywords: *lactose, intolerancy, population, milk*

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INTRODUCTION

Milk sugar or lactose ($C_{12}H_{22}O_{11}$) is the main carbohydrate of milk, composed of one molecule of $\alpha(\beta)$ -D-glucose and one molecule of β -D-galactose. The concentration of lactose in milk remains approximately the same throughout the year at about 4.70% in average (Sarić, 2018; Sarić and Brenjo, 2022). It is a reducing disaccharide where glucose and galactose are linked β (1 $\rightarrow$ 4) glycosidic bond (Jelen, 2022; Barać *et al.*, 2025). Its concentration in the milk of most mammals as the main carbohydrate ranges from 0 to 10% (m/m), and milk is the only known significant source of lactose. Lactose is synthesized in the epithelial cells of the mammary gland from two molecules of glucose absorbed from the blood. One molecule of glucose is converted (epimerized) into galactose via the Leloir pathway, which is widely distributed in animal tissues and bacterial cells. Galactose is phosphorylated and condensed with another glucose molecule by the action of a unique two-component enzyme, lactose synthase. Besides lactose, milk contains low concentrations of several sugars, primarily glucose and N-acetylglucosamine (Fox, 2003). In addition, 15-18% of the total carbohydrates in milk are lactose derivatives, chain or branched oligosaccharides consisting of 3-10 monomers, mainly galactose, fucose and sialic acid (Fukuda *et al.*, 2010). It is believed that lactose derivatives contribute to the improvement of the body's health by modulating the defense system against pathogens (Barać and Sarić, 2023).

When lactose reaches the human body for physiological use, it must be hydrolyzed in the intestines using the enzyme β -galactosidase (lactase) or lactase-phlorizin hydrolase (LPH), which is located in the brush border of the small intestine (Swallow, 2003). In the proximal small intestine (duodenum and the initial part of the jejunum), lactase hydrolyzes lactose into glucose and galactose (Barać *et al.*, 2026). The presence of lactase gradually decreases from the jejunum to the ileum (Misselwitz *et al.*, 2019). The problem of intolerance occurs when people do not possess or possess very small amounts of β -galactosidase (lactase) (Barać and Sarić, 2023). Consequently, accumulation of lactose in the small intestine happens which leads to increased fluids inflow into the intestinal lumen. Unabsorbed lactose passes into the large intestine and is exposed to the action of colonic bacteria, which results in the formation of short-chain fatty acids and hydrogen. In mammals, lactase expression is highest at birth and then decreased. Humans, unlike the other mammals (Kaur *et al.*, 2006) retain the activity of lactase, creation thus group of lactase-resistant or lactose-tolerant individuals. They digest lactose and can consume large amounts of fresh milk without difficulty. Those with low lactase in adulthood are described as non-persistent lactase (in the literature they are also called primary adult hypolactasia) and are lactose 'maldigesters'. Poor digestion can lead to symptoms of lactose intolerance, which limits the consumption of fresh milk. However, most people with non-persistent lactase can tolerate small amounts of milk (as in tea or coffee), and some can consume a lot without negative effects. Variations in the composition of intestinal flora between individuals, as well as a psychosomatic component, may be the reason for these variations (Swallow, 2011).

Lactose intolerance is caused by the interaction of genome and diet. When a substantial amount of lactose is not absorbed in the intestines, it is known as lactose malabsorption. According to the degree of lactase activity, two types of conditions can be established: alactasia (i) (complete absence of lactase activity) and hypolactasia (ii) (an imbalance between the amount of lactose consumed and the capacity to hydrolyze it, resulting in extremely low lactase activity in the jejunal mucosa) (Kaur *et al.*, 2006). In addition to lactase expression, other factors that contribute to lactose intolerance include intestinal flora, gastrointestinal motility, small intestinal bacterial overgrowth, lactose concentration, and the gastrointestinal tract's sensitivity to the production of gas and other products of fermentation from lactose digestion (Deng *et al.*, 2015).

In the early 1970s, Simoons published an article in which he hypothesized the origin of lactose intolerance as a cultural-historical hypothesis (Simoons, 1970). He hypothesizes that over time, a low incidence of intolerance has developed in an ethnic group that has had abundant milk supplies and inadequate substitutes, both in quantity and quality, and that consumed milk in forms rich in lactose. However, this phenomenon could not have happened among some ethnic groups if milk and lactose-rich milk products had not been used. To ascertain how long milk was consumed in various areas, the genesis and dissemination of dairy products are described. Given this context, the emergence of many old-world communities with varying degrees of intolerance is the explanation.

All groups studied so far within traditional non-dairy areas have been found to have a high incidence of lactose intolerance. Overseas populations, such as afroamerican population, whose ancestors originated in non-dairy areas, have a high incidence of lactose intolerance. Within the areas of milk consumption in Africa and, moreover, in Europe, there are known group differences in tolerance, which is consistent with the hypothesis. Although there are other points of view, the majority of studies confirm Simoons' thesis that the cultural-historical hypothesis has its foundations, that is, that lactose tolerance arose after the intake of milk and dairy products. One of these is the one that says that lactose tolerance arose later than previously thought, after the Bronze Age, when people began to introduce milk and dairy products into their diet (Allentoft *et al.*, 2015).

Depending on the origin, there are four types of lactose intolerance. **Congenital** lactase deficiency (Table 1) is a metabolic impairment in an autosomal recessive condition that causes lactose intolerance. The enzyme is either completely absent or significantly reduced, while the small intestine's histology is normal. It starts at birth and persists throughout the duration of the person's life (Kuokkanen *et al.*, 2006a). **Developmental** or **neonatal** lactase deficiency (Table 1) can occur due to low lactase levels as a result of premature birth (28-32 weeks), as the activity of the enzyme in the fetus increases from the 34th week and reaches its maximum at birth. However, because of the large intestine's metabolism, which favours colonisation by other microbial species like *Bifidobacterium* spp. or *Lactobacillus* spp. when the pH of the large intestine decreases, babies can withstand this shortage and avoid malnourishment and diarrhoea (Kuokkanen *et al.*, 2006b).

Individuals with **secondary lactase insufficiency** (Table 1) exhibit normal enzyme activity. There are several causes and processes for the decrease in lactase. The villous margin of enterocytes in the small intestine is harmed by chronic enteropathies (secondary to immunological processes), such as Crohn's disease, coeliac disease, villous atrophy from calorie-protein malnutrition, and other gastrointestinal disorders. Here, infection is the main cause (Guarino *et al.*, 2008). The most prevalent type, known as **primary lactase deficiency** or adult hypolactasia (Table 1), is caused by a gradual and irreversible decline in enzyme activity.

Complete loss of enzyme function is uncommon, and the amount of lactase that is still present has a significant role in the emergence of symptoms. The most typical average age is between 5 and 7 years old, with the greatest influence happening between 30 and 40 years old. The method and onset time differ (Kuokkanen *et al.*, 2006b). It is believed that 70% of the world's population has this form of lactose intolerance (Heyman, 2006).

Tabela 1. Kategorije i specifičnosti intolerancije na laktozu

Table 1. Categories and specificities of lactose intolerance

Lactose intolerance categories	Lactase activity	Characteristic	Reference
Congenital lactase deficiency	The enzyme is either completely absent or significantly reduced, and the small intestine's histology is normal	It starts at birth and persists throughout the duration of the person's life	Kuokkanen <i>et al.</i> , 2006a
Developmental or neonatal lactase deficiency	Low lactase levels as a result of premature birth	It begins at birth	Kuokkanen <i>et al.</i> , 2006b
Secondary lactase deficiency	Normal enzyme activity	Damage the villous margin of enterocytes in the small intestine due chronic enteropathies (celiac disease, Crohn's disease)	Guarino <i>et al.</i> , 2008
Primary lactase deficiency (adult hypolactasia)	Progressive and permanent decrease in enzyme activity	The process and time of onset vary	Kuokkanen <i>et al.</i> , 2006b

Adult hypolactasia is mainly present in Asia and Africa regions. It occurs with different frequencies, most rarely in Europe. Thus, the lowest frequency rates were recorded in European countries - Scandinavia and Great Britain 7-14%, Germany 6-9%, Russia 16-37% and France 23-50% while a bit higher in Middle east region (24-73%). On the other hand, the incidence rates were significantly higher in Far east Asian countries where milk and dairy products were consumed little or not at all (China 86-92%, Thailand 97-100%, Vietnam 100%, Indonesia 91% and Japan 73-87%). In African countries it was also high (70-95%) while among afroamerican population somewhat

lower, about 75% (Sahi, 1994; Heyman, 2006; Mattar *et al.*, 2012; Diekmann *et al.*, 2015; Pavlović *et al.*, 2000). Although still high, the latter could lead to thinking that a bit lower incidence at afroamerican population occurred due to adaptation and changes in eating habits over time, but more detailed research and available data are needed to confirm this. The problem of lactose intolerance is less pronounced in fermented milk products such as yogurt, since the added bacterial cultures intensively use most and part of the lactose as a source of energy for their activity. Also, the dairy industry overcomes this problem with products that do not contain it at all, the so-called lactose-free. Here, the removal of lactose is based either on its physical removal (using membrane techniques such as ultrafiltration) or on its hydrolysis with the addition of the enzyme β -galactosidase or lactase which hydrolyzes lactose completely (Barać and Sarić, 2023).

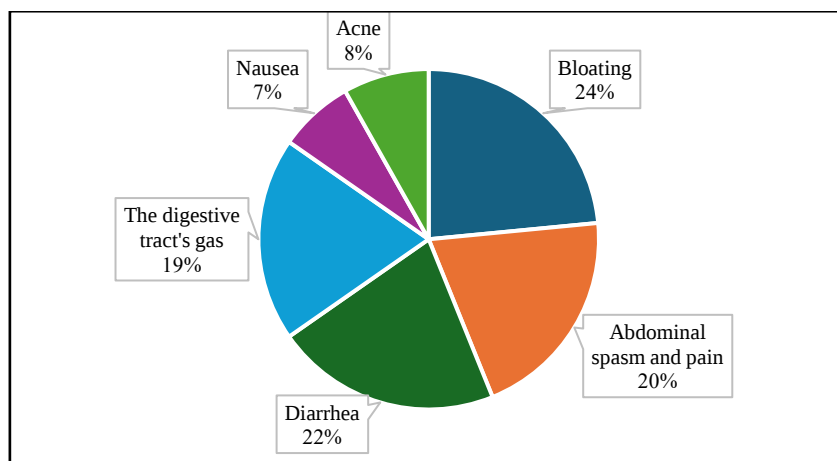
MATERIAL AND METHODS

In order to determine the occurrence of lactose intolerance in different groups of people, an anonymous survey of 100 randomly selected respondents in the territory of Bosnia and Herzegovina was conducted using the Google forms platform, which includes basic information about the respondents as well as their diet. The goal was to determine the prevalence of lactose intolerance of Bosnia and Herzegovina population. The survey included 12 questions related to the age and gender structure of the respondents, information about lactose, frequency and symptoms of lactose intolerance, habits of consuming milk and dairy products and reactions to them. Also, survey included questions about substitutes for milk and dairy products that may be used in the diet. The results are expressed as the number of respondents, or in %.

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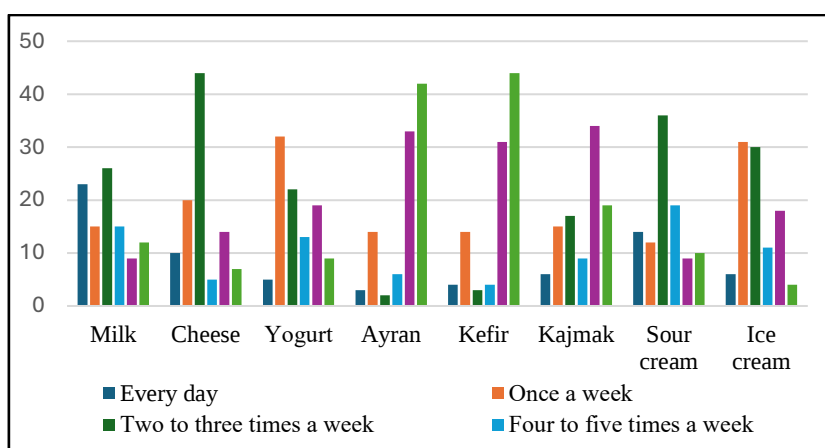
RESULTS AND DISCUSSION

The age range of people who completed the survey was categorized into three age groups: young (<15), mature (16-64), old (>65). Out of 100 respondents, 93 respondents were between 16 and 64 years old, 6 respondents were under 15 and 1 respondent was 65 or older. So, among the respondents, the mature female population prevailed while 72 respondents were female and 28 respondents were male. In terms of information about what lactose is, 15 respondents answered that they do not know while 85 answered that they know it is the sugar found in milk and dairy products. The respondents are quite familiar with the term lactose.



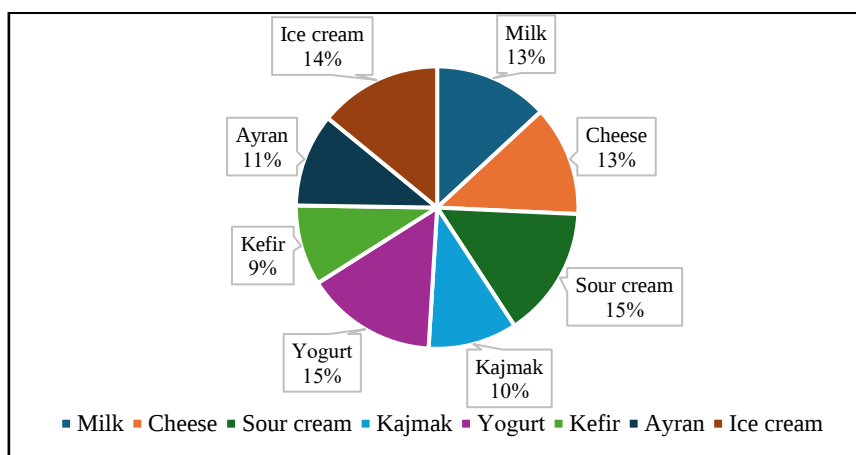
Slika 1. Simptomi intolerancije na laktozu
Figure 1. Symptoms of lactose intolerance

More than half of the respondents answered that they were not lactose intolerant (58%), 20% said they were, and 22% of the respondents did not know. This fits the European pattern when it comes to the incidence of lactose intolerance. However, this has to be taken with caution since for the support of theory of lactase persistency among the population of Bosnia and Herzegovina more detailed clinical research must be conducted. The main symptoms caused by consuming milk and dairy products in lactose intolerant people are bloating, followed by digestive problems such as diarrhea, spasms and abdominal pain, accompanied by gas production (Figure 1). Out of 100 respondents, the majority of them, namely 93 respondents, consume milk and dairy products.



Slika 2. Učestalost konzumiranja mlijeka i mliječnih proizvoda
Figure 2. Frequency of milk and dairy products consumption

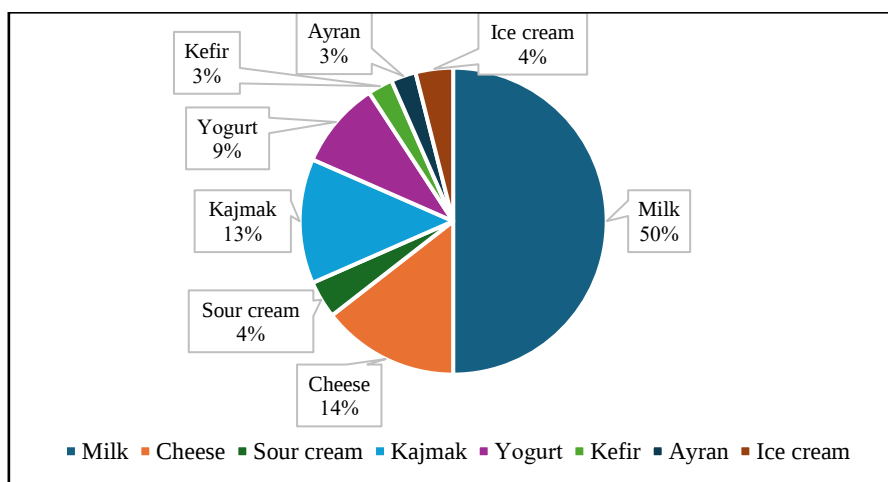
Among the products offered, the respondents had available milk, cheese, yogurt, ayran, kefir, kajmak, sour cream and ice cream. To a large extent, the respondents consume milk every day or two to three times a week, while they consume kefir and ayran the least, i.e. the largest number of respondents, 43 of 100, answered that they do not consume ayran and kefir at all. Also, sour cream, cheese and ice cream are often consumed among the respondents. Based on this data, it can be said that the consumption of kefir and ayran is not sufficiently represented among the population in Bosnia and Herzegovina (Figure 2). When asked whether some of the dairy products do not cause digestive disorders, 58% of the respondents who have intolerance answered that there are certain dairy products that do not cause them digestive disorders.



Slika 3. Mlijeko i mliječni proizvodi koji ne uzrokuju probavne smetnje kod ispitanika
Figure 3. Milk and dairy products that do not cause digestive disorders at respondents

Products that do not generally cause digestive disorders are yogurt and sour cream and, to a somewhat lesser extent, ice cream, milk and cheese. It can be seen that there is no general rule here, so although these are mainly fermented dairy products, some unfermented products such as milk and ice cream do not cause digestive disorders in certain respondents, which means that the individual conditions and metabolisms of the respondents have a considerable influence on this. However, the proportions of yogurt, ayran, kefir and sour cream are significant, all of which have a reduced lactose content and the activity of the starter culture enzymes that is introduced into the body by consuming these products. When looking at cheeses, the data is very relative given the heterogeneity of this group of products (Figure 3). Of course, these data should be taken with a reserve, taking into account the different amounts of dairy products consumed and the relatively small number of respondents. More precise and reliable answers to this are provided by an analysis of data related to the severity of digestive disorders. When asked whether any dairy products cause severe digestive problems, 42% of respondents answered that they do.

When looking at the structure of dairy products when it comes to the severity of symptoms or disturbances after their consumption, milk causes the most severe digestive problems in as many as 50% of respondents, followed by kajmak and cheese with 13% and 14%, respectively, and then yogurt with 9%, while sour cream, kefir and ayran cause more severe consequences in the least number of respondents. The latter is quite expected, although it would be expected that yogurt would also be found in this group. The surprising position of ice cream is with only 4% of respondents who reported severe disturbances after consuming this product (Figure 4). Although it should again be careful in the interpretation of these results, one can nevertheless observe regularity considering the high proportion of milk and the generally lower proportion of fermented milks which is expected in comparison to kajmak and cheeses. However, the type of cheese should be taken into account. This cognition is due to a number of nutritional advantages and functional components, the lower proportion of lactose, and certainly the significant role of the intake of living bacterial cells with their enzymes into the digestive system during consumption. Some positive effects of consuming yogurt and kefir compared to milk among lactose intolerant population were already reported. In the lactose-intolerant population, yoghurt and kefir similarly decreased the perceived intensity of flatulence by 54% to 71% when compared to milk. Flavoured yogurt gave also positive results while flavoured kefir had intermediate results. Since, kefir showed improved lactose digestion and tolerance in this study it was concluded that it has potential to overcome lactose intolerance (Hertzler and Clancy, 2003). Addition to this, lesser amount of lactose in kefir compared to milk and yogurt, 3.1 vs 4.7% was reported by some authors (Li *et al.*, 2023; USDA, 2024; Barać *et al.*, 2026).

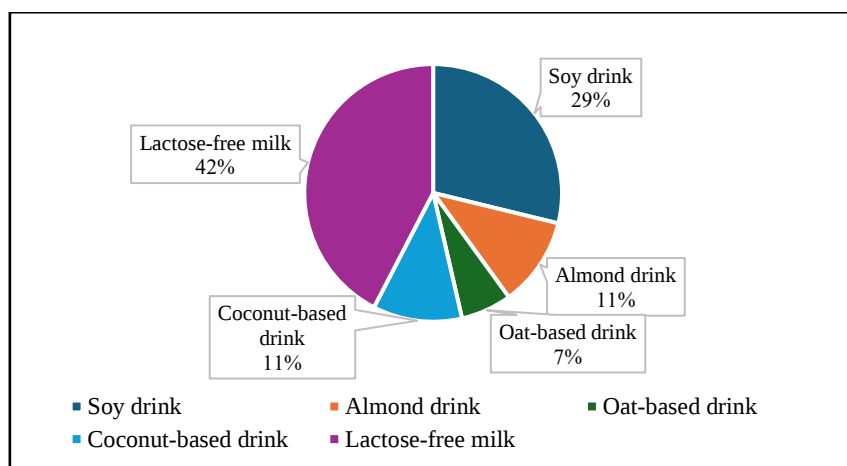


Slika 4. Mlijeko i mliječni proizvodi koji uzrokuju teže probavne smetnje kod ispitanika

Figure 4. Milk and dairy products that cause severe digestive disorders at respondents

In an effort to avoid the problems caused by consuming milk and dairy products, consumers often resort to milk substitutes. Regarding the use of milk substitutes, 31% of respondents said that they use some of them. To a large extent, respondents consume lactose-free milk, followed by soy drinks, and to a much lesser extent almond, coconut or oat drinks (Figure 5).

Based on a survey conducted on the occurrence of lactose intolerance in different groups of people and by comparing it with research data for other countries and regions in the world, it may be said that in Bosnia and Herzegovina there is a much smaller number of people who are lactose intolerant compared to the countries of Asia and Africa. On the other hand, the data are consistent with the results obtained in countries and regions in Europe.



Slika 5. Zamjena za mlijeko i mliječne proizvode koje ispitanici koriste
Figure 5. Substitute for milk and dairy products used by respondents

CONCLUSION

Lactose is the dominant carbohydrate in mammalian milk and is broken down in the small intestine by the action of the enzyme β -galactosidase with the help of water, which breaks down lactose into glucose and galactose. Lactase activity is at its highest level in early childhood, while over time during adulthood it decreases or disappears completely, and then lactose intolerance appears. Undigested lactose passes into the large intestine, and if a larger amount of lactose is remained undigested by active amount of the enzyme β -galactosidase, enteric bacteria produce lactic acid, methane and hydrogen, carbon dioxide, short-chain fatty acids, and the appearance of these products can cause various problems such as gas, bloating, diarrhea, abdominal pain, acne, spasms and nausea.

Lactose intolerance differs and depends on various factors, and the most common form is primary lactase deficiency or hypolactasia in adults as a result of a progressive and permanent decrease in enzyme activity. This type of lactose intolerance is mostly found in Asians and Africans and much less often in Europeans. The phenomenon of lactase persistence occurs in Europeans, which means that the activity of the β -galactosidase enzyme is constantly maintained and that they are able to digest large amounts of lactose regardless of age. This phenomenon is genetically determined. Based on the conducted survey on the occurrence of milk lactose intolerance in different groups of people, it can be concluded that within the population of Bosnia and Herzegovina, the frequency of lactose intolerance is significantly low (20% of respondents) and is at the level of that of many European countries and regions.

The conducted survey found that among respondents who are lactose intolerant, it is milk that causes the greatest digestive disturbances due to the highest lactose content, while other products such as kefir, ayran, yogurt or sour cream cause this to a much lesser extent. Also, based on the data obtained, it was concluded that the respondents did not sufficiently consume kefir and ayran as a useful fermented milk for reducing lactose intolerance.

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UČESTALOST INTOLERANCIJE NA LAKTOZU MEĐU POPULACIJOM BOSNE I HERCEGOVINE

Sažetak

Laktoza je ugljikohidrat koja se jedino nalazi u mlijeku sisara i ona predstavlja jednu od najvažnijih komponenti mlijeka. Nakon unošenja u ljudski organizam, enzim β -galaktozidaza (laktaza) uz pomoć vode u tankom crijevu razgrađuje laktozu na glukozu i galaktozu, ali se njegova aktivost prilikom odrastanja smanjuje ili potpuno nestaje, te konzumiranje laktoze u kasnijem životnom dobu može stvarati probavne smetnje. U ovom istraživanju na bazi literaturnih podataka objašnjeno je zašto pojedine grupe ljudi na svijetu mogu probavljati laktozu bez obzira na starost, a neke druge ne mogu. Takođe je objašnjeno koji proizvodi mogu potencijalno zamijeniti mlijeko i mliječne proizvode. Međutim, primarni cilj ovog rada je pokazati koliko je zastupljena pojava intolerancije na laktozu među stanovništvom Bosne i Hercegovine, te koji mliječni proizvodi im najviše ili najmanje stvaraju probleme.

Većina sprovedenih istraživanja je pokazala da je fenomen perzistencije laktaze genetski određen. Ona se javlja kod evropljana kod kojih se aktivnost β -galaktozidaze konstantno održava i evropska populacija je u mogućnosti da probavi velike količine laktoze bez obzira na starosnu dob. Na osnovu sprovedene ankete o pojavi intolerancije na laktozu kod različitih skupina ljudi u Bosni i Hercegovini može se zaključiti da je znatno manji broj osoba koje su intolerantne na laktozu. Rezultati pokazuju da više od pola, odnosno 58 od 100 ispitanika dobro podnosi laktozu, dok tek 20 ispitanika ne podnosi laktozu. Ovi posljednji su odgovorili da im mlijeko stvara najveće probavne i druge smetnje zbog najvećeg sadržaja laktoze, dok mliječni proizvodi, prvenstveno fermentirana mlijeka kao kefir, ayran i jogurt stvaraju znatno manje problema.

Ključne riječi: *laktoza, intolerancija, skupina, ishrana*

CELIJAKIJA – IZAZOV OBOLJELIH OSOBA U HERCEGOVAČKO-NERETVANSKOM KANTONU

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Sažetak

Celijakija je hronična bolest probavnog sistema uzrokovana unosom glutena kod genetski predisponiranih osoba. Karakteriziraju je učestala pojava i često kasno dijagnosticiranje zbog nespecifičnih simptoma poput hroničnog proljeva, povraćanja, gubitka apetita, umora i anemije, koji se često zanemaruju ili pogrešno pripisuju drugim stanjima. Bolest se često javlja zajedno s drugim autoimunim bolestima. S obzirom na složenu administrativnu strukturu Bosne i Hercegovine, postoje i značajne razlike u sustavu zdravstvene zaštite među kantonima, što utječe na položaj oboljelih i dostupnost odgovarajuće zdravstvene skrbi.

Cilj rada je prikazati celijakiju kroz prizmu bolesti, izazova i mogućnosti oboljelih u Hercegovačko-neretvanskom kantonu. Rad obuhvaća teorijski pregled bolesti, analizu dostupnosti bezglutenskih proizvoda, ponude u ugostiteljstvu i prava iz zdravstvene zaštite, kao i prikaz iskustva osobe oboljele od celijakije.

Pravo na bezglutenske namirnice u HNK imaju pacijenti oboljeli od celijakije (K90.0 morbus coeliacus) u vrijednosti od 200 KM mjesečno, ukoliko pripadaju dječjem uzrastu, kategoriji nazaposlenih osoba ili su u statusu umirovljenika, dok zaposlene osobe oboljele od celijakije ne polažu pravo na bezglutenske namirnice na teret ZZO HNK.

Na području grada Mostara u distribuciji bezglutenskih namirnica na teret ZZO HNK sudjeluju četiri ugovorne apoteke, a na području HNK još pet apoteka u drugim mjestima (Čapljina, Čitluk, Jablanica, Prozor, Konjic).

Istraživanjem tri trgovačka lanca koji imaju najviše trgovina u Mostaru, zaključuje se kako trgovine nude raznoliku ponudu bezglutenskih namirnica.

Restorani u Mostaru ne nude zadovoljavajuću ponudu u svojim jelovnicima što, nesumnjivo otežava društveni život osoba oboljelih od celijakije, naročito mlađih koji su društveno aktivni te putuju i rade. I za jela, koje se u jelovnicima naznačuju kao bezglutenska, preporuča se prije narudžbe, provjeriti s osobljem pripremaju li se u kontroliranim uvjetima i postoji li mogućnost kontaminacije glutenom od pripreme drugih jela.

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Izniman doprinos u poboljšanju kvalitete života osobama oboljelim od celijakije daje Udruga oboljelih od celijakije „Gluten free“ u HNŽ/K, kroz različite aktivnosti i inicijative gradskim strukturama, što se primjećuje u unaprijeđenju kvaliteta života osoba oboljelih od celijakije tijekom posljednje dvije godine otkako je Udruga osnovana.

Ključne riječi: *celijakija, bezglutenska prehrana, zdravstveni sistem, iskustva pacijenata, Hercegovačko-neretvanski kanton*

UVOD

Celijakija je hronična bolest gastrointestinalnog trakta uzrokovana djelovanjem glutena i srodnih prolamina iz hrane, a ispoljava se kod genetski predisponiranih osoba. Odlikuju je učestalost i kasno dijagnosticiranje, zbog tipa i simptoma koji se zanemaruju ili pripisuju nekim drugim stanjima (Mišak i sar., 2022). Najčešći simptomi celijakije su: hronični proljev, povraćanje, nenapredovanje na težini kod djece, gubitak apetita, opstipacija, umor, malaksalost i anemija. Bolest se često javlja uz autoimune i druge bolesti (Barbarić, 2009).

Budući da Bosnu i Hercegovinu čine dva entiteta i deset kantona, važno je osvrnuti se na različitosti unutar kantona koje se ogledaju i u određenim odredbama iz oblasti zdravstvenog osiguranja, zbog čega pacijenti u različitim kantonima imaju i drugačije mogućnosti i izazove u borbi sa celijakijom i drugim bolestima.

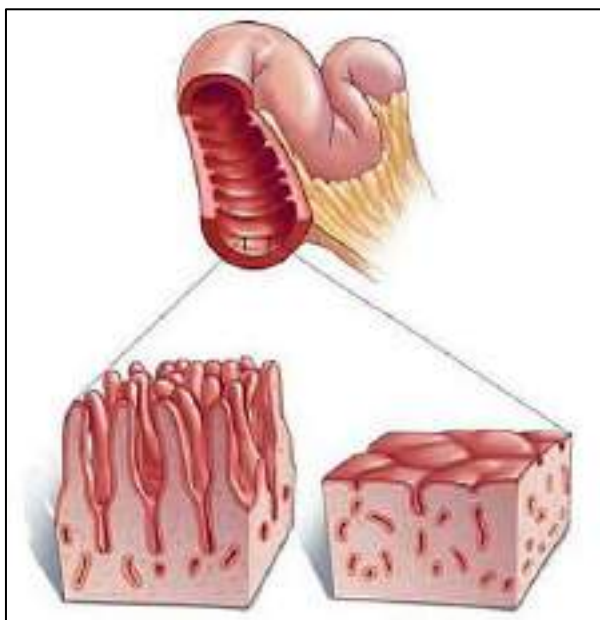
Rad ima za cilj prikazati celijakiju kroz prizmu bolesti, izazova i mogućnosti oboljelih u Hercegovačko-neretvanskom kantonu. Rad je usmjeren na definiciju, simptome i dijagnosticiranje bolesti te prikaz položaja osoba oboljelih od celijakije u HNK kroz analizu dostupnosti namirnica, ponude ugostiteljskih objekata i prava u oblasti zdravstvene zaštite.

PREGLED LITERATURE

Celijakija ili glutenska enteropatija, definiše se kao hronična bolest, čiji su uzrok gluten i srodni prolamini, a nastaje kao rezultat imune reakcije kod genetski predisponiranih osoba (Mišak i sar., 2022). Gluten predstavlja skladišni protein u pšenici, ječmu i raži – žitaricama koje su sastavni dio prehrambenih namirnica (Pelkowski & Viera, 2014). Celijakija se smatra jednom od najčešćih gastrointestinalnih bolesti sa stopom od 1%, a nerijetko se ne prepoznaje ili kasno dijagnosticira (Mišak i sar., 2022). Klasična bolest češća je u ranom djetinjstvu, ali očituje se i kasnije, kod odraslih osoba, sa trajnom (doživotnom) intolerancijom na gluten kao i različitim stepenima oštećenja sluznice tankog crijeva (Votava-Raić i sar., 2006).

Zbog brojnih napredaka u dijagnostici i patogenezi, povećava se i broj dijagnosticiranih slučajeva. Tome u prilog idu i pretpostavke o doprinosu novih tipova žitarica, a koje su uvedene iz tehnoloških, odnosno ne nužno nutritivnih razloga zbog čega se ostavlja za potrebu ispitivati potencijalne okolišne faktore u nastanku celijakije (Ciao i sar., 2019).

Budući da se u mnogim slučajevima celijakija kasno dijagnosticira zbog očitovanja kroz različite simptome (tabela 1.), što često i odgađa dijagnosticiranje, važno je poznavati i pratiti simptome bolesti kako bi se pravovremeno moglo posumnjati i pristupiti pretragama (Mišak i sar., 2022). Odgođena dijagnostika umanjuje kvalitetu života te utječe i na mentalno stanje oboljelih, čemu svjedoče rezultati istraživanja u kojima se kod ispitanika sa kasnije uspostavljenom dijagnozom bilježi veći broj posjeta ljekarima, te upotreba antidepresiva i lijekova za dispepsiju. Tipovi bolesti klasificiraju se u: gastrointestinalne, ekstraintestinalne, refraktorne, potencijalne, subkliničke i seronegativne (Vranešić Bender i sar., 2024). Stoga, osobitu pozornost valja obratiti na simptome u djetinjstvu, s obzirom da se bolest može očitovati u uzrastu od 7. do 24. mjeseca života, sa punom kliničkom slikom već u 18. mjesecu života. U tom razdoblju najčešći simptomi koji upućuju na celijakiju su: hronični proljevi, mršavljenje te anoreksija što rezultira nenapredovanjem djeteta. Po uvođenju brašna u prehranu, opažaju se promjene u stolici kao i hipotonija, što se povezuje sa nakupljanjem plinova i tečnosti u crijevima te mogućom pojavom opstipacije. Ove simptome može pratiti i nedostatak vitamina D kao i anemija zbog koje se javljaju bljedoća kože i sluznice (Votava-Raić i sar., 2006). Ponekad, uz navedene simptome u dječjem uzrastu i promjena zubne cakline može ukazivati na apsorpcijski poremećaj te izazvati sumnju na celijakiju (Zovko Dodig, 2007).



Slika 1. Crijevne resice – zdrave (desno) i oštećene (lijevo)
(Loftus & Murray, 2003)

Kod odraslih, pojava simptoma podrazumijeva: proljeve, gubitak težine, umor te dermatitis herpetiformis. Anemija, kao nedostatak željeza, neuropatija i smanjena gustoća minerala u kostima, također, upućuju na celijakiju, koja se često dijagnosticira kod osoba upravo zbog izraženih ekstraintestinalnih manifestacijama (Pelkowski & Viera, 2014). Važno je istaknuti i činjenicu da se celijakija često javlja pridružena autoimunim ili nekim drugim bolestima među kojima se izdvajaju: šećerna bolest tip 1, autoimune bolesti jetre, autoimuna bolest štitne žlijezde, selektivni nedostatak IgA i uz hromosomske promjene (Down sindrom, Turner sindrom, Williamsov sindrom i dr.) (Mišak i sar., 2022). Istraživanja ukazuju kako, uz genetske faktore rizika, nastanku bolesti mogu doprinijeti i enterovirusne infekcije u ranijem uzrastu (Husby i sar., 2024).

Tabela 1. Oblici i obilježja celijakije (Barbarić, 2009)

Table 1. Forms and characteristics of celiac disease (Barbarić, 2009)

OBLIK CELIJAKIJE	PROBAVNI SIMPTOMI	KLINIČKA SLIKA
Tipična	prevladavaju	proljev, povraćanje, nenapredovanje na težini, gubitak apetita, opstipacija
Atipična	minimalni/odsutni	umor, malaksalost, anemija, niski rast, autoimune bolesti ostalih organskih sustava
Tiha	odsutni	promijenjena sluznica tankog crijeva
Latentna	odsutni	normalna sluznica tankog crijeva, kasniji razvoj promjena i smetnji

Organizacije koje proučavaju gastrointestinalne bolesti, u preporukama o dijagnostici celijakije iz 2012. godine, nude četiri dijagnostička pristupa. Oni najčešće podrazumijevaju kombinaciju kliničke slike, seroloških analiza i biopsiju tankog crijeva. Serološki testovi usmjereni su na ispitivanje anti-tkivne transglutaminaze (tTG) ili anti-deamidiranog gliadinskog peptida (DGP) (Kaswala i sar., 2015). Serološkom testiranju na celijakiju, valja prethoditi glutenska prehrana barem 30 dana zbog serumskih antitijela čiji je poluvijek od 30 do 60 dana. U nekim slučajevima, kao isključni test, koristan u dijagnostici može biti i genetski test - analiza DQ2DQ8 heterodimera na 6. hromosomu (Vranešić Bender i sar., 2024). Preporuka je, pri uspostavljanju dijagnoze, usporediti razinu antitijela i rezultate biopsije kako bi se sa sigurnošću uspostavila dijagnoza zbog vrijednostima testova koji su slabije ili granično pozitivni (Husby i sar., 2024)

Budući da se liječenje celijakije temelji na bezglutenskoj ishrani, važno je educirati se o skrivenim izvorima glutena, proučavati deklaracije proizvoda, te planirati uravnotežene obroke naročito na putovanjima i boravku izvan kuće (Pelkowski & Viera, 2014). Bezglutenska ishrana uvodi se tek kada se uspostavi dijagnoza, a zahtijeva strogo pridržavanje i kontrolu prehrambenih namirnica kako bi se izbjegli i tragovi glutena, koji bi mogli dovesti do oštećenja sluznice. Rezultat pravilnog provođenja bezglutenske

prehrane očituje se u nestanku simptoma, smanjenju komplikacija te oporavku sluznice tankog crijeva što znatno poboljšava kvalitetu života (Mišak i sar., 2022). Osobama koje provode bezglutensku dijetu, uz hranu bogatu vlaknima, preporuča se uvođenje i unos vitamina i minerala, osobito vitamina D, željeza, cinka te vitamina B kompleksa (Vranešić Bender i sar., 2024). Studije o psihosocijalnoj kvaliteti života osoba na bezglutenskoj prehrani ukazuju uglavnom na nedovoljno kvalitetne mogućnosti, naročito u mlađem uzrastu, što ostavlja prostor za unaprijeđenje ponude bezglutenskim proizvodima, ali i podršku stručnjaka i sredine kako bi se unaprijedio kvalitet života osoba na bezglutenskoj dijeti (Mazzola i sar., 2024).

Istraživanja ukazuju kako oko 5% osoba oboljelih od celijakije ne reagira na bezglutensku prehranu, a u takvim slučajevima preporuča se ponavljanje pretraga kao i moguće uvođenje kortikosteroida i imunomodulatora u liječenje (Pelkowski & Viera, 2014). Nove studije ukazuju na razvoj terapije i mogućnosti učinkovitijeg načina liječenja u budućnosti.

MATERIJAL I METODE

Kako bi se ostvario cilj rada, planirana je kombinacija metoda i to metode istraživanja i terenskog rada te deskriptivne metode. Rad se temelji na prikazu prava, mogućnosti i kvalitete života osoba oboljelih od celijakije i usporedbi dostupnih bezglutenskih namirnica kroz:

- analizu literature i prava osoba oboljelih od celijakije na teret Zavoda zdravstvenog osiguranja HNK,
- istraživanje ponude bezglutenskih namirnica u četiri ugovorne apoteke u Mostaru, a kriterij za odabir navedenih apoteka je status ugovornih apoteka koje distribuiraju proizvode u skladu sa ZZO HNK,
- analizu i popis bezglutenskih namirnica na policama tri trgovačka lanca u Mostaru, a za izbor ovih trgovina preusudna je brojnost poslovnica na prostoru grada Mostara,
- istraživanje ponude bezglutenskih jela u jelovnicima deset ponudom istaknutijih restorana u Mostaru.

Istraživanje je provedeno od novembra 2025. godine do januara 2026. godine.

REZULTATI I DISKUSIJA

Istraživanje prava osoba oboljelih od celijakije u Hercegovačko-neretvanskom kantonu te ponude bezglutenskih namirnica na teret Zavoda zdravstvenog osiguranja HNK, zaključuje se konstatacijom kako pravo na bezglutenske namirnice imaju pacijenti oboljeli od celijakije (*K90.0 morbus coeliacus*) u vrijednosti od 200 KM mjesečno, ukoliko pripadaju dječjem uzrastu, kategoriji nazaposlenih osoba ili su u statusu umirovljenika. Zaposlene osobe oboljele od celijakije ne ostvaruju pravo na bezglutenske namirnice na teret Zavoda.

Kako bi pacijenti ostvarili ovo pravo, dužni su dostaviti potrebnu medicinsku dokumentaciju (nalaz specijaliste gastroenterohepatologa sa jasno naznačenom dijagnozom) i ispuniti Obrazac ZZO HNK. Djeca mlađa od 12 godina, oslobođena su endoskopskih pretraga. Njima se dopušta uspostaviti dijagnozu utemeljenu na serološkim nalazima. Rješenje o pravu na bezglutenske namirnice na teret Zavoda zdravstvenog osiguranja HNK, djeci i studentima izdaje se na 12 mjeseci, a nezaposlenim osobama i umirovljenicima u trajanju od 3 mjeseca. Važno je spomenuti kako je mjesečna vrijednost za bezglutenske namirnice na teret ZZO HNK do 2023. godine iznosila 80 KM, što se promijenilo sa osnivanjem i aktivnim djelovanjem članova *Udruge oboljelih od celijakije „Gluten free“ u HNŽ/K*. Ista Udruga, pokretanjem inicijative Gradu Mostaru u 2024. godini, ostvarila je sporazum da se djeci oboljeloj od celijakije, koja su korisnici usluga vrtića, umanju cijena boravka u vrtiću za 30% zbog hrane koju ne konzumiraju u vrtiću. Za ostvarenje ovog prava, roditelji/staratelji podnose zahtjev upravi vrtića.

Udruga oboljelih od celijakija „Gluten free“ u HNŽ/K neprofitna je i nevladina udruga osnovana u Mostaru 2023. godine. Cilj udruge je unaprijeđenje položaja i poboljšanje kvaliteta života osoba oboljelih od celijakije i njihovih obitelji. Udruga okuplja stručnjake iz različitih oblasti, a njihovim udruživanjem i uzajamnim djelovanjem napravljeni su značajni pomaci za položaj osoba oboljelih od celijakije u HNK/Ž. Udruga nudi mogućnost za tri vrste članstava i to: aktivno, podupiruće i počasno članstvo. Prema podacima Udruge dostupnim na web stranici, važno je istaknuti kako je Udruga tijekom dvije godine djelovanja: organizirala 25 radionica i seminara, realizirala 3 projekta te okupila tim od 22 stručna savjetnika (<https://glutenfree.ba/>).

Istraživanje ponude bezglutenskih namirnica na koje pacijenti polažu pravo, provedeno je u četiri mostarske ugovorne apoteke u decembru 2025. godine. Rezultati istraživanja ukazuju kako je A1¹ u Mostaru poslovnica koja već osam godina izdaje namirnice pacijentima uz predodžbu rješenja ZZO, a u ponudi su namirnice brendova: *Schär*, *Balviten*, *Aleksandrija* i *Podravka*. Izbor namirnica je jako raznovrstan, od brašna do gotovih tjestenina, pahuljica, slatkiša i peciva, čime se zadovoljavaju potrebe pacijenata različitih uzrasta.

A2 već godinu dana sudjeluje u distribuciji bezglutenskih namirnica, a u svojoj raznovrsnoj ponudi ima namirnice proizvođača: *Schär*, *Balviten*, *Aleksandrija* i *Molendini*. U apoteci ljubazno navode kako su u proteklom periodu osluškivali potrebe pacijenata i u skladu s njima vršili izbor namirnica i narudžbe te su odabrali navedene proizvođače kao standard u bezglutenskoj ponudi.

U A3 oko godinu dana distribuirala bezglutenske namirnice na teret ZZO HNK/Ž, a među njima pacijentima nude namirnice proizvođača *Schär* i *Aleksandrija*.

Sredinom 2025. godine A4 počinje distribuciju bezglutenskih namirnica brendova *Schär* i *Balviten*. Kako zbog kraćeg perioda distribucije, kao i manjeg broja poslovnica, uvođenje brendova odvija se postepeno. Pri tom, uposlenici navode kako ova apoteka ostavlja mogućnost narudžbe određenih namirnica u ranijem dogovoru sa pacijentima u

¹ A – oznaka za apoteku i broj u redoslijedu istraživanja. Nazivi apoteke i njihova lokacija dostupni su na zahtjev, dok je za provođenje istraživanja dobivena pismena/usmena saglasnost.

skladu sa njihovim potrebama što znatno smanjuje propadanje namirnica i omogućuje slobodu izbora. U periodu objave ovog rada, A4 obustavila je distribuciju bezglutenskih namirnica, a pacijente preusmjerila u A1.

Prema navodima Udruge oboljelih od celijakije „Gluten free“ u HNŽ/K, pored navedene četiri apoteke u Mostaru, na području HNK u distribuciji bezglutenskih namirnica na teret ZZO HNK/Ž sudjeluje još pet ugovornih apoteka i to u: Čapljini, Čitluku, Jablanici, Konjicu i Prozoru.

Bezglutenskim proizvodima, prema reuglativi EU (*Regulativa 828/2014*), smatraju se oni proizvodi u čijem se sastavu nalazi manje od 20 ppm glutena, odnosno 0,02 g glutena po 1 kg. Proizvodi „sa vrlo malo glutena“ moraju sadržavati manje od 100 ppm glutena, što je 0,1 g glutena na 1 kg. Oznakom precrtanog klasa, certificirane tvrtke upućuju na bezglutenski proizvod, što je općeprihvaćen znak za bezglutenske namirnice (<https://glutenfree.ba/>).

Istraživanje ponude bezglutenskih namirnica provedeno je u decembru 2025. godine u tri veća trgovačka lanca, koji imaju više poslovnica u Mostaru.

U mostarskim trgovinama, bezglutenske namirnice dio su ponude na izdvojenim policama, a njihova raznovrsnost ovisi od trgovine do trgovine. U ponudi prednjači T1¹, u čijim se trgovinama mogu pronaći različite prehrambene namirnice brendova: *Aleksandrija, Barilla, Celita, Cretamel, DM-Bio, Dolcela, Dr. Oetker, Econ, Frankonia, Nestlé, Sam Mills i Schär*.

Trgovački lanac T2, u mostarskim poslovnicama nudi bezglutenske namirnice proizvođača: *Aleksandrija, Caputo, Celpo, Dolcela, Frankonia, Benlian, Gabbiano, Granolio, Kandit, Molendini, Rice up, Sam Mills i Schär*.

Na policama trgovačkog lanca T3 u Mostaru, nude se bezglutenske namirnice proizvođača: *Aleksandrija, Balviten, Bauck Mühle, Dolcela, Dr. Oetker, Gabbiano, Glutenino, Molendini, Molisana, Nutrifit, Podravka, Sam Mills, Schär, Senza*.

Važno je istaknuti kako su u ispitivanim trgovinama, najviše zastupljeni proizvodi proizvođača *Schär*. Ponuda namirnica je raznolika, a primjetne su i razlike u cijenama proizvoda.

Istraživanje ponude bezglutenske hrane u jelovnicima mostarskih restorana provedeno je u novembru i decembru 2025. godine, a obuhvatilo je ponudu deset istaknutijih restorana u gradu. Rezultati istraživanja ukazuju kako se bezglutenski specijaliteti mogu pronaći u restoranima: R1² (bezglutenske torte), R2, R3, R6, R9 i R10. No, važno je znati kako su to glavnom kombinacije jela s roštilja, kuhanog ili grilanog povrća te riblji specijaliteti. Pri tome je neophodno obratiti pozornost na mogućnost kontaminacije namirnica glutenom zbog pripreme uz glutenska jela te provjeriti sa osobljem na koji se način jelo pripravlja, kako se u njemu ne bi našli tragovi glutena, koji bi mogli izazvati reakciju kod osobe oboljele od celijakije.

¹ T – oznaka za trgovinu i broj u redoslijedu istraživanja. Nazivi trgovina i lokacija poslovnice dostupni su na zahtjev, a za provođenje istraživanja dobivena je pismena saglasnost uprave ispitivanih trgovačkih lanaca.

² R – oznaka za restoran i broj restorana u redoslijedu istraživanja. Za svaki od restorana dobivena je usmena saglasnost za istraživanja, a na zahtjev je moguće dobiti naziv restorana i lokaciju.

Neophodno je, prije narudžbe, interesirati se o načinu pripreme jela (korištenje istog ulja za prženje hrane, dodatak brašna u svrhu povezivanja i zgušnjavanja i sl.) Često nedovoljna informiranost i nerazvijena svijest mogu glutenom i u tragovima kontaminirane namirnice držati za bezgluteski proizvod te nenamjerno izazvati teškoće kod oboljelih.

Takva činjenica kazuje kako osobe oboljele od celijakije nemaju mogućnost za redovnim i sigurnim obrocima u restoranima, te kako u našem društvu još uvijek nije osobito izražena svijest za njihovim prehrambenim potrebama, što nesumnjivo može utjecati na kvalitetu njihovog društvenog života i pripadnosti sredini u kojoj žive.

ISKUSTVO OSOBE OBOLJELE OD CELIJAKIJE

U svrhu istraživanja, proveden je intervju sa osobom oboljelom od celijakije, čija situacija ukazuje na pritajenost bolesti te na zanemarivanje simptoma od različitih stručnjaka prije konačne dijagnoze. Naša sugovornica (49), koja živi u živi Mostaru, zaposlena, visoko obrazovana osoba, dijeli sljedeće iskustvo.

„Od djetinjstva sam anemična, ali nikada nijedan pedijatar tu anemičnost nije povezivao sa celijakijom, a kasnije ni neki drugi specijalist u odraslom periodu života, iako su nalazi ukazivali na izraženu anemiju. Posljednjih 15 godina pratila me pojava učestalih dermatitisa, na koje bi uglavnom pozitivno djelovala primjena kortikosteroidnih krema, ali po prestanku korištenja kreme, dermatitisi bi se ponovno javljali. Ni tada, nitko nije pripisivao te promjene celijakiji. Unazad 5 godina, nakon konzumiranja peciva (koja bi se često našla na mom stolu) osjećala bih pojačanu nadutost, ali i to sam podnosila do trenutka kada su se počele javljati izuzetne nadutosti koje nisam mogla kontrolirati. Budući da sam uposlena u bolnici, konsultirala sam se sa kolegom koji je gastroenterolog. On je odmah predložio biopsiju tankog crijeva, a rezultati su potvrdili celijakiju. Prema simptomima koji su mi se javljali od djetinjstva i postupno se pridruživali drugima, može se zaključiti kako sam celijakiju imala cijeli život. Kasnije sam, boreći se sa izazovima koje nosi celijakija i promjenama koje sam uvela u svoju svakodnevicu, imala učestale proljeve, umor i anemičnost, što sam povezivala sa dijagnosticiranom bolešću, no uz nju se pojavio karcinom s kojim se borim sada. Posve sam promijenila prehranu, konzumiram samo bezglutensku hranu koju sama pripremam i nemam više izražene simptome koje sam imala do početka liječenja celijakije“ zaključuje naša sagovornica.

ZAKLJUČAK

Budući da je celijakija vrlo učestala bolest gastrointestinalnog trakta, koja se nerijetko ne dijagnosticira pravovremeno, važno je što detaljnije poznavati simptome bolesti i raditi na podizanju svijesti o izazovima osoba oboljelih od celijakije. Kako se gluten, kao skladišni protein nalazi u žitaricama, koje su sastavni dio prehrambenih namirnica, a bolest se liječi strogo bezglutenskom ishranom, značajno je bilo istražiti koja prava

i mogućnosti imaju osobe oboljele od celijakije u Hercegovačko-neretvanskom kantonu/županiji.

Iz istraživanja je važno istaknuti kako pravo na bezglutenske namirnice imaju pacijenti oboljeli od celijakije (K90.0 *morbus coeliacus*) u vrijednosti od 200 KM mjesečno, ukoliko pripadaju dječjem uzrastu, kategoriji nazaposlenih osoba ili su u statusu umirovljenika, dok zaposlene osobe oboljele od celijakije ne polažu pravo na bezglutenske namirnice na teret ZZO HNK.

Na području grada Mostara u distribuciji bezglutenskih namirnica na teret ZZO HNK sudjeluju četiri ugovorne apoteke, a na području HNK još pet apoteka u drugim mjestima (Čapljina, Čitluk, Jablanica, Prozor, Konjic).

Trgovine nude raznoliku ponudu bezglutenskih namirnica. U usporedbi cijena, primjetna je razlika za iste ili slične proizvode u različitim trgovinama. Restorani u Mostaru ne nude zadovoljavajuću ponudu u svojim jelovnicima što, nesumnjivo otežava društveni život osoba oboljelih od celijakije, naročito mladih koji su društveno aktivni te putuju i rade. I za jela, koje se u jelovnicima naznačuju kao bezglutenska, preporuča se prije narudžbe, provjeriti s osobljem pripremaju li se u kontroliranim uvjetima i postoji li mogućnost kontaminacije glutenom od pripreme drugih jela.

Izniman doprinos u poboljšanju kvalitete života osobama oboljelim od celijakije daje Udruge oboljelih od celijakije „Gluten free“ u HNŽ/K, kroz različite aktivnosti i inicijative gradskim strukturama, što se primjećuje u unaprijeđenju kvaliteta života osoba oboljelih od celijakije tijekom posljednje dvije godine otkako je Udruga osnovana.

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CELIAC DISEASE – A CHALLENGE FOR PEOPLE AFFECTED IN THE HERZEGOVINA-NERETVA CANTON

Abstract

Celiac disease is a chronic disorder of the digestive system caused by the intake of gluten in genetically predisposed individuals. It is characterized by a high prevalence and often delayed diagnosis due to nonspecific symptoms, such as chronic diarrhea, vomiting, loss of appetite, fatigue, and anemia, which are frequently pushed aside, or misattributed to other conditions. The disease often occurs in association with other autoimmune diseases.

Having in mind a complex administrative structure of Bosnia and Herzegovina, there are also significant differences in the healthcare system among cantons, which ultimately affects the position of patients, as well as the availability of adequate healthcare.

The aim of this paper is to present celiac disease through the perspective of the condition itself, as well as the challenges and opportunities faced by patients in the Herzegovina-Neretva Canton. The paper contains a theoretical overview of the disease, an analysis of the availability of gluten-free products, the offer within the hospitality sector, patients' healthcare rights, and finally, a presentation of the experience of a person living with celiac disease.

The right to gluten-free foods in Herzegovina-Neretva Canton is granted to patients suffering from celiac disease (K90.0 morbus coeliacus) in the amount of 200 BAM per month, if they belong to the pediatric age group, if they are unemployed, or retired. At the same time, patients suffering from celiac disease who are employed are not entitled to gluten-free foods at the expense of the Health Insurance Institute of Herzegovina-Neretva Canton (ZZO HNK).

In the city of Mostar, four contracted pharmacies participate in the distribution of gluten-free food supplies covered by the Health Insurance Fund of the Herzegovina-Neretva Canton, while in the other parts of the Herzegovina-Neretva Canton there are another five pharmacies which are involved in distribution (territories of Čapljina, Čitluk, Jablanica, Prozor, and Konjic).

The analysis of the three retail chains with the largest number of stores demonstrated that these retailers provide a diverse range of gluten-free food products.

Restaurants in Mostar do not offer a satisfactory selection on their menus, which undoubtedly makes the social life of individuals with celiac disease more difficult, especially younger, socially active individuals who travel and work. Even dishes labeled as gluten-free on their menus are recommended to be checked with staff before ordering if they are being prepared under controlled conditions, and whether there is a possibility of gluten contamination from the preparation of other meals. A significant contribution to improving the quality of life of people with celiac disease is provided by the Association of People with Celiac Disease “Gluten free” in the Herzegovina-Neretva Canton, through various activities and initiatives addressed to city authorities, which has resulted in noticeable improvements in the quality of life of people with celiac disease over the past two years since the association was founded.

Keywords: *Celiac disease, Gluten-free diet, Healthcare system, Patient experience, Herzegovina-Neretva Canton*

COMPARATIVE ANALYSIS OF ECONOMIC RESULTS OF MILK PRODUCTION IN HOLSTEIN AND SIMMENTAL CATTLE BREEDS ON A MODERN FARM IN BOSNIA AND HERZEGOVINA

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Original scientific paper

Abstract

This paper presents a comparative analysis of the production and economic results of Holstein-Friesian and Simmental cows on a modern dairy farm in Bosnia and Herzegovina. The research was conducted on a sample of 30 pregnant heifers of each breed, imported from Denmark and Austria, and kept under identical farm conditions. The analysis included age at first calving, milk production in the first lactation, revenue structure, variable costs, and gross margin. Data were obtained from the farm's electronic production database, while descriptive statistics, a two-sample t-test, and gross margin analysis were used.

The results showed that Holstein-Friesian cows achieved higher milk production, with an average daily yield of 34.52 litres compared to 28.39 litres in Simmental cows. This difference was statistically significant. Holstein-Friesian cows also achieved a higher total milk yield and higher gross margin. However, the Simmental breed generated higher additional income from the sale of male and female young cattle and culled cows, confirming the economic relevance of its dual-purpose character. Feed costs were the dominant variable cost category in both breeds.

Keywords: *Holstein-Friesian, Simmental, milk production, gross margin, variable costs*

INTRODUCTION

According to data from the Ministry of Foreign Trade and Economic Relations, animal husbandry accounts for about 37% of the total value of agricultural production, and cattle breeding is considered one of the key segments of livestock production in BiH. The Holstein-Friesian breed is bred in the territory of the entire FBiH, the largest part of the population is located on large dairy farms with intensive breeding. The extensive breeding method for this breed is less common, given that it has extremely demanding nutritional and breeding requirements.

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Estimates indicate that Holstein-Friesian cattle in the FBiH territory today account for 15% of the total cattle population in BiH (MPVŠ FBiH, 2018). There are no official data on the number of breeds per breed, and the available sources from the Federal Ministry of Agriculture, Water Management and Forestry provide only estimates. Estimates indicate that the Simmental breed of cattle in the territory of FBiH accounts for 45% of the total cattle population in BiH today (MPVŠ FBiH, 2018).

Studies have been conducted in Bosnia and Herzegovina on Holstein-Friesian and Simmental cattle, most often on production and reproductive characteristics. The studies were conducted at different times and under different feeding and housing conditions. Examination of production and reproductive characteristics of two breeds of cows, conducted in Semberija through lactation seasons in the period 1990 to 1998. In milk production, the Holstein-Friesian breed had average production of 4,795 kg in the first, 5,334 kg in the second, and 5,417 kg in the third standard lactation. The Simmental had an average production: 4,084 kg in the first, 4,440 kg in the second and 4,483 kg in the third lactation. The Holstein-Friesian breed had better milk production results than the Simmental (Budimir *et al.*, 2011). The authors state that the research was conducted under poor nutritional conditions, as reflected in the amount of milk produced. This research showed higher milk yield in Holstein-Friesian cattle than in Simmental cattle. On the other hand, this research showed that Simmental had better predispositions for weight and meat production, consistent with previous research. The highest average weight before slaughter, as well as the mass of hot and cold carcasses, was recorded in male Simmental cattle, then in females of the Simmental breed, and then in young male bulls of the same breed. The lowest average weight before slaughter was recorded in Holstein-Friesian cattle. Carcass utilisation percentage (meat yield) was higher in cattle with higher pre-slaughter weight. Cooling losses of the studied carcasses were variable (Lukić *et al.*, 2016).

Profitability is the primary driver of any production activity, including livestock production. Therefore, a system that is not profitable cannot survive. Krupová *et al.* (2009) found that Holstein cows are more profitable than Slovenian Simmentals and Pinzgau cows. In another study comparing the profitability of Holstein and Jersey cows, Cunha *et al.* (2010) concluded that Holstein cows are more profitable than Jersey cows due to lower total production costs and higher gross milk income resulting from higher milk yield per lactation. Nutrition is one of the most important factors determining the production performance and health status of cows. Cow rations should contain high-quality roughage, a balanced ratio of grains and protein, and vitamins and minerals. In their study, Demerican *et al.* (2006) reported that feed cost was the dominant variable cost, accounting for more than 50% of total production costs. Furthermore, El-Awady *et al.* (2013) found in their research that food costs, as part of variable costs, accounted for 86.74%, 89.56%, and 89.34% at different levels of production.

In previous studies, the calving advantage has been found more strongly in Simmentals. Moderate assistance was present in both breeds. Roche *et al.* (2023) investigated the impact of dystocia (difficult calving) on the future health and productivity of Holstein dairy cows in the province of Alberta, Canada. Data were collected from 2,159 cows on

21 commercial dairy farms. Dystocia was defined in four categories: no assistance, light pulling, heavy pulling, and moderate-to-very-heavy pulling/surgery. Cows that required moderate to very heavy assistance or surgery produced 4.0 kg/day less milk, 0.18 kg/day less milk fat, and 0.14 kg/day less protein compared to cows without assistance ($p < 0.05$). These cows also had higher somatic cell counts. Cows requiring only light pulling produced 0.03 kg/day less milk fat and were 1.7 times more likely to retain the placenta compared to unassisted cows. The results show that a higher degree of assistance during calving has significant negative consequences for milk production, udder health, reproduction, and cow survival in Holstein herds.

Age at first calving (AFC), Torshizi (2016) reported that a range of 24 to 26.5 months of age at first calving represents the optimal calving age for Holstein heifers to maximise 305-day milk yield. In this study, they used data from 72,946 heifers from 724 farms, with a total of 638,063 daily control records, that calved between 2001 and 2011. These data were analysed to determine the influence of age at first calving and calving season on Wood's lactation curve parameters. The genetic trend of lactation curve parameters across different calving years was also assessed. Increasing the age at first calving by one month, from 18 to 26 months, increased the 305-day milk yield by about 138 kg, whereas increasing the age from 27 to 32 months decreased the yield by about 61 kg. Therefore, the optimal age range at first calving in research for the Holstein-Friesian breed is 24 to 26.5 months. They also state that in certain ranges, increasing the age by one month can increase milk production. When it comes to the recorded ages at the moment of first calving in Simmental and Holstein-Friesian breeds at Farma Spreča in the observed research, they may be the result of different factors and priorities that inseminators in the countries from which they originate worked.

This paper presents the economic indicators for purchased pregnant heifers imported from Denmark (Holstein-Friesian) and from Austria (Simmental). From both groups, 30 individuals were selected by random sampling to monitor pregnancy status, calving, age at calving, milk production in the first lactation, and variable costs. As a result of the analysis, economic results were presented as gross margin for both observed breeds. The aim of the paper is to determine and compare the production and economic results of Holstein and Simmental cows on a modern farm in Bosnia and Herzegovina.

MATERIAL AND METHODS

The research includes samples of 30 pregnant heifers from both groups, kept under modern dairy farm conditions in 2025. Parameters related to the degree of pregnancy, age at first calving, calving success, production in the first lactation, and variable costs of their keeping were analysed. The data were downloaded directly from the electronic database, i.e. software that contains and monitors numerous elements and parameters in animal production on this farm. The methods used for data processing were descriptive statistics, a t-test to determine differences in milk production between these two breeds, and economic indicators of production, including income, variable costs, and the gross margin.

Income took into account the quantities of milk produced, the amount of beef sold from production, and the value of culled cows. Production costs include food, health care, water and energy, reproduction costs, and other costs. Human labour was not taken into account because the entire workforce is permanently employed on the farm, making it a fixed cost. Head depreciation was not performed, because replacement is carried out from the own herd, from the obtained female calves.

During the research period, no heads had reached the end of their productive lives and were ready for sale, as the research focused on heifers in the initial phase of production. However, for the purposes of the economic analysis, the estimated value of the culled animal at the end of the production life was used. The assessment was based on the average body weight of adult cows and the market price of live weight in Bosnia and Herzegovina. The basic assumption was that, based on this farm's experience, the Holstein breed is culled after five years and the Simmental after six years of use. In this context, the analysed calculations assumed that 5 Simmental cows and 6 Holstein-Friesian cows are selected from the 30 cows per year.

The gross margin (GM) was defined as the difference between total income and total variable costs per hectare (Kay *et al.*, 2015):

$$\text{GM} = \text{Revenue} - \text{Variable cost}$$

Data consolidation and all necessary calculations have been done in MS Excel.

RESULTS AND DISCUSSION

The modern concept of keeping dairy cows on the Spreča farm is based on the free way of keeping cows in barns. This method is beneficial for the cows because they have the opportunity to move, choose a place to lie down, gain and maintain fitness, and increase production levels. All operations in the barns are separated. This means that feeding, watering, and milking are carried out in different places, which positively affects the cows' health and fitness and their more adequate grouping. The age at first calving (age at first calving/AFC) on the farm is an important indicator for a large number of reasons, one of which is whether the heifer had its first successful insemination in the optimal interval. In these specific situations, we had a case in which the average age of the Simmental at the time of calving was 27.4 months, while the average age of the Holstein-Friesian at the time of first calving was 24 months.

So, there is already a difference between these two breeds of pregnant heifers; one could say a significant difference. So the average age of Holstein-Friesian heifers at calving was 3.4 months lower than that of Simmental heifers. Of course, this does not necessarily indicate a characteristic of the breed, but rather a characteristic of the work of the inseminator with the heifers and the staff working on reproduction. Holstein-Friesian heifers were successfully inseminated earlier, which enabled earlier calving or earlier entry into production. It is possible that this is a targeted approach by the inseminators, indicating that they had specific intentions regarding calving planning, but calving heifers at 24 months is of great importance to the farm, because after calving,

that heifer has already entered production and, over the next 3.4 months, produces 3,570 litres of milk. If we take into account that this is a number of 30 heifers, that is 107,100 litres of milk.

Table 1. Comparison of milk production in the first lactation of Holstein and Simmental breeds based on a sample of 30 cows for each breed

Description	Holstein	Simmental
Average daily production (l)	34.52	28.39
Average duration of lactation (days)	302.6	302
Total milk yield per cow in the first lactation (l)	10,446	8,574

The value of Holstein-Friesian production is 104,958 KM plus subsidies of 54,578 KM. The later the heifers calve and enter production, and the shorter their gestation period, the longer they need to be fed. The Holstein-Friesian breed is a dairy breed, so it was expected that the result in terms of milk production would be on their side (10,446 l per head). However, the Simmental also achieved a result (8,574 l per head) that met the farm's expectations, especially considering that it is a combined breed whose calves achieve more satisfactory results in fattening, as do the cows themselves in the case of slaughter. The Holstein-Friesian cows had an average production of 34.5 l per day, while the Simmental had an average production of 28.39 l. On the other hand, the Simmental, as a combined breed, has an advantage in the sale of fattened calves and steers. The meat of this breed is more highly valued in the market, so it commands higher prices when sold than Holstein-Friesian meat.

Table 2. Descriptive statistics for the observed Holstein and Simmental breed cattle in milk production

Description	Holstein	Simmental
Mean	34.5	28.4
Median	34.2	27.9
Mode	34.2	25.3
Standard Deviation	3.0	2.8
Minimum	28.3	23.0
Maximum	40.5	34.7
Count	30	30
Coefficient of variation	8.6	9.8

Median and mode values for the Holstein breed were very close to the arithmetic mean, which indicates a relatively symmetrical and even distribution of production. In the Simmental breed, the arithmetic mean and median are also relatively close, but the modal value is lower, which may indicate a slightly higher concentration of heads at a lower production level.

The standard deviation was 3.0 in the Holstein and 2.8 in the Simmental breed. Although the absolute variability is slightly higher in the Holstein, the coefficient of variation

shows that milk production is relatively more stable in the Holstein breed. The coefficients of variation of 8.6% in Holsteins and 9.8% in Simmentals indicate low variability in both breeds, but also slightly higher production uniformity in Holstein necks.

The production range for the Holstein breed was 12.2, while for the Simmental breed it was 11.7. The minimum production of the Holstein was 28.3, which is almost equal to the average production of the Simmental breed of 28.4. This data additionally confirms that the distribution of milk production in the Holstein breed is shifted towards higher values.

The results confirm the expected superiority of the Holstein breed in milk production. However, the final economic evaluation cannot be based solely on the amount of milk, because the Simmental breed can generate significant additional income through the sale of calves/heifers and the higher value of cows produced. Therefore, in the continuation of the analysis, it is necessary to include the structure of income and expenses by breed.

Table 3. Comparison of Milk Yield between Holstein and Simmental Cows Using a Two-Sample t-Test

Description	Holstein	Simmental
Mean	34.5	28.4
Variance	8.8	7.8
Observations	30	30
Hypothesized Mean Difference	0	
Df	58	
t Stat	8.24	
P(T<=t) two-tail	2.43E-11	
t Critical two-tail	2.00	

To determine the statistical significance of the difference in average milk production between the Holstein and Simmental breeds, a two-sample t-test was used. Given that the variances in the observed groups were relatively similar, i.e. that the variance in the Holstein breed was 8.83, and in the Simmental breed 7.78, a t-test was applied assuming equal variances. The test results showed that the average milk production in Holstein cows was statistically significantly higher than in Simmental cows ($t = 8.24$; $df = 58$; $p < 0.001$). These results confirm that the Holstein breed in the observed sample achieves significantly higher milk production.

For the purpose of analysing the economic results of milk production, a calculation of variable costs and revenues was made for a herd of 30 Holstein heifers (Table 4). The gross margin represents the difference between total revenue and variable costs, indicating how much remains to cover fixed costs and potential profit.

The revenue structure for the Holstein breed clearly shows that milk sales are the main source of income. Revenue from milk sales amounted to 307,105 KM, or approximately 57.7% of total revenue. Milk subsidies also had a very important role, amounting to 162,954 KM, or about 30.6% of total revenue. This indicates that the farm's economic performance depends not only on market-based milk sales but also significantly on the agricultural support system. Additional revenues were generated from the sale of male and female young cattle, as well as from the estimated value of culled cows. Although these revenues are lower than those from milk and subsidies, they represent an important complementary component of the overall economic result, particularly in production systems where the value of animals is also economically relevant.

A particularly important part of the analysis is the structure of variable costs. Total feed costs amounted to 267,774 KM, which represents approximately 81.3% of total variable costs. This is a very high share, clearly indicating that feed is the dominant cost category in milk production. In practical terms, the profitability of this production is largely determined by feed prices, ration quality, and the efficiency with which feed is converted into milk. Any increase in feed prices or any decline in feed efficiency can therefore have a direct and significant impact on the final economic result of the farm.

Table 4. Determination of gross margin for the Holstein-Friesian breed based on a sample of 30 animals, expressed in BAM

Opis	Jedinica	Količina	Cijena	Ukupno
A) REVENUE				
Milk	l	313,373	0.98	307,105
Subsidise	l	313,373	0.52	162,954
Sale of bullocks (510 kg)	No.	15	2,397	35,955
Sale of heifers (450 kg)	No.	8	2,115	16,920
Value of culled animals	No.	6	1,595	9,570
Total revenue				532,504
B) VARIABLE COSTS				
B1. Food				
Corn silage	kg	226,950	0.1	21,560
Concentrates	kg	110,540	1.2	132,648
Hay	kg	72,624	1.2	84,970
Straw	kg	22,695	1.3	28,596
B2. Water and energy				
Water	m ³	650	1.7	1,105
Electricity	kWh	8,669	0.2	1,387
B3. Health care				
Vaccinations	No.	30	60	1,800
Antiparasitic drugs	No.	30	190	5,700
Interventions	usluga	30	250	7,500
B4. Reproduction				
Genetic material	doza	45	50	2,250

Insemination	No.	45	40	1,800
Pregnancy US examination	No.	90	30	2,700
B5. Other expenses				
Consumables	v	30	505	15,150
Fertilizer disposal	m ³	30	470	14,100
Veterinary expenses	No.	30	270	8,100
Total variable costs				329,366
GROSS MARGIN (A-B)				203,138

Within feed costs, concentrates are the largest individual cost item, at 132,648 KM. They account for around 40.3% of total variable costs and almost half of total feed costs. Hay is the second most important feed cost item, with a total value of 84,970 KM, representing approximately 25.8% of total variable costs. Straw and maize silage have smaller, but still relevant, shares in the overall cost structure. This cost distribution shows that the farm is strongly dependent on feed inputs, especially concentrates and hay, which should be carefully monitored in economic planning.

The data shows that the farm has a positive gross margin and that milk production remains economically sustainable within variable costs. However, the significant proportion of feed costs underscores the importance of feed management as a key area for enhancing economic efficiency. Consequently, future analysis should focus on the connection between milk yield, feed expenses, and gross margin.

Table 5. Determination of gross margin for the Simental breed based on a sample of 30 animals, expressed in BAM

Opis	Jedinica	Količina	Cijena	Ukupno
A) REVENUE				
Milk	Lit	257,213	0.98	252,069
Subsidise	KM	257,213	0.52	133,751
Sale of bullocks (570 kg)	Kom	15	4,161	62,415
Sale of heifers (520 kg)	Kom	9	3,796	34,164
Value of culled animals	Kom	5	3,010	15,050
Total revenue				497,449
B) VARIABLE COSTS				
B1. Food				
Corn silage	Kg	226,950	0.10	21,560
Concentrates	Kg	110,540	1.20	132,648
Hay	Kg	72,624	1.17	84,970
Straw	Kg	22,695	1.26	28,596
B2. Water and energy				
Water	m ³	650	1.70	1,105
Electricity	kWh	8,669	0.16	1,387
B3. Health care				
Vaccinations	Kom	30	60	1,800
Antiparasitic drugs	Kom	30	190	5,700
Interventions	usluga	30	250	7,500
B4. Reproduction				

Genetic material	Doza	45	50	2,250
Insemination	kom	45	40	1,800
Pregnancy US examination	Kom	90	30	2,700
B5. Other expenses				
Consumables	Kom	30	505	15,150
Fertilizer disposal	m ³	30	470	14,100
Veterinary expenses		30	270	8,100
Total variable costs				
GROSS MARGIN (A-B)				168,083

The calculation of the gross margin for the Simmental breed shows that total revenue was 497,449 BAM, while total variable costs were 329,366 BAM. Based on these values, the gross margin was 168,083 BAM. This indicates that production achieved a positive economic result at the variable-cost level, although the margin is relatively lower than in systems with higher milk production. In relative terms, variable costs accounted for approximately 66.2% of total revenue, while the gross margin accounted for about 33.8%.

The revenue structure confirms that milk production remains the main source of income, even for the Simmental breed, which has a dual-purpose production profile. Revenue from milk sales amounted to 252,069 BAM, representing around 50.7% of total revenue. Milk subsidies amounted to 133,751 BAM, or approximately 26.9% of total revenue. Together, milk sales and subsidies generated 385,820 BAM, which represents about 77.6% of total revenue. This clearly shows that the farm's economic results are still primarily based on milk production and the support system linked to delivered milk quantities.

However, the Simmental breed also generates a significant part of its income from animal sales. Revenue from the sale of male fattened cattle amounted to 62,415 BAM, while the sale of female young cattle generated 34,164 BAM. In addition, the estimated value of culled cows amounted to 15,050 BAM. These three categories together generated 111,629 BAM, or about 22.4% of total revenue. This is an important result because it confirms that the economic value of the Simmental breed cannot be assessed only through milk yield. Its dual-purpose character provides additional income through fattening and the higher market value of animals.

Since practically identical technology is used as in Holstein, the cost structure is identical to Holstein's; therefore, the main differences arise from the structure and amount of income.

Comparative analysis of gross margin calculations shows that the Holstein-Friesian breed achieved a higher total revenue and higher gross margin than the Simmental breed. Total revenue for Holstein-Friesian cows amounted to 532,504 BAM, while the Simmental breed generated 497,449 BAM. Since total variable costs were the same in both calculations, amounting to 329,366 BAM, the difference in gross margin was entirely determined by the revenue structure. Holstein-Friesian cows achieved a gross margin of 203,138 BAM, compared to 168,083 BAM for Simmental cows.

The most important difference between the two breeds is visible in the structure of revenues. In the Holstein-Friesian breed, milk sales and milk subsidies generated 470,059 BAM, representing 88.3% of total revenue. In the Simmental breed, these two categories amounted to 385,820 BAM, or 77.6% of total revenue. This confirms the strong advantage of Holstein-Friesian cows in milk-oriented income, primarily due to higher milk yield.

The Simmental breed achieved considerably higher revenue from animal sales. Income from male and female young cattle and culled cows amounted to 111,629 BAM, or 22.4% of total revenue, while the same categories in Holstein-Friesian cows generated 62,445 BAM, or only 11.7%. This clearly reflects the dual-purpose character of the Simmental breed.

Although Simmental cows partly compensated for lower milk production through higher animal-related revenues, this was not sufficient to offset the higher milk and subsidy income achieved by Holstein-Friesian cows.

It is important to note that in the analysed year (2025), there was no mortality among the observed individuals, so the calculations were performed accordingly. However, it should be emphasised that mortality is expected to range from 1-3%, depending on breeding conditions and the herd's genetic predispositions.

CONCLUSION

The results of this research confirm clear differences in production and economic performance between Holstein-Friesian and Simmental cows kept under the same conditions on a modern dairy farm in Bosnia and Herzegovina. Holstein-Friesian heifers calved earlier, with an average age at first calving of 24 months, compared with 27.4 months in Simmental heifers, enabling earlier entry into milk production. Holstein-Friesian cows also achieved significantly higher milk production, with an average daily yield of 34.52 litres, compared to 28.39 litres in Simmental cows. The difference in milk yield was statistically highly significant, confirming the expected dairy superiority of the Holstein-Friesian breed.

The economic analysis showed that Holstein-Friesian cows achieved higher total revenue and gross margin. Total revenue amounted to 532,504 BAM, while the gross margin reached 203,138 BAM. In the Simmental breed, total revenue amounted to 497,449 BAM, with a gross margin of 168,083 BAM. The main advantage of Holstein-Friesian cows was generated through higher milk sales and milk subsidies. However, the Simmental breed achieved considerably higher income from the sale of young male and female cattle and culled cows, confirming the importance of its dual-purpose production characteristics.

In both breeds, feed costs were the dominant variable cost category, accounting for approximately 81.3% of total variable costs. Therefore, feed management represents the key factor for improving economic efficiency. Overall, Holstein-Friesian cows achieved better economic results, while Simmental cows partially offset lower milk yield with higher animal-related revenues.

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KOMPARATIVNA ANALIZA EKONOMSKIH REZULTATA PROIZVODNJE MLIJEKA HOLSTEIN I SIMENTAL PASMINA GOVEDA NA SAVREMENOJ FARMI U BOSNI I HERCEGOVINI

Sažetak

Ovaj rad predstavlja komparativnu analizu proizvodnih i ekonomskih rezultata krava holštajn-frizijske i simentalke pasmine na savremenoj mliječnoj farmi u Bosni i Hercegovini. Istraživanje je provedeno na uzorku od 30 steonih junica svake pasmine, uvezenih iz Danske i Austrije, koje su držane u identičnim uslovima na farmi. Analiza je obuhvatila starost pri prvom teljenju, proizvodnju mlijeka u prvoj laktaciji, strukturu prihoda, varijabilne troškove i bruto maržu. Podaci su prikupljeni iz elektronske baze proizvodnje na farmi, dok su za obradu korištene deskriptivna statistika, t-test za dva nezavisna uzorka i analiza bruto marže.

Rezultati su pokazali da su krave holštajn-frizijske pasmine ostvarile veću proizvodnju mlijeka, sa prosječnim dnevnim prinosom od 34,52 litre u odnosu na 28,39 litara kod simentalke krava. Ova razlika bila je statistički značajna. Holštajn-frizijske krave su također ostvarile veći ukupni prinos mlijeka i veću bruto maržu. Međutim, simentalke pasmine generisala je veće dodatne prihode od prodaje muške i ženske teladi te izlučenih krava, čime se potvrđuje ekonomski značaj njenog kombinovanog (dvonamjenskog) karaktera. Troškovi ishrane bili su dominantna kategorija varijabilnih troškova kod obje pasmine.

Ključne riječi: *Holštajn-frizijska pasmina, simentalke pasmine, proizvodnja mlijeka, pokrivanje varijabilnih troškova, varijabilni troškovi*

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IN MEMORIAM

Prof. dr. Lutvija Karić

Profesorica Lutvija Karić rođena je 14. marta 1970. godine u Tuzli. Svoje djetinjstvo i mladost provela je u Živinicama, gdje je završila osnovnu i srednju školu sa odličnim uspjehom. Nakon toga svoj obrazovni put nastavila je na Poljoprivrednom fakultetu Univerziteta u Sarajevu, gdje je 1988. godine kao redovan student upisala studij na Odsjeku za ratarstvo, a diplomirala 1995. godine.

Njen naučni i stručni put bio je obilježen stalnim usavršavanjem, predanim radom i težnjom ka novim saznanjima. Postdiplomski studij upisala je 2001. godine. Magistarski rad pod naslovom „Uticaj sistema uzgoja i doze azota na dinamiku rasta i prinos praziluka i celera“ odbranila je 2004. godine i stekla zvanje magistra poljoprivrednih nauka.

Svoj naučni razvoj krunisala je odbranom doktorske disertacije pod naslovom „Kvantitativne i kvalitativne osobine praziluka u zavisnosti od sorte i gnojidbe azotom“, koju je odbranila 20. novembra 2009. godine na Poljoprivredno-prehrambenom fakultetu Univerziteta u Sarajevu, čime je stekla zvanje doktora poljoprivrednih nauka. U februaru 2015. godine izabrana je u zvanje vanrednog profesora, a u septembru 2020. godine u zvanje redovnog profesora za oblast Povrtlarstvo.

Profesionalni put profesorice Karić bio je ispunjen odgovornošću, stručnim radom i velikim doprinosom razvoju poljoprivredne nauke i obrazovanja. Tokom agresije na Bosnu i Hercegovinu, u periodu 1992 - 1993. godine, bila je angažovana kao nastavnik hemije i biologije, pokazujući posvećenost obrazovanju i u najtežim okolnostima.

Od marta 2000. do septembra 2002. godine radila je kao stručni saradnik na Poljoprivrednom institutu Butmir, u laboratoriji za ispitivanje kvaliteta i zdravstvene ispravnosti namirnica i predmeta opšte upotrebe. U tom periodu bavila se analizama teških metala, kontrolom kvaliteta u hemijskoj laboratoriji, kao i mikrobiološkom kontrolom ispravnosti namirnica. Učestvovala je u edukativnim programima i u radu komisija za ocjenu kvaliteta biljnih proizvoda na međunarodnim sajmovima u Gradačcu i Sarajevu.

Od septembra 2002. godine započinje svoj akademski rad na Poljoprivrednom fakultetu Univerziteta u Sarajevu kao asistent na predmetima Povrtlarstvo i Tehnologija čuvanja proizvoda. Godine 2005. izabrana je u zvanje višeg asistenta na predmetu Povrtlarstvo, a 21. maja 2010. godine u zvanje docenta za oblast Povrtlarstva.

Tokom svoje akademske karijere bila je nosilac i realizator nastave na brojnim predmetima iz oblasti povrtlarstva, biljne proizvodnje i čuvanja poljoprivrednih proizvoda, među kojima su: Povrtlarstvo I, Povrtlarstvo II, Specijalno povrtlarstvo, Proizvodnja povrća u zaštićenom prostoru, Proizvodnja gljiva, Proizvodnja rasada, Biološki i ekološki činioci uzgoja povrća, Agrobiotopi zaštićenog prostora, Uskladištenje i čuvanje ratarsko-povrtnarskih proizvoda, Poznavanje i kontrola sirovina, Opšte ratarstvo i povrtlarstvo i Čuvanje povrća.

U nastavnom radu profesorica Karić nije samo prenosila znanje, nego je svojim pristupom oblikovala generacije studenata i budućih stručnjaka. Kontinuirano je unapređivala kvalitet nastave, povezivala teoriju i praksu i podsticala studente na istraživački rad. Njena posvećenost, dostupnost i stručnost ostavili su dubok trag kod svih koji su imali priliku učiti od nje.

Kao profesorica ostvarila je značajan doprinos razvoju povrtlarke nauke i prakse. Objavila je 68 naučno-stručnih radova i sedam knjiga, te učestvovala u realizaciji više od 34 projekata, od kojih je u šest domaćih i devet međunarodnih bila rukovodilac.

Poseban doprinos dala je razvoju povrtlarstva i hortikulture proizvodnje u Bosni i Hercegovini, kroz naučni i stručni rad, ali i kroz primjenu savremenih pristupa u proizvodnji i unapređenju ruralnog razvoja. U okviru ovog djelovanja bila je i voditeljica projekata Turske agencije za međunarodnu saradnju i koordinaciju (TIKA), koji su bili usmjereni na ekonomsko osnaživanje žena i domaćinstava u ruralnim područjima kroz dodjelu plastenika, sistema za navodnjavanje, sadnog materijala i edukacije iz plasteničke proizvodnje. Ovi projekti su imali i širi društveni značaj, jer su doprinosili razvoju povrtlarstva i unapređenju dostupnosti hrane, posebno za socijalno osjetljive kategorije stanovništva.

Profesorica Karić značajno je doprinijela i razvoju visokog obrazovanja na Poljoprivredno-prehrambenom fakultetu Univerziteta u Sarajevu. Aktivno je učestvovala u procesu transformacije studija prema principima Bolonjskog procesa i bila koordinator aktivnosti na izradi dodiplomskih i master studijskih programa Fakulteta ispred Instituta za ratarstvo. Bila je član Odbora za II ciklus studija i Vijeća doktorskog studija Fakulteta.

Poseban doprinos njenom stručnom razvoju dale su brojne međunarodne posjete i programi usavršavanja. Među njima se izdvaja jednomjesečni boravak u Izraelu 2008. godine, gdje je učestvovala na kursu „Internacionalni standardi povrća i voća“, čime je dodatno unaprijedila svoje znanje iz oblasti standardizacije i kvaliteta poljoprivredne proizvodnje.

Kroz brojna stručna usavršavanja, međunarodne konferencije i saradnju sa naučnim i obrazovnim institucijama u zemlji i inostranstvu, profesorica Karić kontinuirano je pratila savremena dostignuća u oblasti povrtlarstva. Učestvovala je na brojnim stručnim skupovima, često kao član naučnih i organizacionih odbora, te prenosila stečena znanja u nastavni i kroz praktični rad.

Svoje znanje i iskustvo nesebično je dijelila i izvan matične institucije. Tokom dvije akademske godine bila je angažovana kao nastavnik na Biotehničkom fakultetu Univerziteta u Bihaću, gdje je izvodila nastavu iz predmeta Povrtlarstvo.

Kao stručni ekspert održavala je edukacije i predavanja iz oblasti povrtlarstva u različitim gradovima Bosne i Hercegovine, a njena stručnost bila je prepoznata i kroz učešće u komisijama za ocjenu kvaliteta i izbor nastavnika u akademska zvanja na više visokoškolskih ustanova.

Poseban dio njenog akademskog rada predstavljao je rad sa studentima i mladim istraživačima. Bila je mentor na 10 master radova i dvije doktorske disertacije. Pored toga, učestvovala je u izradi i odbrani brojnih završnih, magistarskih i doktorskih

radova, te bila mentor na više desetina završnih radova prvog ciklusa studija. Kao članica ili predsjednica komisija učestvovala je u ocjeni i odbrani više od 40 završnih radova drugog ciklusa studija na Poljoprivredno-prehrambenom fakultetu Univerziteta u Sarajevu.

Od 2018. do 2021. godine obavljala je funkciju prodekana za nastavu Poljoprivredno-prehrambenog fakulteta, gdje je svojim znanjem, iskustvom i odgovornošću doprinijela unapređenju kvaliteta nastavnog procesa.

Iza profesorice Lutvije Karić ostaje izuzetno bogato akademsko i stručno naslijeđe - naučni radovi, knjige, projekti, unaprijeđena nastava i generacije studenata koje je oblikovala. Njeno ime ostat će trajno povezano sa razvojem povrtlarske nauke u Bosni i Hercegovini, ali i sa predanošću, znanjem i ljudskošću koje je unosila u svoj rad.

Pored vrlo značajnog naučnog doprinosa, profesorica Karić je ostavila neizbrisiv trag u srcima svojih kolegica, kolega, prijatelja, poznanika, i ono najvažnije, svoje porodice, koja joj je uvijek bila na prvom mjestu. Profesorica Karić je vjerovala da je važnije biti dobar čovjek nego imati sve ovozemaljske titule. Kako se riječi nižu, uviđam koliko je teško pretočiti sve emocije u riječi dostojne da opišu profesoricu Karić kao moju mentoricu i profesoricu. Kada bih mogla izabrati jednu sliku koja će mi zauvijek ostati u sjećanju i podsjećati me na nju, to bi bila slika: savršena frizura, blistave plave oči, okružena najljepšim cvijećem i svojom porodicom.

Doc. dr. Čerima Zahirović Sinanović

UPUTSTVO ZA OBJAVLJIVANJE RADOVA

Radovi Poljoprivredno-prehrambenog fakulteta Univerziteta u Sarajevu (Radovi) su godišnjak u kojem se objavljuju naučni, izuzetno i stručni radovi, te izvodi iz doktorskih i magistarskih teza odbranih na Poljoprivredno-prehrambenom fakultetu Univerziteta u Sarajevu (Fakultet).

Radovi imaju karakter naučnog časopisa i kao takvi podliježu propozicijama za takve publikacije. Od broja 52 Radovi su indeksirani kod CAB Publishing - UK.

Članci za objavljivanje se klasificiraju, po preporuci UNESCO-a, u ove kategorije: naučni radovi, prethodna saopštenja, pregledni i stručni radovi. Autori predlažu kategoriju za svoje članke, recenzenti preporučuju, a konačnu odluku o kategorizaciji donosi Redakcija Radova. Naučni radovi sadrže rezultate izvornih istraživanja. Njihov sadržaj treba da bude izložen tako da se eksperiment može reprodukovati i provjeriti tačnost analiza i zaključaka. Prethodna saopštenja sadrže one značajne naučne rezultate, koji zahtijevaju hitno objavljivanje. Ova istraživanja mogu biti vremenski kraća od uobičajenih. Pregledni radovi sadrže pregled neke problematike na osnovu već publikovanih tekstova, koja se u pregledu analizira i diskutuje. Stručni radovi su korisni prilozi iz područja struke, koji ne predstavljaju izvorna istraživanja.

Članci se pišu na bosanskom, srpskom, hrvatskom ili engleskom jeziku. Na početku rada treba pisati naziv rada (velikim slovima) na maternjem i na engleskom jeziku, a nakon toga ime (imena) autora. Naziv radne organizacije autora upisuje se u fusnotu (Ariel 7). Ispod imena autora obavezno se upisuje i kategorija rada.

U časopisu se publikuju radovi iz oblasti: poljoprivredna biljna proizvodnja, animalna proizvodnja, prehrambene tehnologije i održivi razvoj agrosektora i ruralnih područja. Poželjno je da članci naučnog karaktera imaju uobičajenu strukturu naučnog rada i to: rezime (na bosanskom, srpskom i hrvatskom), uvod, pregled literature (može se dati i u uvodu), materijal i metode rada, rezultati istraživanja, diskusija (može biti objedinjeno sa rezultatima istraživanja), zaključci, literatura, summary na engleskom jeziku. Rezime i summary na našim jezicima i engleskom jeziku mogu imati maksimalno 200 riječi, uz obavezno upisivanje ključnih riječi. U spisku literature daju se samo autori i radovi koji se spominju u tekstu. Latinska imena biljaka, životinja i mikroorganizama treba (osim imena autora) pisati kurzivom. Tabele, grafikoni i slike moraju imati svoj naziv, a ako ih je više i broj. Broj i naziv tabele pišu se u istom redu, iznad tabele, dok se broj i naziv grafikona, crteža i slika pišu ispod tih priloga. U tabelama, grafikonima i slikama naslove, zaglavlja i objašnjenja poželjno je dati i na stranom jeziku. Slike i grafički prikazi moraju biti visokog kvaliteta, u rezoluciji ne manjoj od 300 dpi i formatima JPEG, PNG ili TIFF, kako bi se osigurala besprijekorna reprodukcija u knjizi.

Radovi, po pravilu, ne bi trebali prelaziti osam autorskih kartica (do 14.400 znakova, uključujući razmake).

Za sadržaj članka odgovara autor. Članci se prije objavljivanja po "double blind" principu recenziraju od strane dva nezavisna recenzenta. Redakcija, uz konsultovanje sa autorima, zadržava pravo manjih redaktorskih i jezičkih korektura u člancima.

Autor dostavlja Redakciji rukopis putem e-maila uređen prema uputstvima za pisanje radova. Prilikom slanja radova Redakciji obavezno je naznačiti kontakt adresu i e-mail adresu u posebnom dokumentu.

Svi prispjeli rukopisi će biti podvrgnuti inicijalnoj provjeri u pogledu zadovoljenja kriterija oblasti iz kojih časopis objavljuje radove i tehničke pripreme rukopisa u skladu sa uputstvima autorima.

Podneseni rukopis nakon inicijalne provjere od strane Redakcije može biti odbijen bez recenzija, ako uredništvo ocijeni da nije u skladu s pravilima časopisa. Autoru će u roku od 20 dana biti upućena informacija o inicijalnom prihvatanju rada ili razlozima za njegovo neprihvatanje.

Po završetku postupka recenziranja koji, u pravilu, ne bi trebao trajati duže od tri mjeseca Redakcija, na osnovu konačnih preporuka recenzenata, donosi odluku o objavljivanju, odnosno neobjavljivanju rada. Nakon toga rad se šalje na Univerzitet, Službi za izdavačku djelatnost, koja vrši provjeru potencijalnog plagijarizma. O svojoj odluci Redakcija informiše autora, uz informaciju o broju i terminu izlaska časopisa u kojem će rad prihvaćen za objavljivanje biti štampan.

Elektronsku verziju rada treba pripremiti u Wordu u formatu stranica 170 x 240 mm, sa slijedećim veličinama margina: gornja i donja 2,2 cm, lijeva 2,0 cm, a desna 1,5 cm, te formatirati parne i neparne stranice. Isključivo koristiti font Times New Roman, veličina 11, dok za fusnote treba koristiti font Arial, veličina 7. Tekst treba da je obostrano poravnat. Nazive poglavlja u radu treba pisati velikim slovima, boldirano i sa srednjim poravnanjem, te jednim redom razmaka od teksta.

Prilikom formatiranja članka ne treba uređivati zaglavlje i podnožje članka (Header and Footer) niti numerisati stranice.

Autorima čiji maternji jezik nije engleski strogo se preporučuje da osiguraju profesionalnu lekturu teksta ili koriste alate za jezičku provjeru, poput Grammarly-ja. Prilikom pisanja na engleskom jeziku treba koristiti jasne engleske izraze bez žargona i izbjegavati duge rečenice. Prihvatljivi su i britanski i američki „spelling“, ali on mora biti konzistentan u cijelom tekstu rada na engleskom jeziku.

Prije pisanja članaka za Radove, poželjno je da autori pogledaju formu radova već objavljenih u jednom od zadnjih brojeva ili da na web stranici: www.ppf.unsa.ba (radovi.ppf.unsa.ba), pronađu uputstva sa primjerom pravilno uređenog članka.

Pridržavajući se ovih uputstava, autori ne samo da olakšavaju posao Redakciji, nego i doprinose da njihovi radovi budu pregledniji i kvalitetniji. Više informacija, autori mogu dobiti obraćanjem Redakciji na e-mail: radovi@ppf.unsa.ba.

Redakcija

INSTRUCTION FOR PUBLISHING PAPERS

“Radovi Poljoprivredno-prehrambenog fakulteta Univerziteta u Sarajevu” (“Works of the Faculty of Agriculture and Food Sciences of University of Sarajevo”), hereinafter: “Radovi” (the “Works”) is an almanac in which (original) scientific papers, exceptionally professional papers, and also some excerpts from doctoral/PhD or master theses defended at the Faculty of Agriculture and Food Sciences (the Faculty) of University of Sarajevo (Univerzitet u Sarajevu) are published.

“Radovi” (the “Works”) has a character of scientific magazine and, as such, is subject to the propositions for such publications. Since its issue no. 52, “Radovi” (the “Works”) has been indexed at CAB Publishing - UK.

Articles for publishing are classified, according to the recommendation by the UNESCO, into these categories: (original) scientific papers, previous statements, (scientific) review and professional papers. The authors propose the category for their articles; critics recommend it and final decision on their categorisation is made by the Editorial Board of the “Radovi” (the “Works”). (Original) Scientific papers contain results of authentic research. Their content should be presented in such a manner that an experiment may reproduce and verify accuracy of the analyses and conclusions. Previous statements contain those significant scientific results that require urgent publishing. This research can be shorter in time than the usual ones. (Scientific) Review papers contain an outline of certain problems based on previously published texts that are analysed and discussed about in the review. Professional papers are useful articles/works from the professional domain that do not present authentic research.

Articles are written in one of the three official languages of BiH (Bosnian/Serbian/Croatian) or English. The title of the paper should be written at the beginning of the paper (in capital letters) in one’s mother tongue and in English and after that the author’s name (authors’ names). The author’s working organisation name is written in the footnote (Ariel 7). It is mandatory to write out the category of the paper below the author’s name as well.

Papers from the areas of agricultural plant production, animal production, food technologies and sustainable development of agro-sector and rural areas are published in the journal.

It is desirable that articles of scientific character have common structure of a scientific paper, namely: summary in one of the three official languages of BiH (Bosnian/Serbian/Croatian), introduction, references (may be given in the introduction, too), material and methods, results of research, discussion (may be integrated with results of research), conclusions, bibliography and summary in English. Summary in one of the three official languages of BiH (Bosnian/Serbian/Croatian), and summary in English respectively may have maximum 200 words, with mandatory enlisting of the key words. In the list of bibliography, only authors and papers that are mentioned in the text are given. The authors’ names in the text are written with expanded spacing. Latin names of plants, animals and micro-organisms should be written in italics. Tables, graphs and pictures must have their title and if they are numerous, their number. The

number and the title of the table are written in the same row above the table while the number and the title of the graph, drawing and pictures are written below them. It is desirable to give titles, headings and explanations in the tables, graphs and pictures in the foreign language, too. Graphs and drawings should be done exclusively in black-and-white technique. Tables should be framed in lines of thickness of 1/2 pt, without shading of individual cells or rows and columns. Pictures and graphic illustrations should be done impeccably to be top-quality reproduced in the book.

Papers, as a rule, should not be longer than 12 typed pages (with appendices). Excerpts from master theses may be even up to 15 pages, and from doctoral/PhD theses up to 25 typed pages.

The author is responsible for the contents of the article. Prior to their publishing, articles are reviewed under "double blind" principle by two independent reviewers. The Editorial Board, in consultations with the authors, reserves the right to minor editorial and linguistic corrections in the articles.

The author submits one's manuscript to the Editorial Board by the means of e-mail edited according to the instructions for writing papers. When sending papers to the Editorial Board it is obligatory to indicate the contact address and e-mail address in a separate document.

All the submitted manuscripts shall be subject to initial check in terms of meeting the criteria of the field which the magazine publishes papers from as well as technical preparation of the manuscript in accordance with the instruction to the authors.

Upon the initial check by the Editor, the submitted manuscript may be rejected without review if the Editor evaluates it is not in accordance with the journal's rules. Within the term of 20 days, the notification shall be sent to the author about either initial acceptance of the paper or reasons for its rejection.

Upon completion of the reviewing procedure which, as a rule, should not last longer than three months, the Editorial Board, based on final recommendations by reviewers, makes decision on publishing the pertinent paper or not. The Editorial Board then informs the author about their decision, in addition to the information on the issue and term of the article publishing which the paper accepted for publishing is going to be published in.

Electronic version of the paper should be prepared in Word, in page format of 170 x 240 mm, with the following size of margins: the upper and lower ones of 2,2 cm, the left one of 2,0 cm and the right one of 1,5 cm and then the even and odd pages formatted. The font of Times New Roman, size 11, is to be exclusively used, while for footnotes the font of Arial, size 7 should be used. The text should be aligned on both sides. The title of chapters in the paper should be written in capital letters, bold and with medium alignment as well as with one row of space from the text.

While formatting the article, neither header and footer nor page numbering should be arranged.

Authors whose mother tongue is not English are strongly recommended to provide professional corrections to the text that is going to be reviewed. While writing in English, clear English phrases without jargon should be used and long sentences should

be avoided. Prior to sending the manuscript, it is strongly recommended for the author to carry out checking the text in English by using the option of “spelling and grammar“. Both British and American spelling is acceptable, but it must be consistent throughout the text of the paper in English.

Before writing articles for the “Radovi” (the “Works”), it is desirable that authors have a look at the form of papers having already been published in one of the recent issues or to find the instruction with an example of properly arranged article on the web site: www.ppf.unsa.ba (radovi.ppf.unsa.ba).

By adhering to these instructions, authors not only facilitate the job for the Editorial staff but also contribute to their papers to be presented better and in a more qualitative manner. Authors can get more information by contacting the Editorial Board at the e-mail: radovi@ppf.unsa.ba

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