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EFFECT OF BIO STIMULATORS AND INOCULATION ON THE PEA YIELD (*Pisum sativum* L.)

Adrijana Filipović[1,2], Mile Pažin[1], Ivan Ostojić[1], Ana Mandić[1], Višnja Vasilj[1]

Original scientific paper

Summary

The research aimed to determine the efficiency of the nodule inoculation and the application of bio stimulators to the vegetative growth of pea yield (*Pisum sativum* L.). One-factor filed trial was was set up by a random block design in three replication with four different treatments. The treatments included a variant (I) with the inoculation (nodular applied bacteria) a variant (B) with the applied bio stimulator, a variant (I+B) that implied the combination of the first two and the control variants (C) (without any application). Morphological properties were observed (number of plants per variants, the mass of pods, stem height, number of nodules per root) and the pods yield of was determined. The results showed that the average yield of pea varietys of "Miracle of America" is significantly higher when using a combination of inoculation and bio stimulators, even by 21% compared to the control variant, whereas the individual effect of inoculation or application of bio stimulators shows a lower yield of about 11% compared to the highest achieved yield 1134.3 g m^{-2}. A similar result is followed by the weight of the pods, where the largest mass was obtained in a combined variant of 9.67 g, which is by 42% more than the weight produced in the control variant and for 12% more than the individual effects of inoculation and used bio stimulator. The number of pods showed statistically significantly higher results for 48% of the variants with combination and individually applied bio stimulators then the control variant. Stem height was found to be significantly different in all variants of the experiment. The height of the stem was greatest in a combined variant with an average of 55.63 cm, followed by a variant with applied bio stimulators of 49.78 cm and inoculants of 46.16 cm. The lowest stem height had a control variant of 35.97 cm. The number of nodules showed 78% lower nodules on variants with the applied bio stimulators and the control variant compering to the variant with applied inoculation as well and combined variant.

Key words: *Pisum sativum L., field trial, yield, inoculation, bio stimulator*

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INTRODUCTION

Legumes are different components of sustainable cultivation system because they can use the atmospheric N_2 through a symbiotic relationship of roots with certain bacterial rhizomes existing in the soil by forming of specialized organs called nodules. Supply of nitrogen through biological nitrogen fixation has ecological and economic benefits (Ndakidemi *et al*., 2006). Symbiotic N_2 fixation in legumes was not obligatory for surviving of the host plants but it is usually utilize for generating mineral N soil (Namvar *et al*., 2011; Voisin *et al*., 2003). Leguminous plant yields can be improved by using a modest amounts of mineral fertilizers (unlike cereals) and generally very little fertilizer in pea production to avoid unnecessary financial investment in fertilizers and the poor economic profits (Ndakidemi *et al*., 2006). The application of optimal fertilization amounts in pea cultivation can double the yield (Dakora, 1984; da Silva *et al*., 1993), contribute to plant growth and nitrogen fixation compared to cultivation without fertilization (Ndakidemi *et al*., 2006). Inoculation of pea seed by *rhizobium* strains can also increase legume grain yield, which on one hand decreases soil degradation and on the other hand these measures a commonly leads to economically safer higher yields (Ndakidemi *et al*., 2006). However, despite the potential to reduce the application of nitrogen fertilizers and reduce the level of investment in production demand for inoculants worldwide is still quite low (Kannaiyan, 1993). Inoculation of leguminous seeds with *rhizobium* strains increases nodule number, protein and chlorophyll content, increases nitrogen assimilation, growth intensity and height of legume yield (Sogut, 2006; Togay *et al*., 2008; Erman *et al*., 2011; Namvar *et al*., 2011). Understanding symbiotic nitrogen fixation enables greater utilization of this natural process with the aim of ensuring a more successful, profitable and environmentally sound production of legumes or adhesives (Sikora and Redžepović, 2003). Bio stimulators play an important role in the cultivation of many vegetable crops, especially in the juvenile stages. Bio stimulators are physiologically active substances that help plants to grow and develop. The synergistic effects of their components affect the soil-plant-root system. The most important feature of a bio stimulator is that it reduces the harmful effects of drought, freezing, mechanical and chemical damage and mitigates the effects of viral infections on the plant. In addition to environmentally friendly ways of using inoculation with leguminous plants to reduce fertilizer use and encourage better crop yield, bio stimulators are increasingly being used. Organic farming with the help of bio stimulators is very complex and requires extensive preparation and education to produce successful results. In particular, the influence of selection of inoculants, as well as selection of bio stimulators, does not have the same effects on all crops and varieties. The results of such an experiment are considered in this paper, where the individual and combined effects of selected inoculants and bio stimulant on yield and its traits were presented for the pea variety the Miracle of America.

MATERIALS AND METHODS

The trial filed has conducted at location Stolac, Bosnia and Herzegovina during 2018 growing vegetation season. The research aimed to determine the efficiency of the inoculation (nodule bacterization) and the application of bio stimulators to the vegetative growth of pea yield (*Pisum sativum* L.) for variety Miracle of America. One-factor trial field was set up by a random block design in three replication with four different treatments. The treatments included a variant (I) with the seed inoculation (nodular applied bacteria of BiofixiN-S), a variant (B) with the applied bio stimulator (Synergon 2000), a variant (I+B) that implied the combination of the first two and the control variants (C) (without any application). The inoculation material is a product of the Department of Microbiology, Faculty of Agriculture, University of Zagreb, Biofixin-S. For biostimulator the Sinergon 2000 was used, which contains an organic fertilizer with magnesium and iron. Inoculation of pea seeds was done pre-sowing and the application of the bio stimulator was carried out about 35 days after planting by foliar treatment of the pea vegetative biomass. The sowing were preformed manually in rows 20 cm wide and plants were 5 cm apart. The field trial was set for April 14, 2018, and the results were collected two months after (June 15, 2018). Morphometric characteristics and yield of the peas were measured on five randomly selected plants per each variant of the experiment. The experimental plot size was approximately 40 m^2. Monitoring characteristics included the number of nodules per root, the height of the stem, the number of pods and the yield of peas (kg ha^{-1}). Soil analyses were done before sowing, pH reaction by potentiometric method (BAS ISO 10390:2009) v/v 1:2.5, total carbonate content ($CaCO_3$) by Scheibler and active lime by method of Druineau – Gallet (JDPZ, 1966). Total nitrogen content in soil has detected by modified Kjeldahl method (BAS ISO 11261:2010). Concentration of phosphorus (spectrophotometer) and potassium (flame photometer) in soil samples have determined by ammonium lactate method (Egner *et al.*, 1960). Content of soil organic matter has done by Kotzmann method (JDPZ, 1966). Based on soil analysis, it was determined that no additional fertilization was needed since it was chosen a peat-fertile garden soil. During the field trial, meteorological data were also collected, available from the nearest meteorological station of the Federal Hydro-meteorological Institute, Mostar. Meteorological datas were used to interpret the results obtained through the field trial, followed by the maximum, minimum and average monthly temperatures (°C) for the spring period of 2018, as well as the sum of total and maximum monthly precipitation (mm).

The study results obtained for the measured properties were statistically processed by analysis of variance (ANOVA). LSD test were provide for differences between average values, less than or equal to $P \geq 0.05$ were considered significant and their average values were further tested by Student's t-test. The GENTSAT7 statistical program was used for data processing.

RESULTS AND DISCUSSION

For soil chemical analysis, an average soil sample was taken from a field plot. Based on analysis for the 0-30 cm tiller layer, the standard soil chemical parameters are shown in Table 1.

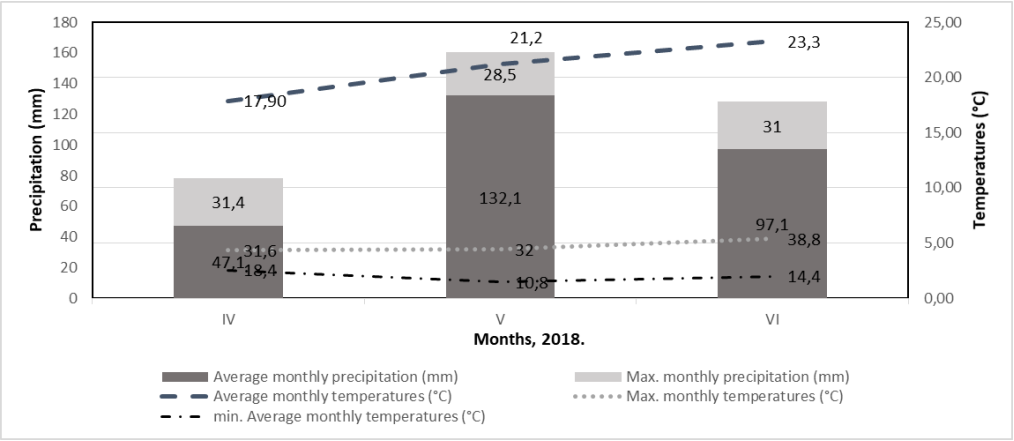
Tab. 1. Soil chemical analysis

Depth of soil sample	Spil pH		Total $CaCO_3$ (%)	Lime (%)	Total N (%)	mg K_2O/ 100 g soil	mg P_2O_5/ 100 g soil	Organic matter (%)
	H_2O	1M KCl						
0-30	8.42	7.48	11.8	2.32	0.36	39.28	42.85	3.86

According to the results of the chemical analysis of the soil, the alkaline pH of the soil was determined. Niste *et al*. (2013) found that most legumes for growth require neutral to acidic soils, especially when they depend on symbiotic nitrogen fixation, whereas the bacterial strains *rhizobium* according to Zhang *et al*. (2011) require a pH range of 6.5 to 7.5 which is the optimum for their development. The total carbonate content is moderate and the amount of active lime low. Nitrogen content up to 0.36% is satisfying as well as humus content up to 3.86% which is quite rich. The phosphorus content of 42.85 mg P_2O_5 100 g^{-1} soil in the test sample is quite good, as the potassium content is also satisfactory the 39.28 mg K_2O 100g^{-1} soil. Based on the obtained results, no additional soil fertilization was needed.

Meteorological conditions during the pea vegetation significantly affect the growth and development of the plant. The most important meteorological parameters were the air temperature, with its minimum and maximum oscillations during certain months, and the amount and distribution of precipitation during the growing season.

Air temperature is limiting factor in the cultivation of most plants, directly affects the physiological processes in the plants as well as the availability of water in the surface layer of the soil. Rainfall water is an indispensable factor that largely determines agricultural production, and its surplus or deficiency can only be partially corrected by irrigation systems, thereby significantly increasing the cost of production. The mean annual air temperatures in 2018 were above the standard normal value (1961-1990) for Bosnia and Herzegovina (FHMZFBIH, 2018). According to the data of the Federal Meteorological Institute (graph 1), the closest meteorological station Mostar recorded the highest number of warm days during the spring period. Monthly temperatures from the beginning to the end of April reise from 18.4°C (April of 14, 2018) to 31.6°C (April 28, 2018). The lowest recorded daily temperature during the May was 10.8°C (May 18, 2018) and the highest 32°C (May 27, 2018). The lowest recorded daily temperature during June was 14.4°C (June 22, 2018) and the highest 38.8°C (June 12, 2018). During this period, nighttime temperature amplitudes varied from 15.2°C-18.4°C.



Graph. 1. Temperature and precipitation oscillations for the pea vegetation period in 2018 at the Mostar measuring station (source: FHMZFBIH)

During the pea emergence period, the mean daily temperature was about 17.9°C, thus fitting into the optimal temperature range for this phenological phase (18° to 25°C).
Analysis of seasonal sums of precipitation averages shows that April was slightly drier with 47.1 mm of rainfall, compared to May, which was a moderate 132.1 mm (FHMZFBIH, Climatological Analysis of the Season, Spring 2018). During the pea vegetation, from sowing to harvesting, a total of 484.9 mm of rainfall was recorded. According to literature sources, recorded precipitations were slightly higher than the plant's required for satisfactory growth and development, as Parađiković (2009) stated the optimum range from 200 to 400 mm. The precipitation schedule was relatively good and there were no excessively long dry periods.
The results of the measured morphological characteristics on peas during the 2018 field trial were statistically processed and presented in Table 2. Based on the results of the research, it was found that the average pea yield of the Miracle of America variety was significantly higher on applyied the third treatment (I + B) for 21% compared to the control variant, while compared to individual treatments (I) pre-sowing inoculation and (B) of bio stimulators, a lower yield of about 11% was found compared to the highest achieved one of 1.13 t ha^{-1} in the combined variant (I + B). The research results show lower yield of peas comparing to the studies of other authors (Thomson *et al*., 1997; Uher *et al*., 2006; Rapčan *et al*., 2017; Vasilj *et al*., 2016, 2019). Thus, in the studies of Thomson *et al*. (1997) a higher pea yield of 1.04 t ha^{-1} to 2.79 tha^{-1} was found depending on the applied irrigation system and without. In a study of livestock pea inoculation, the authors Uher *et al*. (2006) also found a higher yield of live peas for 21% in the inoculation variant compared to the control. Also higher pea yields were found in the studies of Vasilj *et al*. (2016) during the inoculation of two varieties of peas (Little Provence and Miracle of America) inoculated by indigenous *R. leguminosarum* strains (V1 and V13) compared to the control and reference strain *R. leguminosarum* 1001. The Miracle of America variety showed a 6.5% higher yield (3.51 t ha^{-1}) compared to the yield of the Small Provencal variety (3.28 t ha^{-1}). In the studies

of Vasilj *et al*. (2019), a higher yield of peas of 5.64 t ha^{-1} to 4.51 t ha^{-1} was found during two-year experiments using pre-sowing inoculation of the pea variety Mali provansalac with indigenous strains (isolates from Herzegovina), *R. leguminosarum* compare to control (1.36 t ha^{-1}) and reference strain *R. leguminosarum* 1001 (1.73 t ha^{-1}).

Tab. 2. The average values of the measured characteristics determined on the pea variety

Treatments	Yield (kg ha^{-1})	Mass of pods (g)	Number of pods	Height of the steam (cm)	Number of the nodules
Inoculants (I)	1018 B	8.53 B	4.6 B	46.16 C	15.6 A
Bio stimulators (B)	1011 B	8.4 B	5.87 A	49.78 B	3.47 B
Combination (I+B)	1134.3 A	9.67 A	6.73 A	55.63 A	16.07 A
Control (C)	887.7 C	5.6 C	3.4 C	35.97 D	3.47 B
F-test	**	**	**	**	**
LSD 5%	29.59	0.89	0.91	3.34	2.73
LSD 1%	39.4	1.19	1.22	444	3.64

In addition, some authors (Silim *et al*., 1992; Rapčan *et al*., 2017; Vasilj *et al*., 2019) state that pea yields are highly dependent on environmental conditions such as drought (especially in flowering period and soaking of the pods), sowing dates (closely related to weather conditions during vegetation), which are also confirmed by other studies (Popović and Stjepanović, 1992; Duchene *et al*., 1994; Rapčan *et al.*, 2004; Vasilj *et al*., 2019). In moderately dry areas, water stress is a major factor in reducing yield (Martin *et al*., 1994). Whereas in studies in the Wimmer area of Victoria, authors Bretag *et al*. (2000) found that later sowing reduced yield by 40% due to the sowing blight. According to Kanižai-Šarić *et al*. (2016) pea variety Miracle of America in a studied experiment using *R. leguminosarum* inoculation and nitrogen fertilization the 30 kg N ha^{-1} and 60 kg N ha^{-1} obtained a yield of 2.87 t ha^{-1} and 2.98 t ha^{-1}, which is 61-62% higher than in the control variant (1.11 t ha^{-1}). According to a four-year study on five different lines of beans, Uzun *et al*. (2005) found that respect to seasonal variations, yields average varied from 1.26 t ha^{-1} to 1.92 t ha^{-1}. Based on the listed results of the wider number of researchers, it is clear that the pea yields in this study are slightly lower, while the average pea yields in Northern Europe range from 3 t ha^{-1} to 4 t ha^{-1} as determined by Heath and Hebblethwaite (1985), Davies *et al*. (1985). Also much higher pea yields rangin from 4 t ha^{-1} to 7 t ha^{-1} have been found by other researchers (Silim *et al*., 1992; Stelling, 1989; Biarnes-Dumoulin *et al.*, 1996).

Regarding the precipitation amount for this survey conducted from April to June, as a factor that significantly influences the yield, they were relatively good, as Uzun *et al*. (2005) estimated that rainfall during this period ranging from 175 mm to 316 mm is quite sufficient for stable and good yield. However, we conclude that some of the other factors had a poorer effect on the achieved yield of the Miracle of America variety during the field trial. Possibly extreme daily piks in terms of air temperature, especially in May (<31 °C) may have affected the yield. Popović *et al*. (2002), stated thet temperatures exceeding 26°C at the stage immediately after flowering, due to the decay

of the flowers, can significantly reduce yield. In terms of soil fertility parameters, the nitrogen, phosphorus, potassium and humus contents are in favorable ranges, which should not adversely affect the yield or any other measured characteristics. The carbonate content is more pronounced, however the active lime content is not high, which should also exclude these parameters as a negative factor on the measured characteristics. Eventually high pH and pronounced soil alkalinity may have some influence on the degree of inoculation of the pea seeds. The high variation in soil pH, salinity, alkalinity and fertility have serious implications for the survival of the *Rhizobiom* strains and their efficacy, requiring the re-inoculation of leguminous seeds (Brockwell *et al*., 1995). The effect of the inoculation of leguminous plants and their symbiotic efficacy and infectivity in soil is highly dependent on the soil pH response, which was established in research of Brockwell *et al*. (1995). A similar result of the yield is followed by the mass of the pods. The highest mass was achieved by applying the third treatment (I + B) with average of 9.67 g plant^{-1}, which is 42% more than the weight of the pods obtained in the control variant and approx. 12% more then the weight obtained in the first treatment (I) of inoculation and the second treatment (B) of the biostimulator. Rapčan *et al*. (2017) found a higher mass of pods of 326.26 g m^{-2} on inoculated variant compared to controls for the pea variety Miracle of America.
During the field experiment, a highest number of pods per plant aprox. 48% was found in the third (I + B) and the second treatment (B) compared to the control (3.4 pods plant^{-1}). A slightly smaller number of 4.6 pods plant^{-1} was determined using the first treatment (I). According to the results of Rapčan *et al.* (2004) the number of pods of the Sobel pea variety in the experiment with different sowing dates and assembly varied from 4.68 to 6.58 pods plant^{-1} in the first year of experiment and from 4.04 to 7.46 pods plant^{-1} in the second year of experiment. Same authors achived the higher number of pods in the first sowing period, with a smaller set, and this was also contributed by nitrogen fertilization (60 kg N ha^{-1}). The number of pods per plant in the study by Erman *et al*. (2008) varied from 3.3-6.2. The best result in their study were obtained in fertilization treatment by 20 kg N ha^{-1} with pre-sowing inoculation od the seeds. The study of Brkić *et al.* (2004) found significantly higher number of pods (8.83) influenced by pre-sowing inoculation of pea seeds with different *Rhizobium leguminosarum* strains, fertilization of 40 kg N ha^{-1} and foliar applied molybdenum sowed on two different soil types plant versus control variant. In studies by Senković (2015), a large number of pods was identified in the range of 7-38, with the highest number of pods in treatments with a combination of inoculants and soil improvers. Regarding the facts that the number of pods per plant is a variable characteristic, it is highly dependent on weather conditions, agrotechnical procedures, sowing time, density of the assembly, as well as variety. The results of a field experiment in 2018 on the number of pods per plant on the Miracle of America variety are in line with the research obtained by Erić *et al.* (2007). These authors determined 5.45 to 7.15 number of pods per plant, which is an average of 6.3 pods per plant. However, in the studies of the author Yücel Özveren (2013), a slightly higher number of 9.3–17.4 pods per plant was found, which is not in accordance with the results obtained in this field experiment.

In the field experiment, the height of the stem was monitored and statistically significant differences were found between treatments. Thus, the maximum height 55.63 cm of the pea stem was determined in the third treatment (I + B), followed by the second treatment (B) and hight was 49.78 cm, then in the first treatment (I) was 46.16 cm while the the lowest height of the stem was determined by the control the 35.97 cm. Study conducted by Senković (2015) on low legume beans using treatments with and without silica based soil improvers, as well as treatments with and without inoculation with *Rhizobium leguminosarum* bv. *phaseoli* 3622, determined the height of 38.9 cm a much higher than the control variant. He also found that the smallest height of the bean stem was determined in a combination of bean treatments (pre-sowing inoculation without silica based soil improvers), where the sem height was up to 37.8 cm.

The number of nodules at the root of the Miracle America variety was variable regard to the used treatments. The highest number of nodules per plant was determined in the third treatment (I + B) and the first treatment (I), while the 78% lower number of nodules was determined in the second treatment (B) and control. The use of the inoculation of the Miracle American pea variety with Biofixin-S, as well as the combination of the treatments (I + B), had a valid effect on the number of nodules on the pea root, while the single effect of second treatment (B) and control showed no differences. The number of nodules found at the root of the peas varied from 3.47 to 16.07 per plant, which is a relatively small number comparing to the effect of inoculation in leguminous beans, which can reach over 100 nodules as identified by others authors applying pre-sowing inoculation (Senković, 2015; Linderman and Glover, 1990). Also, a larger number of nodules per plant were identified in studies Rapčan *et al*. (2017) and Vasilj *et al*. (2019) when applying pre-sowing pea inoculation by indigenous strains comparing to the controls. During the field experiment (2018), a smaller number of nodules was identified in the control variant, which confirms the existence of a natural population in the soil. However, their ability to nodulate and influence the monitored morphological characteristic of the Miracle of America variety were not statistically different regarding the applied tretments of biostimulators (B). The presence of the natural *Rhizobia* population in the control variant on the Miracle of America pea variety in the experimental field during 2018 and their poor nodulation ability are also consistent with the research results of other authors (Komesarović *et al*., 2007; Sikora *et al*., 2008; Ali *et al.,* 2008; He *et al*., 2011; Rapčan *et al*., 2017; Argaw and Mnalku, 2017; Vasilj *et al*., 2016; 2019).

Based on the results of the chemical analysis of the soil, it is evident that the soil has a slightly increased level of major macronutrients, which may reflect pre-intensive fertilized garden soil, which disrupted even the natural soil microflora, resulting in poor inoculation of peas in the control variant. This is supported by the fact that the application of inoculation of the seeds contributed to the nodulation of the pea root by 77% more than in the control, whereas with the inoculation and used the bio stimulators, this contribution was slightly higher. Indigenous bacterial strains cannot express their full capacity for biological fixation under restrictive conditions (eg salinity, unfavorable soil pH, nutrient deficiency, mineral toxicity, extreme temperatures, insufficient or

excessive soil moisture, inadequate photosynthesis, plant diseases and weeds) as this limits the capacity of the host plant (Peoples *et al*., 1995).

CONCLUSIONS

The highest yield 1134.3 g m^{-2} and weight of the pea pods 9.67 g of the variety Miracle of America were achieved by using a combination of inoculants and bio-stimulant. The results show 21% higher values than the control variant. In addition to these economically important properties, the combined application of inoculant BiofixiN-S and bio stimulant Sinergon 2000 has shown a positive effect on other measured properties in the cultivation of the pea of the Miracle of America variety. The obtained results of nodule number lead to the conclusion that natural soil conditions do not favor nodulation of peas at this trial site. Based on the results of the chemical analysis of the soil, it is evident that the soil has a slightly increased level of major macronutrients, which may reflect over-intensive fertilized garden soil, which disrupted even the natural microflora of the soil, resulting in poor nodulation of peas in the control variant. This is supported by the fact that the application of seed inoculation contributed to the nodulation of the pea root by 77% more than in the control, while with the inoculation and the use of bio stimulators, this contribution was only slightly higher visible through better yield. Most of the measured properties were found to be slightly lower in their averages than previously determined values through various studies by other authors and certainly the unfavorable factor in pea cultivation at this locality was soil, especially with a pronounced nutrient level and prominent alkalinity, as well as temperature peaks during vegetation, which certainly varies from season to season. Significant contribution to the research would be achieved by monitoring the isolated effect of a foliar application of a particular amino acid contained in a biostimulator or by inoculation on a specific metabolic process or component, in order to give a more precise answer to the direct efficiency and advantage of growing the plant itself.

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UTJECAJ PRIMJENE BIOSTIMULATORA I BAKTERIZACIJE NA PRINOS GRAŠKA (*Pisum sativum* L.)

Rezime

Provedeno istraživanje imalo je za cilj utvrditi efikasnost bakterizacije kvržičnim bakterijama i primjene biostimulatora na vegetativni rasti prinos graška (*Pisum sativum* L.). Jednofaktorijalni poljski proveden je u proljeće 2018. na obiteljskom poljoprivrednom gospodarstvu. Pokus je postavljen po metodi slučajnog bloknog rasporeda u tri ponavljanja i četiri različita tretmana. Tretmani su obuhvaćali varijantu (I) s primijenjenom inokulacijom kvržičnim bakterijama, varijantu (B) s primijenjenim bio stimulatorom, varijantu (I+B) koja je podrazumijevala kombinaciju prve dvije navedene i kontrolna varijanta (C) (bez primjene navedenog). Promatrana su morfološka svojstva (broj mahuna po biljci, masa mahune, visina stabljike, broj kvržica po korijenu) te je utvrđen tržni prinos mahuna. Rezultati su pokazali da prosječni prinos graška kultivara Čudo Amerike je značajno veći prilikom primjene kombinacije mikorizacije i primjene bio-stimulatora, čak za 21% u odnosu na kontrolnu varijantu, dok pojedinačni učinak mikorize ili primjene bio-stimulatora pokazuje niži prinos za oko 11% u odnosu na najviši ostvareni 1134,3 g m^{-2}. Sličan rezultat prati i masa mahune, gdje je najveća masa ostvarena u kombiniranoj varijanti od 9,67 g, što je za 42% više u odnosu na masu mahune ostvarenu u kontrolnoj varijanti i za oko 12% više u odnosu na pojedinačne učinke inokulacije i primjenog bio-stimulatora. Broj mahuna je pokazao statistički značajno veće rezultate za oko 48% na varijanti sa primijenjenom kombinacijom i pojedinačno primijenjenim bio stimulatorima u odnosu na kontrolu. Visina stabljike se pokazala u svim varijantama pokusa značajno različitom. Visina stabljike je bila najveća na kombiniranoj varijanti sa prosjekom od 55,63 cm, zatim je slijedi varijanta sa primijenjenim bio-stimulatorima od 49,78 cm, potom varijanta sa primijenjenom inkulacijom od 46,16 cm i najnižu stabljiku je imala kontrolna varijanta od 35,97 cm. Broj kvržica je također između varijanti pokazao značajna variranja, gdje je najveći broj ostvaren na kombiniranoj varijanti i varijanti sa primijenjenom

inokulacijom, dok su za 78% niži broj kvržica u prosjeku ostvarile varijante sa primijenjenim bio-stimulatorima i kontrolna varijanta.

Ključne riječi: *Pisum sativum L., poljski pokus, inokulacija, biostimulator*

ISPITIVANJE ALELOPATSKOG POTENCIJALA NEVENA (*Calendula officinalis* L.) NA INICIJALNI RAST NJIVSKE LUBENIČARKE (*Hibiscus trionum* L.) I ŠTIRA (*Amaranthus retroflexus* L.)

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Originalni naučni rad - *Original scientific paper*

Rezime

Cilj rada je bio ispitati efikasnost primjene različitih koncentracija vodenih ekstrakata nevena pripremljenih pojedinačno iz osušenih cvjetova i listova na parametre početnog rasta korovskih vrsta *Hibiscus trionum* L. i *Amaranthus retroflexus* L. Ogled je postavljen u laboratorijskim uvjetima u Petrijevim posudama u četiri ponavljanja. Urađena je dvofaktorijalna (koncentracija ekstrakta x dio biljke nevena) analiza varijanse korištenjem statističkog programa PAST v 3.25. Vodeni ekstrakti koncentracije 10 i 5% od osušenih cvjetova i listova nevena su inhibirali početni rast ispitivanih korova. Shodno povećanju koncentracije primjenjivanih ekstrakata povećavao se inhibitorni efekat. U odnosu na ostale kombinacije, vodeni ekstrakt cvijeta nevena koncentracije 10% je ispoljio najbolji inhibicijski efekat prema početnom rastu obje korovske vrste. Mogućnost korištenja alelopatskog potencijala nevena u cilju suzbijanja korova u okviru održive poljoprivrede, zahtijeva dodatna istraživanja prvenstveno u poljskim uvjetima.

Ključne riječi: *neven, vodeni ekstrakti, parametri početnog rasta, inhibicija, korovi*

UVOD

U intenzivnoj biljnoj proizvodnji jedna od obaveznih agrotehničkih mjera koja se koristi za suzbijanje korova je primjena herbicida. Uz sve prednosti koje ova sredstva pružaju, njihovo učestalo korištenje sa sobom nosi i negativne posljedice po ljudsko zdravlje i životnu sredinu. Smanjena upotreba herbicida i primjena savremenih alternativnih mjera suzbijanja korova su jedni od temelja održive poljoprivrede. Kada je riječ o savremenim trendovima suzbijanja korova, neizostavno se pominje alelopatija. Alelopatija u suštini podrazumijeva stimulativan ili inhibitoran utjecaj jednog organizma na drugi djelovanjem alelohemikalija. Biljke mogu proizvoditi alelohemikalije u većim ili manjim količinama u različitim organima, ovisno o fazi razvoja, razdoblju dana ili godine (Narwal *et al*., 2005). Najčešće listovi posjeduju najveći alelopatski potencijal, a koji se može pripisati većoj koncentraciji

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alelohemikalija smještenih u istim (Xuan *et al*., 2004). Smatra se da je najveća količina alelohemikalija otpuštenih u okoliš putem razgradnje biljnih ostataka i ispiranjem iz lista. Biološka aktivnost - odgovor biljaka koje dolaze u dodir sa ovim alelohemikalijama zavisi od koncentracije i praga štetnosti. Uslijed niskih koncentracija, utjecaj može biti stimulativan ili pak inhibitoran povećanjem koncentracije (Lovett, 1989). Inhibitorni efekat alelohemikalija najčešće se manifestuje u inhibiciji klijanja, nicanja i rasta osjetljivih biljaka (Đikić, 2001). Ovi simptomi slični su simptomima koje bi u biljkama izazvalo tretiranje smanjenim subletalnim dozama herbicida (Novak, 2017). Alelopatski potencijal nevena prema korovima, s obzirom na broj korovskih biljaka koje se danas pojavljuju na poljoprivrednim površinama je i dalje aktuelna tema istraživača. Saznanja o alelopatskom djelovanju nevena prema nekim korovima mogu pomoći u suzbijanju korova naročito u održivim sistemima poljoprivredne proizvodnje kojima, između ostalih, pripada i organska proizvodnja. Neven je čest usjev kod organskih proizvođača, kao provjerena biljka u borbi protiv nekih štetnih organizama i korova. Proučavajući alelopatske efekte združene sjetve nevena, ruzmarina i paradajza, Koocheki *et al*. (2008) su dokazali smanjenu mogućnost pojave *Alternaria solani* Sor., uzročnika pjegavosti lista paradajza. Autori navode da je jedan od mehanizama ove pojave alelopatski inhibitoran utjecaj nevena i ruzmarina na klijanje spora *A. solani*. U prilog naprijed navedenog ide i činjenica da je neven u odnosu na neke druge ispitivane aromatične i medicinske biljke otporniji na alelopatski inhibitoran uticaj vrste poput *Conocarpus erectus* L. (Abdul Ameer & Al-Rekaby, 2017). Također, dodatna upotreba istog u vidu ekstrakta bi značajno olakšala provođenje mjera zaštite biljaka. Ovim radom obuhvaćena su ispitivanja različitih koncentracija vodenih ekstrakata pripremljenih iz različitih biljnih dijelova (cvijeta i lista) nevena u fenofazi cvjetanja sa ciljem evaluacije alelopatskog potencijala na primjeru njivske lubeničarke (*Hibiscus trionum* L.) i štira (*Amaranthus retroflexus* L.).

MATERIJAL I METODE

Ispitivanje alelopatskog potencijala nevena je provedeno u Laboratoriji za ratarstvo Poljoprivredno-prehrambenog fakulteta u Sarajevu. Biljni materijal nevena je prikupljen u fazi cvjetanja tokom 2017. godine. Prikupljena biljna masa nevena je osušena na sobnoj temperaturi tokom nekoliko dana, a potom samljevena pomoću električnog mlina u prah sitnih čestica. Od usitnjenih glavičastih cvasti nevena prema metodi Norsworthy (2003) pripremljeni su vodeni ekstrakti u koncentracijama 10, 5 i 2%. Na isti način su pripremljeni vodeni ekstrakti od lista nevena. Korovske biljke (*H. trionum* i *A. retroflexus*) su korištene kao indikatorske vrste. Prije upotrebe sjeme ispitivanih korova je dezinfikovano potapanjem u 1% rastvor natrij hipohlorita (NaOCl), u trajanju od dvadeset minuta (Siddiqui *et al*., 2009) u cilju uklanjanja eventualno prisutnih mikroorganizama i isprano nekoliko puta destilovanom vodom (Bašić *et al*., 2018). Dormantnost sjemena korovske vrste *H. trionum* prekinuta je skarifikacijom, potapanjem u rastvor koncentrovane sulfatne kiseline (H_2SO_4) u trajanju

od 20 minuta. Dormantnost sjemena korovske vrste *A. retroflexus* je prekinuta potapanjem u 2% rastvor KNO_3 tokom 24 sata. U Petrijeve posude (Ø 90 mm) sa filter papirom je postavljeno 30 klijavih sjemenki korova, a potom je vršeno tretiranje pripremljenim ekstraktima. U posudama koje su predstavljale kontrolnu varijantu je primjenjivana dejonizovana voda. Jednaka količina određenog ekstrakta/dejonizovane vode (3 ml za *A. retroflexus* i 4 ml za *H. trionum*) je dodana u Petrijeve posude. Ogled je postavljen po slučajnom planu u četiri ponavljanja. Posude su stavljene u termostat sa podešenom temperaturom od 20±2°C u uslovima mraka u trajanju od 10 dana za *A. retroflexus* te 15 dana za *H. trionum*. Kako bi se spriječilo isušivanje sjemena indikatorskih vrsta dodatno su primjenjivani ekstrakti/dejonizovana voda.
Klijavost (%), dužina klijanca (cm) i svježa masa (mg) isklijalih korovskih vrsta su određene po završetku ogleda. Kako bi se utvrdilo postojanje statistički značajnog uticaja oglednih faktora (koncentracija ekstrakata i dio biljke) i njihovih interakcija na parametre početnog rasta korovskih vrsta, urađena je dvofaktorijalna analiza varijanse asimetričnog modela (4x2). Za ovu analizu korišten je program PAST v 3.25 (Hammer *et al*., 2001). Pošto je uslov za primjenu bilo kojeg modela analize varijanse, homogenost varijanse i distribucija podataka, dodatno je provjerena ispunjenost ovih pretpostavki. Za naknadna poređenja sredina korišten je Tukey test.

REZULTATI RADA I DISKUSIJA

U tabeli 1 su prikazani rezultati dvofaktorijalne analize varijanse u cilju utvrđivanja postojanja statistički značajnog uticaja oglednih faktora (koncentracija ekstrakta i dio biljke nevena) i njihovih interakcija na parametre početnog rasta indikatorske vrste *H. trionum.* Prema vrijednostima Fišerovog pokazatelja primjenjivani ekstrakti različitih koncentracija (faktor A) su ispoljili statistički veoma visoko značajan uticaj na sve ispitivane parametre početnog rasta vrste *H. trionum*. Dio biljke nevena (faktor B) je ispoljio statistički veoma visoko značajan uticaj na procenat klijanja korova dok na druge ispitivane parametre ovaj faktor nije imao statistički značajan uticaj. Međudjelovanje ova dva faktora je statistički veoma visoko značajno uticalo na sva tri analizirana parametra *H. trionum.*

Tabela 1. Vrijednosti Fišerovog pokazatelja i statistička značajnost utjecaja oglednih faktora na parametre početnog rasta *H. trionum*
Table 1. F values and the statistical significance of the effect of the experimental factors on the initial growth parameters of H. trionum

Ispitivani parametri ***Examined parameters***	**Ogledni faktori** ***Experimental factor***	**F pokazatelj** ***F value***	**p**	**Nivo značajnosti**
Klijavost (%) ***Germination (%)***	Ekstrakt	58,92	<0,001	***
	Dio biljke	33,55	<0,001	***
	Međudjelovanje	8,57	<0,001	***
Svježa masa (mg) ***Fresh biomass (mg)***	Ekstrakt	93,37	<0,001	***
	Dio biljke	0,38	>0,05	n.s
	Međudjelovanje	24,86	<0,001	***
Dužina klijanca (cm) ***Seedling length (cm)***	Ekstrakt	163,76	<0,001	***
	Dio biljke	2,52	>0,05	n.s
	Međudjelovanje	15,74	<0,001	***

n.s. nije značajna razlika; * značajno; ** visoko značajno; *** veoma visoko značajno

Primjenom Tukey testa testirane su razlike svih mogućih parova u ogledu, po pitanju sva tri analizirana parametra početnog rasta korovske vrste *H. trionum*. Rezultati ovog testa su prikazani u tabelama 2, 3 i 4.

Tabela 2. Rezultati Tukey testa primijenjenog za ispitivanja značajnosti razlika za parametar procenat klijavosti vrste *H. trionum*
Table 2. Results of the Tukey test applied for testing significance of differences for the H. trionum germination (%)

Dio biljke ***Plant part***	**Ekstrakt (%)** ***Extract (%)***				**Opšti prosjek za dio biljke**
	10	5	2	0	
Cvijet ***Flower***	3,13a	55b	76,88c	73,13c	52,03a
List ***Leaf***	46,88a	78,13b	85,63b	73,13b	70,94b
Opšti prosjek za ekstrakt	25,01a	66,57b	81,26c	73,13bc	

Tabela 3. Rezultati Tukey testa primijenjenog za ispitivanja značajnosti razlika za parametar svježa masa (mg) klijanca vrste *H. trionum*
Table 3. Results of the Tukey test applied for testing significance of differences for the H. trionum fresh biomass (mg)

Dio biljke ***Plant part***	**Ekstrakt (%)** ***Extract (%)***				**Opšti prosjek za dio biljke**
	10	5	2	0	
Cvijet ***Flower***	0,1a	8,18b	29,13c	26,55c	15,99a
List ***Leaf***	7,26a	14,04b	13,26b		15,34a
Opšti prosjek za ekstrakt	3,68a	11,11b	21,20c	26,55d	

Tabela 4. Rezultati Tukey testa primijenjenog za ispitivanja značajnosti razlika za parametar dužina (cm) klijanca vrste *H. trionum*
Table 4. Results of the Tukey test applied for testing significance of differences for the seedling length (cm) of *H. trionum*

Dio biljke ***Plant part***	**Ekstrakt (%)** ***Extract (%)***				**Opšti prosjek za dio biljke**
	10	5	2	0	
Cvijet ***Flower***	0,5a	0,61a	6,3b	6,36b	3,44a
List ***Leaf***	0,62a	1,91b	3,5c	6,36d	3,09a
Opšti prosjek za ekstrakt	0,56a	1,26a	4,9b	6,36c	

Iz priloženih tabela može se uočiti da su vodeni ekstrakti koncentracije 10% dobijeni iz cvijeta nevena statistički veoma visoko značajno djelovali inhibitorno na analizirane parametre vrste *H. trionum* u odnosu na kontrolnu varijantu. Numerički niži ali i dalje statistički veoma visoko značajan inhibitorni efekat su ispoljili ekstrakti koncentracije 5% dobijeni iz cvijeta nevena na svježu masu i dužinu klijanca pomenute vrste. Ekstrakti koncentracije 2% nisu djelovali statistički značajno na analizirane parametre u odnosu na kontrolu. Kada su pitanju vodeni ekstrakti dobijeni iz lista nevena, postignut je sličan inhibitoran efekat povećanjem koncentracije. I u ovom slučaju najveći inhibitoran efekat (statistički visoko značajan) je ispoljila najveća testirana koncentracija ekstrakta prema analiziranim parametrima. Primjena ekstrakta koncentracije 2% je statistički značajno inhibirala svježu masu i dužinu klijanca vrste *H. trionum.* U pogledu interakcije za parametar klijavost, kombinacija tretmana 10% cvijet - 10% list se statistički veoma visoko značajno razlikuje, dok se kombinacija 5% cvijet - 5% list, statistički značajno razlikuje (grafikon 1). Za parametar svježa masa kombinacija tretmana 10% cvijet - 10% list se statistički veoma visoko značajno razlikuje dok se kombinacija 2% cvijet - 2% list statistički značajno razlikuje (grafikon 2). Istovjetna kombinacija se također statistički značajno razlikuje i za parametar dužina klijanca (grafikon 3).

U tabeli 5 su prikazani rezultati dvofaktorijalne analize varijanse u cilju utvrđivanja postojanja statistički značajnog uticaja oglednih faktora (koncentracija ekstrakta i dio biljke nevena) i njihovih interakcija na parametre početnog rasta indikatorske vrste *A. retroflexus.* Prema vrijednostima Fišerovog pokazatelja slično prethodno analizi primjenjivani ekstrakti različitih koncentracija su ispoljili statistički veoma visoko značajan uticaj na sve ispitivane parametre početnog rasta vrste *A. retroflexus*. Dio biljke nevena je imao samo statistički (veoma visoko) značajan uticaj na klijanje korova. Međudjelovanje ova dva faktora je imalo statistički veoma visoko značajan uticaj na klijanje i dužinu, odnosno statistički visoko značajan uticaj na masu ove vrste.

Tabela 5. Vrijednosti Fišerovog pokazatelja i statistička značajnost uticaja oglednih faktora na parametre početnog rasta vrste *A. retroflexus.*
Table 5. F values and the statistical significance of the effect of the experimental factors on the initial growth parameters of A. retroflexus

Ispitivani parametri ***Examined parameters***	**Ogledni faktori** ***Experimental factor***	**F pokazatelj** ***F value***	**p**	**Nivo značajnosti**
Klijavost (%) ***Germination (%)***	Ekstrakt	121,28	<0,001	***
	Dio biljke	15,43	<0,001	***
	Međudjelovanje	13,05	<0,001	***
Svježa masa (mg) ***Fresh biomass (mg)***	Ekstrakt	29,94	<0,001	***
	Dio biljke	0,29	>0,05	n.s
	Međudjelovanje	6,40	>0,01	**
Dužina klijanca (cm) ***Seedling length (cm)***	Ekstrakt	69,08	<0,001	***
	Dio biljke	0,15	>0,05	n.s
	Međudjelovanje	9,72	<0,001	***

S obzirom na ostvarene rezultate, primjenom Tukey testa testirane su razlike svih mogućih parova u ogledu za sva tri analizirana parametra početnog rasta korovske vrste *A. retroflexus*. Rezultati ovog testa su prikazani u tabelama 6, 7 i 8.

Tabela 6. Rezultati Tukey testa, primijenjenog za ispitivanja značajnosti razlika za parametar procenat klijavosti vrste *A. retroflexus*
Table 6. Results of the Tukey test applied for testing significance of differences for the A. retroflexus germination (%)

Dio biljke ***Plant part***	**Ekstrakt (%)** ***Extract (%)***				**Opšti prosjek za dio biljke**
	10	5	2	0	
Cvijet ***Flower***	0a	2,31a	36,54b	46,54b	21,35a
List ***Leaf***	0a	0,39a	7,31a		13,56b
Opšti prosjek za ekstrakt	0a	1,35a	21,93b	46,54c	

Tabela 7. Rezultati Tukey testa, primijenjenog za ispitivanja značajnosti razlika za parametar svježa masa klijanca vrste *A. retroflexus*
Table 7. Results of the Tukey test applied for testing significance of differences for the A. retroflexus fresh biomass (mg)

Dio biljke ***Plant part***	**Ekstrakt (%)** ***Extract (%)***				**Opšti prosjek za dio biljke**
	10	5	2	0	
Cvijet ***Flower***	0a	3,25b	2,77b	4,27b	2,57a
List ***Leaf***	0a	0,73a	4,53b		2,38a
Opšti prosjek za ekstrakt	0a	1,99b	3,65c	4,27c	

Tabela 8. Rezultati Tukey testa, primijenjenog za ispitivanja značajnosti razlika za parametar dužina klijanca vrste *A. retroflexus*
Table 8. Results of the Tukey test applied for testing significance of differences for the seedling length (cm) of A. retroflexus

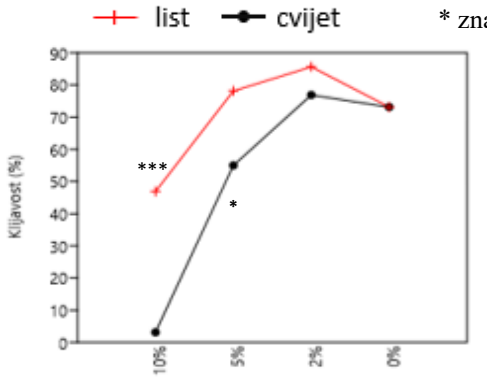
Dio biljke ***Plant part***	**Ekstrakt (%)** ***Extract (%)***				**Opšti prosjek za dio biljke**
	10	5	2	0	
Cvijet ***Flower***	0a	2,53b	3,25bc	4,38c	2,54a
List ***Leaf***	0a	0,75a	5,41b	4,38b	2,64a
Opšti prosjek za ekstrakt	0a	1,64b	4,33c	4,38c	

Iz podataka prikazanih u tabelama 6, 7 i 8, može se uočiti da su ekstrakti koncentracije 10% djelovali statistički veoma visoko značajno u slučaju kada su pripremljeni iz cvijeta, odnosno statistički visoko značajno značajno kada su pripremljeni iz lista nevena, na inhibiciju parametara početnog rasta vrste *A. retroflexus,* u odnosu na kontrolu. Ekstrakti koncentracije 5% su ispoljili nešto slabiji inhibitoran uticaj koji je naročito bio izražen u slučaju pripremanja od lista nevena. Najslabiji inhibitoran efekat je ispoljila najniže pripremljena koncentracija kako iz lista tako i iz cvijeta nevena. U pogledu interakcija, za vrstu *A. retroflexus* kombinacija 2% cvijet - 2% list se statistički veoma visoko značajno razlikuje kod parametra procenat klijavosti (grafikon 4). U okviru analiziranja parametra svježa masa, kombinacija 5% cvijet - 5% list se također statistički veoma visoko značajno razlikuje. Za parametar dužina klijanca, kombinacije 5% cvijet - 5% list i 2% cvijet - 2% list se statistički visoko značajno razlikuju.

Shodno prikazanim rezultatima, ispitivanje alelopatskog potencijala nevena u dvofaktorijalnom ogledu je pokazalo osjetljivost obje indikatorske vrste, što bi moglo imati praktični značaj kada se uzme u obzir činjenica da su iste prisutne u većem broju, jedan od ograničavajućih faktora uspješne biljne proizvodnje na području BiH. Rezultati međuodnosa ispitivanih faktora su pokazali da je najveći inhibicijski efekat prema početnom rastu obje indikatorske vrste (*H. trionum* i *A. retroflexus*) u odnosu na ostale kombinacije, ispoljio vodeni ekstrakt cvijeta nevena koncentracije 10%.

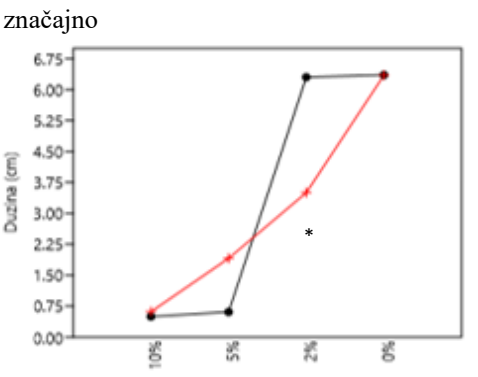
U svojim istraživanjima i drugi autori su došli do sličnih rezultata u pogledu inhibitornog efekta nevena na parametre početnog rasta pojedinih korovskih vrsta. Prema Đikić (2004) vodeni ekstrakti koncentracije 20% dobijeni iz svježe mase nevena u ogledu sa Petri posudama su ispoljili statistički značajan inhibitoran efekat na procenat klijanja korovske vrste *Galinsoga parviflora* Cav.
Baličević *et al*. (2014) su ispitivali alelopatski potencijal nevena prema korovskoj vrsti *Cardaria draba* L. Zajedničko klijanje nevena i analiziranog korova rezultiralo je u stimulativnom efektu nevena prema korovu. Međutim, ekstrakt suhe mase nevena smanjio je klijavost korova za 96,9%. Ekstrakt svježe mase u prosjeku je smanjio klijavost za 11,9% a najviše za 17,6%. Balah & Latif (2013) su u laboratorijskim

uvijetima dokazali alelopatski inhibitoran uticaj vodenih ekstrakata pripremljenih od osušene nadzemne mase nevena prema korovskim vrstama *Lolium multiflorum* Lam. i *Phalaris paradoxa* L., a koje su često prisutne u usjevima pšenice. Autori smatraju da ekstrakti imaju herbicidno svojstvo te zbog sposobnosti inhibicije procenta klijanja i rasta klijanaca korova i pšenice se ne bi smjeli koristiti u najvećim količinama (40 mg ml^{-1}). Međutim, u ograničenoj upotrebi sa najvećim količinama, isti bi se prema navedenim autorima mogli koristiti u *pre emergence* periodu, kako bi se spriječila pojava pojedinih korova te izbjegao štetan uticaj na prinos pšenice.

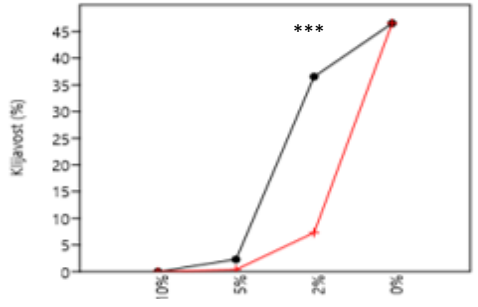


Grafikon 1. Odnos sredina modaliteta faktora za klijavosti *H. trionum*

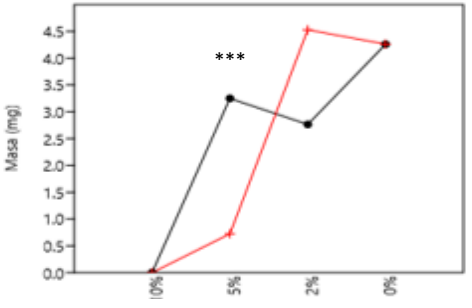
Grafikon 2. Odnos sredina modaliteta faktora za masu *H. trionum*



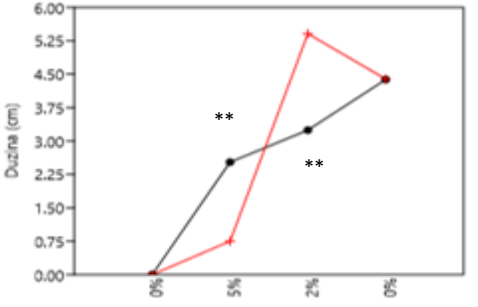
Grafikon 3. Odnos sredina modaliteta faktora za dužinu *H. trionum*



Grafikon 4. Odnos sredina modaliteta faktora za klijavosti *A. retroflexus*



Grafikon 5. Odnos sredina modaliteta faktora za masu *A. retroflexus*



Grafikon 6. Odnos sredina modaliteta faktora za dužinu *A. retroflexus*

* značajno; ** visoko značajno; *** veoma visoko značajno

ZAKLJUČAK

Rezultati ovog ogleda su pokazali da primjena vodenih ekstrakata (10 i 5%) od osušenih cvjetova i listova nevena utiče na inhibiciju početnog rasta ispitivanih korovskih vrsta. Proporcionalno povećanju koncentracije primjenjivanih ekstrakata, povećavao se inhibitorni efekat. Podjednako na različite ekstrakte su bile osjetljive obje korovske vrste. Mogućnost korištenja alelopatskog potencijala nevena u cilju suzbijanja korova, zahtijeva dodatna istraživanja u laboratorijskim i poljskim uvjetima.

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INVESTIGATION OF MARIGOLD (*Calendula officinalis* L.) ALLELOPATHIC POTENTIAL ON THE INITIAL GROWTH OF FLOWER OF AN HOUR (*Hibiscus trionum* L.) AND REDROOT PIGWEED (*Amaranthus retroflexus* L.)

Summary

The goal of this study was to examine effect of different concentration of aqueous extracts from dried flowers and leaves of marigold on the initial growth parameters of weed species *Hibiscus trionum* L. and *Amaranthus retroflexus* L. The experiment was set up under laboratory conditions in Petri dishes in four replication. Two-factorial (concentration of extract x part of marigold plant) analysis of variance was performed using statistical program PAST v 3.25. The aqueous extracts of 10 and 5% concentration exhibited inhibitory effect on the analyzed parameters of the initial growth of weed species.

Due to the increase in the concentration of the extracts, the inhibitory effect increased. In comparison to the other variants, marigold flower aqueous extracts (10%) showed the best inhibitory effect against the initial growth of both weeds. Possible use of marigold allelopathic activity for weed control in sustainable agriculture demands an additional testing primarily under field conditions.

Key words: *marigold, aqueous extracts, initial growth parameters, inhibition, weeds*

ANALYSIS OF CATTLE PRODUCTION IN OSIJEK-BARANJA COUNTY USING THE COBB-DOUGLAS MODEL

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Original scientific paper

Summary

Local development is inconceivable without investment in the creation of new value. This process means an increase in production of goods and services, with simultaneous structural transformations and changes in the functioning of the local economy. The purpose of this study was to, through Cobb-Douglas's function, calculate the value of cattle production in Osijek-Baranja County, that is to show the relationship between a certain amount of labour and capital. Based on performed analysis it could be concluded that Cobb-Douglas's model of production value calculation is applicable in practice. Also, labour productivity and technological capital have been demonstrated as two parameters that affect the volume of production and by different combinations of these two parameters the volume of production can be changed. Generally speaking, it is necessary to focus on cost reduction. In this case, the Osijek-Baranja County has a lower opportunity cost in cattle production compared to other counties in the Republic of Croatia. With this, lower costs and specialization of production have a relative advantage over the competition. Greater labour costs reduce production volume and move production to other areas where the wages are lower. But also, low labour costs, although increasing the volume of production, have a disincentive effect on the labour supply, or stimulate the migration of working-age people into areas where wages are higher.

Key words: *cattle production, Cobb-Douglas function, labour productivity, capital*

INTRODUCTION

Charles Cobb and Paul Douglas in 1928 published a study entitled "*The theory of production*" in which they presented the model of growth of the US economy in the period between year 1899 and 1922. With a very simple overview of the state economy, a function of production was determined. The value of function determines the relationship between a certain amount of labour and the amount of capital. The production function used to model production is as follows:

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$$P(L;K) = bL^{\alpha} K^{\beta} \qquad (1)$$

Where:
P - Value of all goods produced in one year (total production)
L - Total number of working hours of all persons working in one year (labour)
K - Value of invested capital (capital)
b - The parameter that reflects the technological level of production
α - Measure of the approximate percentage change in productivity P one percent change capital
β - Measure of productivity change P at one percent change of labour L and constant capital value K.
Cobb-Douglas's function is most commonly used in the case of $\beta = 1 - \alpha$, so the following equation is derived (Varijan, 2008):

$$P(L;K) = bL^{\alpha} K^{1-\alpha} \qquad (2)$$

The reason is that this function has the property that if the quantity of capital K and the amount of working hours L are increased by m times, then the quantity of production P will be increased by m times. Furthermore, the difference in opportunistic costs makes it possible to redesign production from one region to another (Golub and Hsieh, 2000). Accordingly, to Jones (1965) the production orientation focuses on the specialization of the production of those goods where the opportunity cost is lower than the production of other goods, where the resources can be utilized at a lower cost. Agricultural production in Osijek-Baranja County is a strategic industry for the reason that this area is rich in high-quality arable land. Since every economy has limited resources, and thus limited production possibilities, concessions have to come to the fore (Porter, 1990), i.e. produce more of those goods that bring greater benefit than other goods where the benefit is less pronounced. The purpose of this study was to, through Cobb-Douglas's function, calculate the value of production, analyse the combination of labour and capital, and determine what happens when production doubled and finally show the regression between total working hours and the value of invested capital.

MATERIALS AND METHODS

The analysis of production possibilities was carried out on cattle production in Osijek-Baranja County. The data presented in Table 1 represent the parameters that are required to apply the Cobb-Douglas function. The data were obtained from the Agricultural Payments Agency and refer to the period from year 2015 – 2018.

Tab. 1. The value of the production of cattle, the consumption of working hours and the value of the invested capital in the Osijek-Baranja County (in 000 Eur)

Year	P (value of cattle production)	L (total number of working hours)	K (value of invested capital)
2015	87,867	82,384	95,327
2016	84,258	79,258	95,233
2017	86,292	80,992	96,886
2018	86,331	81,331	98,366

RESULTS AND DISCUSSION

The values of calculated production using the Cobb-Douglas function for analysis of data are presented in Table 2:

Tab. 2. The value of the calculated production Using the Cobb-Douglas function (in 000 Eur)

Year	**P(L;K)**	**$bL^{\alpha} K^{1-\alpha}$**	**Calculated P**
2015	82,384; 95,327	1.01*(82,384)*0.75*(95,327)*0.25	86,084.94
2016	79,258; 95,233	1.01*(79,258)*0.75*(95,233)*0.25	83,602.69
2017	80,992; 96,886	1.01*(80,992)*0.75*(96,886)*0.25	85,337.10
2018	81,331; 98,366	1.01*(81,331)*0.75*(98,366)*0.25	85,929.91

The obtained amounts are approximately equal to the real values (P) presented in the Table 1. According to the calculation parameters, it can be concluded that the production of one unit in cattle production depends more of the change of the en-gaged labour and less of the value of capital.

Applying the same equation, it is possible to determine the combination of labour and capital required to produce 100,000 units in cattle production, and to analyse what happens when doubling production for the function $P(L;K) = bL\alpha\ K\ 1-\alpha$.

If we determine that the parameter that reflects the technological level of production is 1000 then:

$P(L;K) = 1000L^{0.8} K^{0.2}$

$100.000 = 1000L^{0.8} K^{0.2}$

whereupon after shortening and potentiation we get

$L^4K = 100^5$, respectively:

$K = 100^5/L^4$

Each combination of work and capital that meets this equation allows us to produce 100,000 units of products. If the production is doubled, then the function is as follows:

$200.000= 1000L^{0,8} K^{0,2}$.

The regression model (Figure 1 and 2) shows trends in changes of parameters of labour and capital in the production of cattle according to data from the Table 1. If the value of cattle production increase by 1, it would cause an increase in number of working hours for 0.87 on the representativeness of 98.78% (Figure 1).

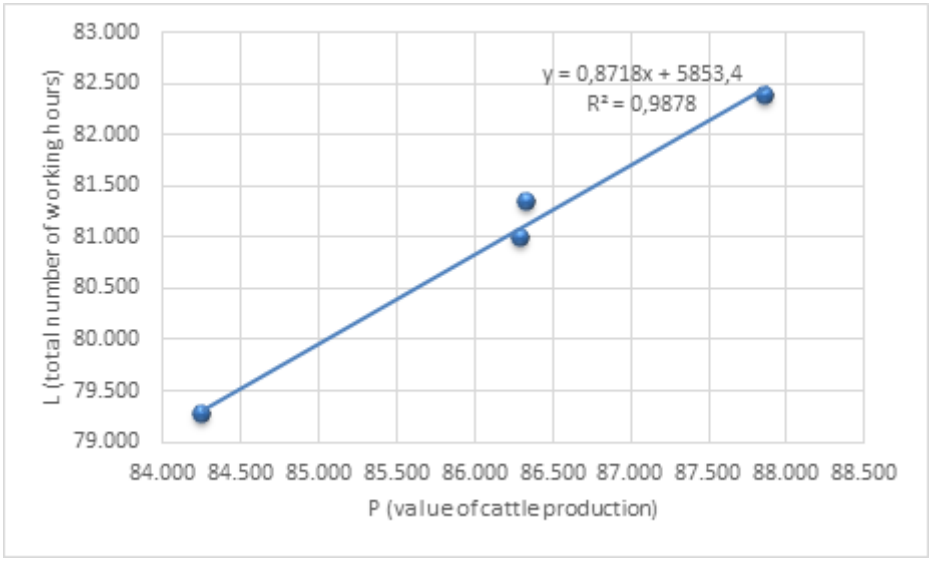

Fig. 1. Linear regression between value of cattle production (P) and total number of working hours (L)

If the value of cattle production increase by 1, it would cause an increase in the value of invested capital for 0.12 on the representativeness of 1.41% (Figure 2).

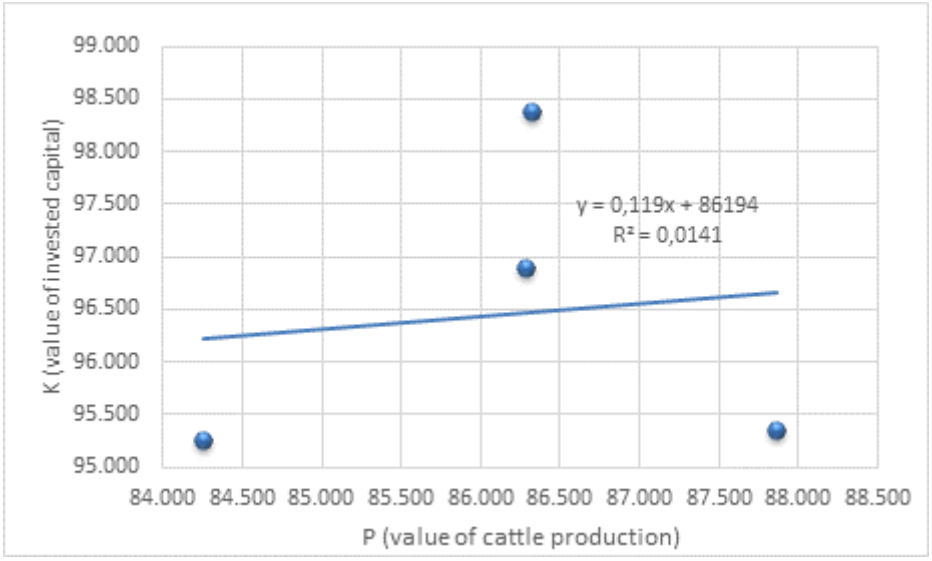

Fig. 2. Linear regression between value of cattle production (P) and K (value of invested capital)

Accordingly, to Haluška and Čubela (1999) the value of cattle production depends on labour productivity, degree of technical resources, production technology, labour organization and other elements of production. An important factor in economic growth is human capital, which represents the amount of skills and knowledge a certain worker owns and uses in the work or production process. The macroeconomic perception of this definition observes the average level of knowledge and skills of the workforce of a particular country or geographic area used in the production process. The relationship between human resources and economic growth is based on the fact that the levels of knowledge and skills of the labour force are inversely proportional to the productivity of labour. Furthermore, the importance of accumulation of knowledge and skills, resulting from "formal" education or, to a certain extent, the consequences of the learning process through work, should be emphasized. Lucas (1988) states that the faster the accumulation of human capital the faster is growth of productivity and the higher equilibrium GDP growth rate per worker. The additional productivity needed to neutralize the static drop in yields, keeping the ratio of capital to production as a constant size is realized by technical changes (Brkić, 1993). Furthermore, Ćorić and Petrović Mališević (2013) stated that human knowledge is very important because it precisely determines the maximum rate of technological progress - the speed of creation of knowledge is conditioned by the accumulation of knowledge. Innovation efforts are often identified with companies, but their importance refers to the entire economy, since as just as businesses need to constantly update through innovations, economies must also change. The ability to innovate is inextricably linked to the competitiveness of both individual companies and entire economies, and the effect of the lack of innovation on both is greater than it had been before. According to Atkinson and Ezell (2014) before the race for global innovation advantage, innovation failure meant slower growth but today, this failure creates unsuccessful companies, loss of national competitiveness, stagnation and ultimately a structural economic crisis, especially in developed countries.

CONCLUSIONS

Based on conducted research it could be concluded that Cobb-Douglas's model of production value calculation is applicable in practice. Furthermore, labour productivity and technological capital have been demonstrated as two parameters that affect the volume of production and by different combinations of these two parameters the volume of production can be changed. However, as economics is a complex area, a volume and value of production are influenced by a multitude of factors. Generally speaking, it is necessary to focus on cost reduction. In this case, the Osijek-Baranja County has a lower opportunity cost in cattle production compared to other counties in the Republic of Croatia. With this, lower costs and specialization of production have a relative advantage over the competition. Greater labour costs reduce production volume and move production to other areas where the wages are lower. But also low labour costs, although increasing the volume of production, have a disincentive effect on the labour

supply, or stimulate the migration of working-age people into areas where wages are higher.

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ANALIZA PROIZVODNJE GOVEDA SUKLADNO COBB-DOUGLAS MODELU NA PRIMJERU OSJEČKO-BARANJSKE ŽUPANIJE

Rezime

Lokalni razvoj nezamisliv je bez ulaganja u stvaranje novih vrijednosti. Ovaj proces označava porast proizvodnje dobara i usluga, uz istovremene strukturne transformacije i promjene u funkcioniranju lokalne privrede. Cilj je ovoga rada, pomoću Cobb-Douglas modela, izračunati vrijednost proizvodnje goveda u Osječko-baranjskoj županiji, odnosno pokazati odnos između određene količine rada i količine kapitala. Temeljem provedene analize može se zaključiti da je Cobb-Douglas model izračuna vrijednosti proizvodnje primjenjiv u praksi. Također, produktivnost rada i tehnološki kapital prikazani su kao dva parametra koja utječu na količinu proizvodnje, a različitim kombinacijama ova dva parametra može se mijenjati i obujam proizvodnje. Općenito govoreći, potrebno je usredotočiti se na smanjenje troškova. U ovom slučaju Osječko-baranjska županija ima niži oportunitetni trošak u proizvodnji goveda u usporedbi s ostalim županijama u Republici Hrvatskoj. Uz to, niži troškovi i specijalizacija proizvodnje imaju relativnu prednost nad konkurencijom. Veći troškovi rada smanjuju obujam proizvodnje i premještaju proizvodnju u druga područja gdje su plaće niže. No, isto tako, niski troškovi rada, iako se povećava obujam proizvodnje, imaju učinak obeshrabrenja na ponudu radne snage, ili potiču migraciju radno sposobnog stanovništva u područjima u kojima su plaće veće.

Ključne riječi: *proizvodnja goveda, Cobb-Douglas funkcija, produktivnost rada, kapital*

ANALYSIS OF SLEEPING BEHAVIOUR IN DAIRY COWS

Mirna Gavran[1], Pero Mijić[1], Zvonimir Steiner[1], Vesna Gantner[1]

Review paper

Summary

Sleep is a naturally-occurring, reversible, periodic and recurring state in which consciousness and muscular activity is temporarily suspended or diminished, and responsiveness to outside stimuli is reduced. Many human sleep studies have been conducted so far, while animal sleep has not yet been fully explored. Precisely, very little is known about sleeping and resting in dairy cattle, but they do lie down for up to 10-14 hours per day, standing up every few hours, eating, stretching and then lying back down again. Cows need time for eating, drinking, milking, and also for performing social behaviour. Some studies shown that the total amount of sleep and distribution of sleep over 24 hours vary depending on age, health status, pregnancy and lactation. Used method was non-invasive electrophysiological technique for recording sleep in dairy cows for investigation variations in sleep pattern. Changes in the environment also effect on distribution of sleep and behaviour in cows, such as moving cows between groups consequently will be reflected in lying time and feeding behaviour. Moreover, lack of lying and sleep has influence on production and welfare of dairy cows. The aim of this study was to review the importance of lying behaviour and sleep and their impact on dairy cows' production and welfare.

Key words: *dairy cows, sleeping, behaviour*

INTRODUCTION

Sleep is a naturally-occurring, reversible, periodic and recurring state in which consciousness and muscular activity is temporarily suspended or diminished, and responsiveness to outside stimuli is reduced. Many human sleep studies have been conducted so far, while animal sleep has not yet been fully explored. Precisely, very little is known about sleeping and resting in dairy cattle, but they do lie down for up to 10-14 hours per day, standing up every few hours, eating, stretching and then lying back down again. Cows need time for eating, drinking, milking, and also for performing social behaviour. According to von Keyserlingk *et al*. (2012), it is well established that lying behaviour is a sensitive measure of cow comfort, but reliable assessment of lying behaviour requires detailed observation of individual cows for extended periods of time. In accordance to Mason (2017), earlier studies of lying behaviour has demonstrated that lying behaviour in free-stall barns is affected by: pen and alley size, layout and flooring; stall location relative to feeding and milking facilities; stall

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dimensions, surface and bedding quality and quantity; stocking density – the number of usable stalls available per cow; social interactions between cows; heat stress; the amount of time cows are restricted from access to stalls; individual cow parity, stage of lactation, production level and health status. Since lying and sleeping represent significant part in life of individual animal the aim of this study was to review the importance of lying behaviour and sleep and their impact on production and welfare.

LYING BEHAVIOUR IN DAIRY COWS

Lying behaviour is high priority behaviour. Lack of lying and sleep has an impact on both production and welfare of dairy cows. The dairy cow appears to have a strong behavioural need for adequate rest. Dairy cattle are highly motivated to lie down for approximately 12 hours per day (Grant, 2004; Cook *et al*., 2005; Drissler *et al*., 2005; Munksgaard *et al*., 2005; Fregonesi *et al*., 2007; Gomez and Cook, 2010). According to Temple *et al*. (2016), lying is high priority behaviour, even higher than eating and social contact when opportunities to perform these behaviours are restricted. Having enough time for lying is important, as reduced lying time can affect both production and welfare in dairy cows. A cow that is lying is more likely to ruminate and produce saliva than a standing cow reducing ruminal acidosis. A lying cow also has an increased blood diffusion through the udder (around 5 litters/min) compared with a standing animal (around 3 litters/min). This improves udder function and milk production. When a cow is standing too much time, the pressure inside the claw capsule increases and produces hypoxia (restricted oxygen supply) and ischemia (restricted blood flow) increasing the risk of lameness. Furthermore, competition for a comfortable resting place can trigger social conflicts between the cows with an increase of chronic stress reaction which predisposes herds to diseases and reproductive problems.

In order to evaluate cows' comfort around resting several behavioural indicators could be used: the time spent lying down, the frequency of lying bouts and the duration of individual bouts. Cows on comfortable flooring lay down for longer times on the entire day and the duration of each lying is shorter meaning that cows stand up more frequently and remained standing for shorter periods of time. Cows prefer to remain standing rather than experience the pain associated with lying or rising movement when housed on rough resting surfaces. They may also be an increased number of cows lying partially or totally out of the resting area (e.g. in the passage way) and in uncomfortable stall an increased number of cows is "perching" (with two front feet in the stall and two rear feet in the corridor) inside the stalls. The average time that cows lie down each day varies, depending on, for instance, aspects of stall design. Uncomfortable conditions (hard floors, wet bedding, or small stalls) reduce cow lying time and reduced lying time has been associated with higher incidence of injuries (Vasseur *et al*., 2012). Chaplin (2000) noticed that the duration of lying depends also on stage of lactation. Furthermore, in the research of Chaplin and Munksgaard (2001), the total lying time was influenced not only by the stage of lactation, but also by the number of lying bouts, maximum bout length and rising behaviour, while slight impact of lactation number was

on lying behaviour. Cows in early lactation spent less time lying and had a shorter maximum bout length than cows in late lactation and dry cows. Dry cows had a lower lying frequency. Cows in late lactation had the least problems when rising. The lying behaviour of cows in early lactation may be affected by udder discomfort, while rising behaviour of dry cows may be disrupted by the extra weight of the calf. In agreement, rising score was lowest for cows in late lactation. Furthermore, the characteristics of resting area (long, short, wide of narrow) affect the cow's position during the lying time (Picture 1).

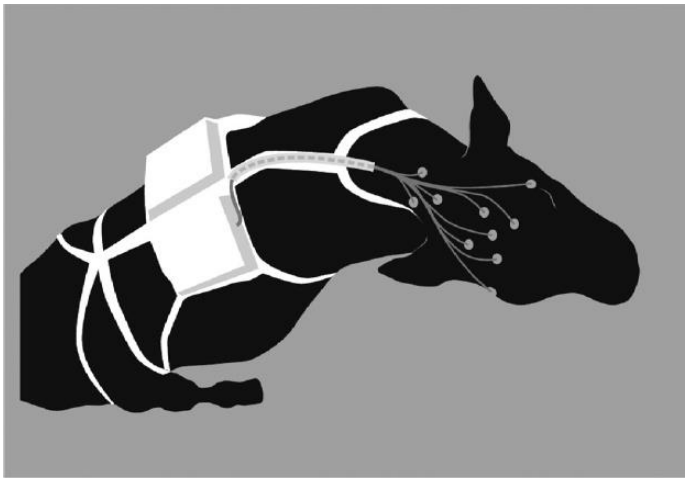
Pic. 1. Cow's position regarding the characteristics of resting area – long, short, wide of narrow (DeLaval, 2007)

SLEEPING BEHAVIOUR IN DAIRY COWS

Enough sleep time is one of the most important preconditions for an adequate metabolic system and for the function of the immune system (Ternman *et al*., 2012). Sleep in animals is often estimated by behavioural observations, or recorded on restrained animals with invasive electroencephalogram (EEG) techniques, which might affect sleep patterns. Earlier studies showed that cows sleep about 4 h per day and drowse almost twice the time. According to Zepelin *et al*. (2005), knowledge about sleep comes primarily from research on mammalian species, whose daily sleep quotas range from 4 to 19 hours, with rapid eye movement (REM) sleep occupying 10% to 50% of this time. Adult cattle sleep for about 4 hours per day, mainly during the night time. Sleep, especially REM sleep (rapid eye movement sleep), occurs most often when the cow is resting with her neck relaxed with the head resting on the side (Picture 2).

Pic. 2. Cow's position during the sleeping (Kull and Krawczel, 2016)

Cows who are well adapted to their environment rarely engage in sleep while is in standing position. Decreased lying time reduces the possibility for the cows to rest and sleep. A reduction in lying time due to poor housing is likely to have a more severe effect on animal welfare if the time spent sleeping is reduced. Lack of sleep can alter the endocrine system, increase energy cost and impair the immune function.
Sleeping behaviour could be monitored by non-invasive EEG method (Picture 3). For instance, Ternman *et al*. (2012) used non-invasive EEG method in their research to record and differentiate between vigilance states in dairy cows. Brain activity, eye movements and muscle activity were recorded for 6 h per animal using surface-attached electrodes to measure different vigilance states. The EEG recordings showed that non-rapid eye movement (NREM) sleep displayed low frequency waves, sometimes with slow wave activity, while on the other hand rapid eye movement (REM) sleep and alert wakefulness shared similar features of desynchronised waves with varying frequency and could be differentiated by reduced neck muscle activity during REM sleep.



Pic. 3. Electrode placement and equipment for non-invasive EEG recordings in dairy cows (Ternman *et al*., 2012)

LYING AND SLEEPING IN FUNCTION OF COW'S WELFARE

The quality of the surroundings in which dairy cows are kept can have a big influence on their well-being. Lying comfort is very important to dairy cows. Long lying times are needed to maintain good cow health. This means that dairy cows need to have comfortable lying areas, to make sure they spend enough time lying down. In accordance to Chaplin (2000), lesions to hocks, knees and teats and association with increased heart rate and changes in cortisol secretion can be as result of problems with lying down and rising in cattle can result, thus affecting animal welfare. On lying down and rising can also affect number of factors in the environment. For instance, tethered cows examined the lying place more prior to lying, had more interruptions of lying down, took longer to lie down and had a reduced frequency of lying compared to cows which were loose housed on straw bedding. According to DeLaval (2007), cows need to lie down, because reduction in lying time reduces milk production. Importance of lying down is evident in: cow rests and ruminates when it is lying down; cow's hooves rest and dry off; there is also more space for other cows to walk around in a barn; there is an increase of blood circulation through the udder by up to 30 percent. Further, it is very important to control flies in resting area because they cause irritation and stress. As a consequence, milk yields decrease and milk quality is also jeopardized due to various bacteria and viruses they might carry. Reducing the fly population in resting area means less stress and less disease. In accordance to Kull and Krawczel (2016), just a few hours of sleep deprivation in humans improves the risk of cancer, cardiovascular disease and the common cold. From the standpoint of dairy cattle, lack of sleep will probably change immune function.

CONCLUSIONS

Lying and sleeping time is highly important part of a cow's day and the absence or decrease in quality of it reflects on cow's performance and health. Lying time is important since: cow rests and ruminates during the lying, the cow's hooves rest and dry off, blood circulation through the udder increases by up to 30 percent (enabling high milk productivity) and finally there is more space for other cows to walk around in a barn (enabling higher comfort level in the facility). Furthermore, sleep is likely to be critical from the welfare aspects, such as sleep helps with healing. Generally, the body goes through a proinflammatory state during the sleeping time. This proinflammatory state is crucial for adequate immune response of an organism. Furthermore, sleeping deprivation in cows will probably alter the immune function resulting in shift of resources away from production and consequently in production decrease. Considering the high importance of lying and sleeping behaviour in cows and their effect on cow's production and welfare, for the adequate functioning of the dairy farm, it is extremely important to ensure optimal conditions in the facilities as well as the natural animal behaviour as much as possible.

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ANALIZA PONAŠANJA PRI SPAVANJU KOD MLIJEČNIH KRAVA

Rezime

Spavanje je prirodno, reverzibilno, periodično i ponavljajuće stanje u kojem se svijest i mišićna aktivnost privremeno obustavljaju ili smanjuju te se smanjuje reakcija na vanjske podražaje. Dosad su provedene mnoge studije ljudskog sna, dok spavanje životinja još nije u potpunosti istraženo. Preciznije, vrlo malo se zna o spavanju i odmaranju kod mliječnih goveda, ali oni leže i do 10-14 sati dnevno, ustaju svakih nekoliko sati, jedu, protežu se i zatim opet leže. Kravama je potrebno vrijeme za jelo, piće, mužnju pa i za društveno ponašanje. Neke studije pokazale su da ukupna količina sna i distribucija sna tijekom 24 sata variraju ovisno o dobi, zdravstvenom stanju, trudnoći i laktaciji. Korištena je metoda neinvazivne elektrofiziološke tehnike snimanja spavanja kod mliječnih krava radi ispitivanja varijacija u obrascu spavanja. Promjene u okolišu utječu i na distribuciju sna i ponašanje kod krava, kao što je kretanje krava između skupina, što će se odraziti na vrijeme ležanja i ponašanje tijekom hranjenja. Štoviše, nedostatak ležanja i sna utječe na proizvodnju i dobrobit mliječnih krava. Cilj ove studije je pregled važnosti ponašanja ležanja i spavanja te njihov utjecaj na proizvodnju i dobrobit.

Ključne riječi: *mliječne krave, spavanje, ponašanje*

APPLICATION OF ESSENTIAL OILS AND PROBIOTICS IN CALF FEEDING

Zvonimir Steiner[1], Mario Ronta[1], Vesna Gantner[1], Mirna Gavran[1], Josip Novoselec[1], Željka Klir[1], Filip Mamić[1]

Original scientific paper

Summary

The aim of the study was to determine the effect of the addition of essential oils and probiotics in the calves feed. The study was conducted on 70 male calves, crossbred Belgian blue cattle and Simmental. The calves are divided into two groups of 35 calves of an average age of 60 days previously weighed and balanced by body weight. The control group was fed a ration without supplements, while essential oils and probiotics were added to the ration of the experimental group. The duration of the study was 77 days. Production traits, i.e. body weight, average daily gain and food conversion, were monitored. The results obtained for body weight were higher in the experimental group than in the control group (5397 : 4918 kg). The results of the average daily gain were also higher in the experimental group than in the control group (0.62 : 0.78 kg). The feed conversion ratio was lower in the experimental group compared to the control (2.10: 1.56 kg / kg). Based on the results it can be concluded that the addition of essential oils and probiotics in calves ration has a positive impact on the monitored production traits.

Keywords: *probiotics, essential oils, natural supplements, calves, production traits*

INTRODUCTION

In order to reduce the use of antibiotics in cattle production, supplements that represent an alternative to antibiotics such as essential oils and probiotics are increasingly used. Essential oils are the most concentrated form of fitobiotics and represent a mixture of secondary metabolites of plants that contain numerous active ingredients such as thymol, anethol, cardol, cardanol, capsaicin, cinnamaldehyde and eugenol (Doorman *et al.*, 2000; Tekeli *et al*., 2007). Essential oils are considered to have antibacterial, antiviral, antifungal, insectic and herbicidal properties and that these properties result from their interaction with the cell membrane causing conformational changes and affecting cell metabolism (Doorman *et al.*, 2000; Benchaar *et al*., 2008; Miguel *et al.*, 2010). Numerous studies indicate that essential oils have a positive effect on rumen fermentation and nutrient utilization (Hristov *et al*., 1999; Beauchemin *et al*., 2007; Calsamiglia *et al*., 2007). The use of essential oils instead of antibiotics in cattle

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feeding can also have a positive impact on production traits such as feed consumption and feed conversion (Calsamiglia *et al*., 2007; Khiaosa-Ard *et al*., 2013), which is of particular interest in young ruminants and is associated with positive changes in the gut microflora (Poudel *et al.*, 2019). In order to establish a favourable intestinal microflora in ruminants, probiotics are increasingly used. As probiotics have a positive effect on the development of beneficial gut flora and inhibit the growth of pathogenic bacteria, their use is expected to have a positive effect on feed utilization, body weight and livestock health (Hou *et al*., 2007). The addition of probiotics during the most delicate phase of calving or weaning can improve production traits (Yohe *et al*., 2015). In older cattle categories, the use of probiotics can improve feed digestion and thus can improve the utilization of forage, especially cellulose, and microbial protein synthesis (Uyeno *et al*., 2015). The most commonly used probiotics in cattle feeding are bacteria from the genera Lactobacillus, Bifidobacterium and Enterococcus (Uyeno *et al*., 2015). Enterococcus faecium is the most commonly used bacterium of the genus Enterococcus and is an integral part of the intestinal microflora and antagonist to enteropathogenic bacteria, it also favorably influences the development of bacteria of the genus Lactobacillus and raises the rumen pH in animals fed a high content of concentrated feeds (Vahjen *et al*., 2002; Nocek *et al*., 2002; Benyacoub *et al*., 2005). The aim of this study was to determine the influence of the addition of essential oils and probiotics (*E. faecium*) in beef cattle.

MATERIALS AND METHODS

The purpose of this experiment is to practically prove the advantage of using Crina ruminants and Cylactin in feeding calves. These preparations are used in the first stage of fattening calves - in the first 60 days after arrival of the calves on the farm. Crina ruminants is a blend of essential oils, it contains thymol, eugenol, vanillin and limonene. Cylactin is a probiotic feed supplement. It contains *Enterococcus faecium* in the amount of 2x1010 per gram.

In our experiment the calves were crossbreeds of Belgian Blue Cattle and Simmental Breeds. All calves were male. On the first day after arrival, the calves received electrolytes, and then for the next five weeks were fed a milk replacer twice daily at 2 L per meal (4 L per day). Within the first three days of arrival at the farm, the calves were treated with: antibiotics, analgesics, antiparasitics and vaccines. After a period of 5 weeks, the calves receive a milk replacer once daily for the next week. The milk replacer consists of skimmed milk powder, sweet whey, a mixture of vegetable oils (palm oil 60%, coconut oil 30%, emulsifier 10%). During the entire experiment, the calves were given water *ad libitum*, as well as a mixture and wheat straw. The calves were divided into two groups, each group of 35 calves of an average age of 60 days previously weighed and balanced by body weight. Each group was in one row, divided into five boxes by seven calves in the box. The calves were weighed before entering the boxes to obtain two groups with as close a weight as possible. The experiment lasted 77 days. To calculate feed conversion, we measured the amount of mixture consumed.

The results of the experiment were processed using the Statistica computer program (StatSoft, Inc., 2012). Significance of differences between group mean values was determined by the GLM (General Linear Model) method, analysis of variance (ANOVA), significance of differences between the mean values of individual groups was determined using the Tukey post hoc test, when analysis of variance showed that there was significance of differences.

Table 1. Composition of premixtures and mixtures

Finished feed + cake	Finished feed
Cake - 11,1 %	Premiks+cake - 21,6 %
Baking soda - 2,3%	Feed flour - 20 %
Salt - 2,3 %	Soybaen meal - (46%)- 14%
Monocalcium phosphate - 2,8 %	Wheat - 16%
Chalk - 11,6%	Corn - 28,4 %
Mikro premiks - 3,7 %	
Mycosorb alltech - 2,3 %	
Carob - 40,7%	
Brewer s yeast - 23,1 %	

RESULTS AND DISCUSSION

The results are presented in figures 1, 2, and 3. Figure 1. shows the average values of the body weight of calves at the beginning and end of the experiment, Figure 2. shows the values of average daily gain of the experiment and Figure 3. Shows the average values of feed conversion of the same.

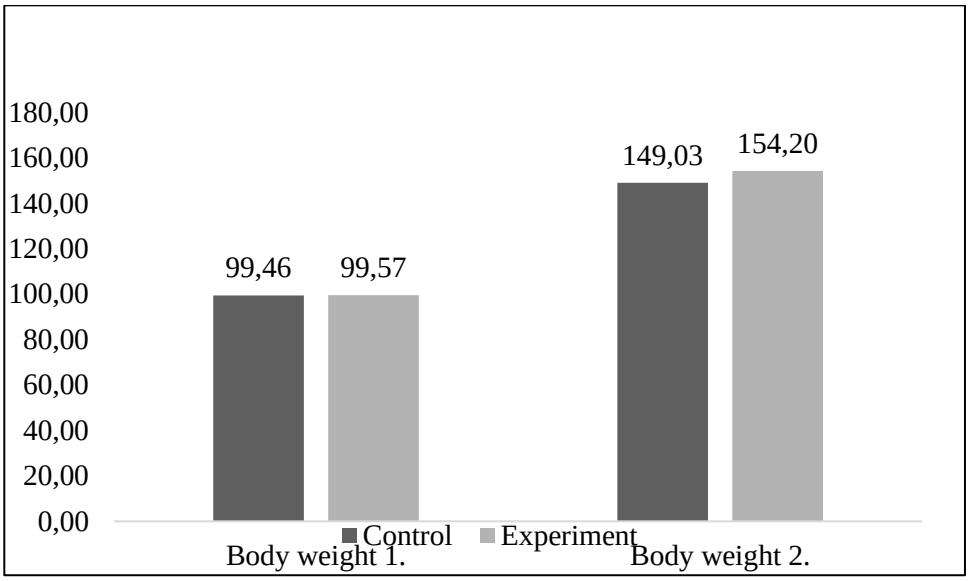

Fig. 1. Body weight of control and experimental group (kg)

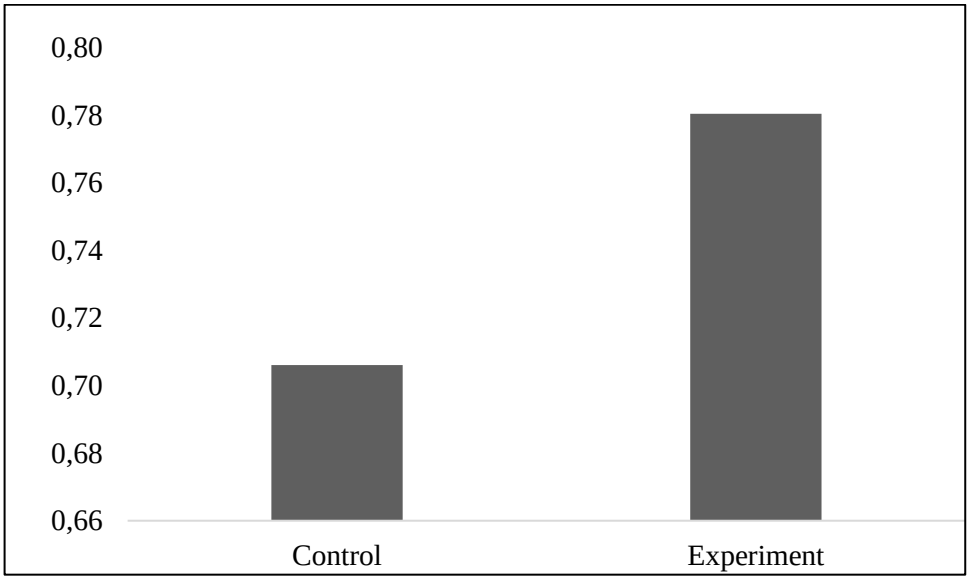

Fig. 2. Average daily gain of control and experimental group (kg)

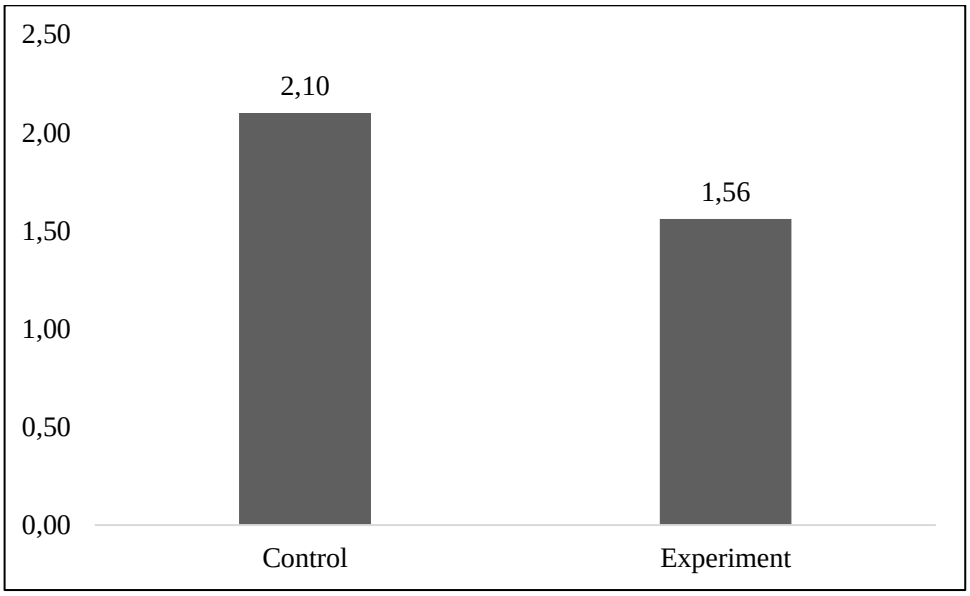

Fig. 3. Feed conversion of control and experimental group (kg/kg)

The average weight of the calves from the control groups was 149.03 kg and the average weight of the experimental group was 154.2 kg. No significant differences were found between body weight values. Similar results were obtained by Benchar *et al.* (2006) in their experiment who also did not find significant differences between body weights using essential oils, as Meyer *et al.* (2007) who used the same supplement as in our experiment. Zhang *et al*. (2016) in their study used probiotics and also found no significant differences. The calves in the control group had an average daily gain of 0.71 kg with an average feed conversion of 2.10 per kg of gain. The calves in the experimental group had an average daily gain of 0.78 kg and an average feed conversion of 1.56 per kg increase. The results of the average daily gain were significantly higher ($P < 0,05$) in the experimental group compared to the control group, with lower feed conversion. Meyer *et al*. (2007) also received lower feed conversion in their study, while the average daily gain did not differ significantly.

Similar results were obtained by Santos *et al*. (2015) in their study, which found no significant differences between body weights and feed conversions using essential oils in experimental group with sucking calves. Significantly higher body weight values and numerically lower feed conversion were obtained in the Jatkauskas and Vrotniakien (2014) studies using probiotics (*Enterococcus faecium*). The same authors explain the results by probiotics competing with the bacteria for the substrate, releasing compounds with antibacterial activity that persist at specific sites in the gut and activate innate immunity, which in turn results in the creation of favorable gut microflora and leads to better growth.

CONCLUSIONS

Based on conducted research it could be concluded that the use of essential oils and probiotics resulted in better production traits. As in most studies the use of essential oils did not result in significantly better growth, the results obtained in our study indicate that the use of probiotics led to better growth and lower feed conversion. In order to better investigate the effect of these two feed additives, or their combination, on production characteristics, rumen fermentation and nutrient utilization on post weaning calves, further research is needed.

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PRIMJENA ESENCIJALNIH ULJA I PROBIOTIKA U HRANIDBI TELADI

Rezime

Cilj istraživanja bio je utvrditi utjecaj dodatka esencijalnih ulja i probiotika u hranidbi teladi. Istraživanje je provedeno na 70 teladi muškog spola križanaca belgijskog plavog goveda i simentalske pasmine. Telad je podijeljena u dvije skupine od 35 teladi prosječne starosti 60 dana prethodno izvagane i ujednačene po tjelesnoj masi. Kontrolna skupina bila je hranjena obrokom bez dodataka, dok su u obrok pokusne skupine dodana esencijalna ulja i probiotici. Trajanje istraživanja bilo je 77 dana. Praćeni su proizvodni pokazatelji odnosno tjelesna masa, prosječni dnevni prirast te konverzija hrane. Rezultati dobiveni za tjelesnu masu bili su viši kod pokusne skupine u odnosu na kontrolnu (5397 : 4918 kg). Rezultati prosječnog dnevnog prirasta također su imali višu vrijednost kod pokusne skupine u odnosu na kontrolnu (0,62 : 0,78 kg). Konverzija hrane bila je niža kod pokusne skupine u odnosu na kontrolnu (2,10 : 1,56 kg/kg). Na osnovu dobivenih rezultata može se zaključiti kako dodatak esencijalnih ulja i probiotika u obrok teladi ima pozitivan utjecaj na praćena proizvodna svojstva.

Ključne riječi: *probiotici, esencijalna ulja, prirodni dodaci, telad, proizvodni pokazatelji*

DAIRY CATTLE WELFARE IN TERMS OF HEAT STRESS

Mirna Gavran[1], Pero Mijić[1], Mislav Đidara[1], Vesna Gantner[1]

Review paper

Summary

Heat stress has significant effects on milk production and composition as well as on cattle welfare. Cows with high production capacity have a faster metabolism, produce more heat in the body and more easily tolerate lower temperatures, while high temperatures can easily cause heat stress. Heat stress is state of an organism exposed to external or internal thermal factors whereby the homeopathic systems of the body are unable to resist their harmful effects. Heat stress directly or indirectly affects the physiology, reproduction, health, feeding, production and behaviour of animals and it can cause even death. Negative effects of heat stress on animal welfare can be observed in changes in animal behaviour. Affected animals are also passive, spend less time in social interactions and less time eating. These factors will certainly lead to drop in production. Therefore, it is necessary to study the welfare of the animal through the mental state of the animal, such as frustration or absence of pain, not just through physiological measures. The aim of this study was to review the connection between the heat stress environment and dairy cows' welfare.

Key words: *heat stress, dairy cattle, welfare, behaviour*

INTRODUCTION

The significance of the dairy cattle sector in Europe could be seen through the fact that in year 2016, dairy farms in Europe produced about 168.3 million tons of milk, with cow's milk production at 163 million tons representing the 96.9% of all quantities (Augère-Granier, 2018). Furthermore, milk production characterises demands for high productivity level per animal resulting in the intensive genetic selection for high milk production. Accordingly, to Kadzere *et al.* (2002), high production level implies larger frames and larger gastrointestinal tracts in animals that enable them to digest feed enough for high milk production. On the other side, larger animals also create more metabolic heat and the animal's ability to regulate temperature in heat stress environment is decreased meaning that increased milk production, feed intake and metabolic heat shifts the thermoneutrality of animal to lower temperatures.

The comfort zone for cattle or the thermoneutral zone for cattle is between 5 and 20°C, at this temperature, minimum energy consumption is achieved for maintaining the organism and, among other things, for cooling and heating. In such conditions, the productivity of the animals is highest because the rest of the energy is used for milk

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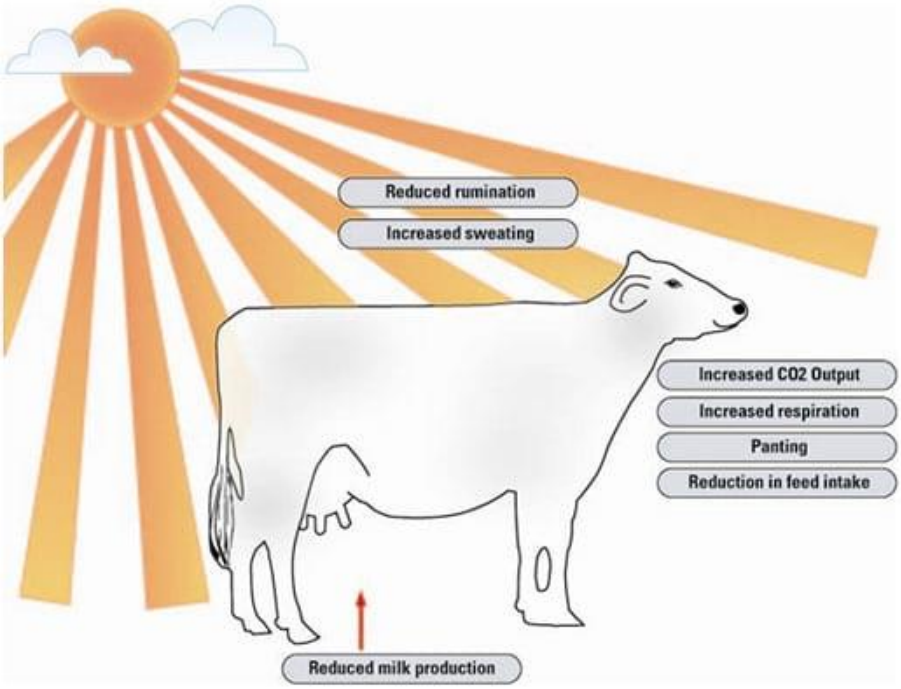
production, fetal growth or growth. The thermoneutral zone may also vary depending on the breed, sex, age, pregnancy, physical activity and body weight. At temperatures above the thermoneutral zone, i.e. above 20°C, thermal stress occurs and is further enhanced by high relative humidity. Animal welfare can be viewed as a prevention of heat stress, whose impact on economic indicators of production is very significant. The heat stress condition also leads to considerable loss of profit, e.g. between $897 million and $1,500 million per year in the USA (Gantner *et al*., 2018). Due to climate change and its great economic importance, heat stress requires increasing attention. Therefore, the aim of this paper was to review the effect of heat stress conditions on performances and welfare in dairy cattle.

EFFECTS OF HEAT STRESS ON DAIRY COWS

The physiological and behavioural controls of dairy cows attempt to maintain a constant body temperature by regulating their thermal energy balance, so that heat input through metabolism (maintenance, exercise, growth, lactation, gestation, and feeding) equals heat loss to the environment (by conduction, convection, and evaporation). When environmental conditions exceed a threshold limit that increases the core-body temperature, heat stress sets in and animal welfare can be compromised. Moreover, cow health, production, and reproduction performance are reduced under heat stress (Fournel *et al.,* 2017). High ambient temperatures, high direct and indirect solar radiation and humidity are environmental stressing factors that impose strain on animals. Despite having well developed mechanisms of thermoregulation, ruminants do not maintain strict homeothermy under heat stress. There is unequivocal evidence that hyperthermia is deleterious to any form of productivity, regardless of breed, and stage of adaptation. The best recognized effect of raised body temperature is an adaptive depression of the metabolic rate associated with reduced appetite. Thus, in domestic ruminants a rise of body temperature marks the transition from aversive stage to noxious stage. Physiological (sweating, panting), hormonal (cortisol, thyroid gland activity), and behavioural thermoregulatory responses are discussed in respect to animal welfare. Factors such as water deprivation, nutritional imbalance and nutritional deficiency may exacerbate the impact of heat stress. The higher sensitivity of cattle to heat stress in comparison with sheep, and of animals at various productive stages in comparison with animals at maintenance is highlighted.



Pic. 1. Effect of heat stress on dairy cows (Dubey and Gnanasekar, 2008)

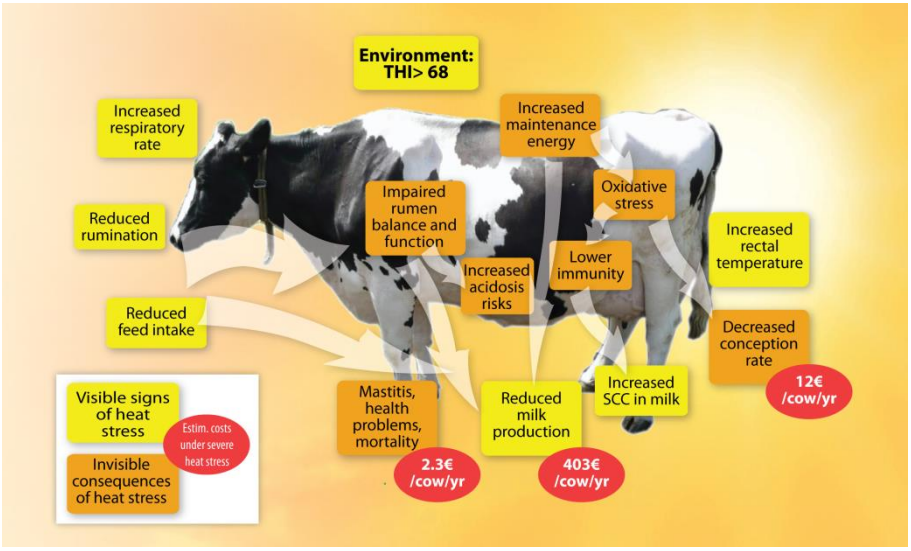
Some practical measures that are applicable under extensive conditions, such as provision of shade shelter, are suggested (Nissim, 2000). Furthermore, according to Pragna *et al.* (2017), heat stress is among livestock owners of major concern in almost all parts of the world. Affected cattle show reduction in milk yield and feed intake and shift metabolism, which in turn leads to a decrease in efficiency in production (Picture 1). Through thermoregulatory mechanisms heat stressed cattle try to decrease the body heat which in turn have an effect on feed conversion efficiency and bring to reduced milk production. Accordingly, to Grandin (2016), heat waves have had a significant detrimental effect on beef cattle welfare in America. About 5000 head of cattle are lost each year due to heat stress. In year 2011 was a heat wave and due to heat stress, almost 15,000 cattle were lost in five Midwest and Great Plains states. With combination of high temperatures, high humidity and low air movement, it is most likely occurring of heat stress losses.

MEASURES OF HEAT STRESS

In accordance to DVC (2019), temperature is not the only environmental factor that affects the intensity of heat stress. Temperature Humidity Index (THI) is a measure that has been used since the early 1990s. It accounts for the combined effects of

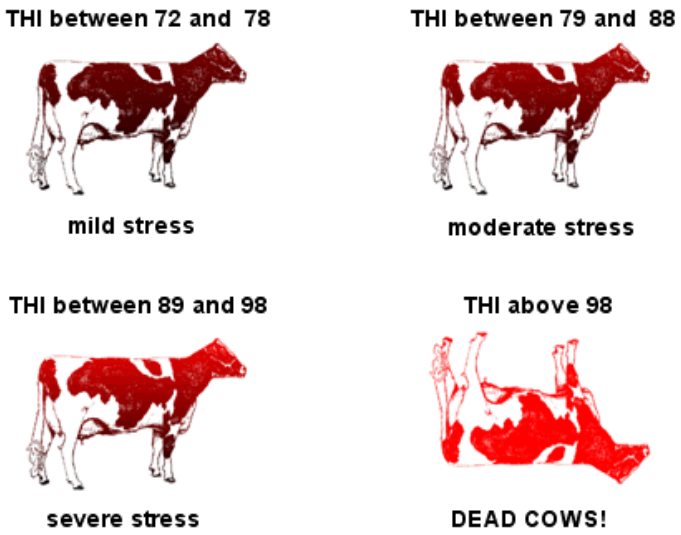
environmental temperature and relative humidity and is a useful and easy way to assess the risk of heat stress. Through research have been determined the THI values above which thermal stress begins. THI values differ between the different livestock species of interest and within the same species, they differ for the different classes of animals. THI is mostly used in cattle breeding, both in dairy and in meat cows.

Cows are indeed very gentle animals, which suffer a lot of heat stress with serious consequences on their productivity and on the quality of their final products. This cause of this is that large part of the energy deriving from food is used to maintain a constant body temperature and for that reason it is not destined for other activities (growth, pregnancy, milk production, fattening, etc.). Some of problems caused by heat stress and with the estimation of costs per animal yearly in the environment characterised by THI > 68 is presented in the Picture 2.



Pic. 2. Examples of problems caused by heat stress and their estimated costs/cow/year in environment characterised by THI > 68 (LAN, 2012)

The level of thermal stress in dairy cows regarding the THI value of environment is presented at the Picture 3. In the environment characterised by THI ranged from 72 to 78 dairy cows are exposed to the mild stress, when THI rises to 79 until 88, cows are in moderate stress, when THI values are in interval from 89 to 98, dairy cows are in severe stress, while in the cases when THI value exceeded 98, high mortality of dairy cows are expected.



Pic. 3. Ranges of THI values and corresponding level of heat stress in dairy cattle (AG, 2019)

HEAT STRESS AND COW WELFARE AND BEHAVIOUR

According to Polsky and von Keyserlingk (2017), most of the scientific literature, when it comes to the effects of heat stress on dairy cattle has focused on physiological measures, describing animal interaction with its environment, such as plasma cortisol, heart rate, and respiratory rate. In spite of, physiological measures best describe the health and biological functioning component of the animal's welfare but fail to address the multidimensional concept of animal welfare that also considers aspects such as mental states (i.e., the absence of pain and frustration), and the ability to live a reasonably natural life. In accordance to Allen *et al.* (2013), in the last decade, research efforts have turned to welfare of cattle experiencing heat stress. Cattle will probably seek shades or other cooling structures in case of increasing ambient temperature or solar radiation. Apart from physiological changes to reduce heat production, this behaviour change, suggests that dairy cows will also look for micro-environments that have a lower ambient temperature. Moreover, cattle are more likely to seek optimum environments that have maximized cooling capacity. For example, recent study (Anderson *et al.,* 2012) showed that cattle were more likely to choose shade over a cooling system directed away from the shade, but were also likely to take advantage of shade that included a cooling system.

Pic. 4. Cattle exhibiting signs of heat stress (Thurlow and Gould, 2018)

CONCLUSIONS, HOW TO MANAGE HEAT STRESS IN DAIRY COWS

For successful management of heat stress in dairy cows, it is necessary to provide a lot of clean water all time. Another important segment is providing sprinklers and fans to help cows to cool. Of great importance is also to provide shade. Overcrowding is one of the biggest challenges on dairy farms. When it comes to overcrowding, the cows are not going to have enough room to eat and lay down. It is also very important if we do some checks, such as pregnancy checks, or if we want to breed cows or move cows, to do that early in the morning to reduce cow stress. These are all significant things, aids for cow comfort, while on the other hand, providing properly balanced, palatable meals, rich in energy will help minimize loss in milk production and reproductive efficiencies due to heat stress.

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DOBROBIT MLIJEČNIH GOVEDA U UVJETIMA TOPLINSKOG STRESA

Rezime

Toplinski stres ima značajne učinke na proizvodnju i sastav mlijeka, kao i na dobrobit goveda. Krave visokog proizvodnog kapaciteta imaju brži metabolizam, proizvode više topline u tijelu i lakše podnose niže temperature, dok visoke temperature lako mogu izazvati toplinski stres. Toplinski stres je stanje organizma izloženo vanjskim ili unutarnjim toplinskim čimbenicima, pri čemu homeopatski sustavi u tijelu nisu u stanju pružiti otpor njihovim štetnim utjecajima. Toplinski stres izravno ili neizravno utječe na fiziologiju, reprodukciju, zdravlje, hranjenje, proizvodnju i ponašanje životinja, a može uzrokovati čak i smrt. Negativni učinci toplinskog stresa na dobrobit životinja mogu se primijetiti u promjenama ponašanja životinja. Zahvaćene životinje su također pasivne, manje vremena provode u društvenim interakcijama i manje vremena jedu. Ovi čimbenici sigurno će dovesti do pada proizvodnje. Stoga je potrebno proučavati dobrobit životinje kroz mentalno stanje životinje, poput frustracije ili odsutnosti boli, a ne samo kroz fiziološke mjere. Cilj ove studije bio je ispitati povezanost između okruženja toplinskog stresa i dobrobiti mliječnih krava.

Ključne riječi: *toplinski stres, mliječna goveda, dobrobit, ponašanje*

DISTRIBUCIJA LOKALNIH POPULACIJA VRSTE *Columba domestica* Linnaeus, 1758 (Aves: Columbiformes: Columbidae) U BOSNI I HERCEGOVINI

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Rezime

Cilj istraživanja bio je utvrditi prisustvo lokalnih populacija vrste *Columba domestica* Linnaeus, 1758 u BiH i na osnovi nalaza kartografski prikazati distribuciju spomenute vrste. Kako bi se došlo do rezultata o distribuciji lokalnih populacija vrste rađene su terenske zabilješke te fotografiranja i video zapisi golubova pomoću tehničkih uređaja. Pripadnici vrste *Columba domestica* Linnaeus, 1758 distribuirani su uglavnom na svim posmatranim lokalitetima Bosne i Hercegovine, izuzev na općini Neum. Prisustvo populacije na području općine Bileća zabilježeno je u predgrađu, dok u gradskoj zoni nisu uočeni. Na temelju dobivenih nalaza konstatovano je da populacija vrste *Columba domestica* Linnaeus, 1758 široko rasprostranjena u BiH.

Ključne riječi: *Columba, domestica, distribucija, Bosna i Hercegovina.*

UVOD

Naučno, biosistematsko istraživanje ptica u Bosni i Hercegovini ima dugu tradiciju, a prvi podaci publicirani su još drugom polovinom 19. vijeka (Bayer, 1881; Dabrowski, 1884; Kadish, 1885; Platz, 1883; Seunik, 1887; Talsky, 1882 i dr.), dok su podaci o bh. pticama u drugim oblicima naučnih istraživanja (poljoprivredni uzgoj, lovstvo itd.) značajno stariji (Obratil, 1967, 1980; Kotrošan, 2012). Najznačajnije djelo o pticama Bosne i Hercegovine svakako je monografija O. Reiserovu "*Materialen zu einer Ornis balcanica*", ali je neophodno napomenuti da je prvi dio ove monografije, objavljen tek nakon Reiserove smrti 1939. godine, a jedina do danas objavljena monografija o bosanskohercegovačkoj ornitofauni (Kotrošan, 2012).

U svim radovima o pticama BiH spomenut je i „divlji golub“, „gradski golub“ za kojeg je u bosanskom jeziku opravdaniji termin golub lutalica ili obični golub (izvođenje iz engleskog narodnog naziva – Commom Pigeon), *Columba livia* Gmelin za kojeg smo u skorijim radovima jasno pokazali da je ustvari *Columba domestica* Linnaeus, 1758 te

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da je biosistematski neopravdano sinonimiziran sa *Columba livia* Gmelin, 1789. Preciznije rečeno najopravdanije je pisati da postoji golub kamenjar (Rock Pigeon, *Columba livia* Gmelin, 1789) na više mjesta na liticama u Bosni i Hercegovini, dok urbane i suburbane sredine skoro u pravilu naseljava obični golub (Common Pigeon, *Columba domestica* Linnaeus, 1758). Uvijek je neophodno dodati da Komisija ICZN-a (International Committee for Zoological Nomenclature) nije istakla pravo prvenstva taksona *livia* Gmelin, 1789 nad *domestica* Linnaeus, 1758 (Donegan, 2015), čime je dokazano da sinonimiziranje navedenih taksa ide u pravcu *Columba domestica livia*, a ne obrnuto (sve dok ICZN Komisija ne uvede pravilo za drugačije tumačenje). Ipak, za dosljedno objašnjenje navedenog preporučujemo za pročitati: Aganović, 2017.
Obični golub gnijezdi se u urbanim i suburbanim područjima te kamenitim predjelima u većini gradova naše planete (Long, 1981; Johnston & Janiga 1995). Zbog mogućnosti iskorištavanja obilja izvora hrane u urbanom okruženju obični golubovi, u nekim gradovima dostigli su veliku gustoću: Barceloni 9,4 jedinki/ha (Sol & Senar 1992); Bazelu 8,4 jedinki/ha (Haag-Wacknagel, 1995); Milanu 20,8 jedinki/ha (Sacchi *et al*., 2002) i Amsterdamu 4-5 jedinki/ha (Buis & van Wijnen, 2001); Wellingtonu u ljetnom periodu 4,5 jedinki/ha, a zimskom 6,8 jedinki/ha (Ryan, 2011); Padovi 8,1 jedinki/ha (Amoruso *et al*., 2014); Poznanu 13.6 jedinki/ha (Przybylska *et al.*, 2012); Milanu do 20,8 jedinki/ha (Sacchi *et al*., 2002). Divlji golubovi posjeduju izraženu sposobnost adaptacije življenja u kontrolisanim uslovima (Aganović & Lelo 2017a). Kako bi ponudili bolji uvid u budućnost i shvatili ekosisteme u svijetu, neophodno je proučavati sredine u kojima žive ljudi. Studije o urbanoj ekologiji ranije su bile fokusirane na utjecaj urbanizacije na domestificirane vrste (Blair, 1996; Rottenborn, 1999). Većina životinja obilje hrane pronalaze u urbanoj sredini (Shochat *et al*., 2006), što bi značilo da su prošle proces sinurbanizacije i prilagodile se uslovima urbane sredine (Luniak, 2004). Izgradnjom objekata sa elementima visokih struktura (tornjevi, višespratnice itd.) kao i utjecajem ljudi na modificiranje zemljišta u dirigovanu formu u ruralnim područjima (uz prisustvo obilja izvora žitarica) obezbijedilo se divljem golubovima prikladno stanište (Hetmański *et al*., 2011). Na porast brojnosti populacije „divljih" golubova u urbanim sredinama presudan utjecaj imaju brojni faktori, uključujući i nedostatak ili manjak predatorstva (Sol *et al*., 1998). Pristupačne građevinske izbočine, nadstrešnice, konstrukcije mostova simuliraju prirodne prostore za gniježđenja (Savard & Falls 1981; Hetmański *et al*., 2011; Przybylska *et al*., 2012). Interval između gniježđenja „divljih" golubova je od 27 do 37 dana zavisno od sezone (Aganović & Lelo, 2017b).

MATERIJAL I METODE RADA

U periodu od maja do oktobra mjeseca 2019. godine na 28 lokaliteta: Sarajevo, Zenica, Doboj, Derventa, Mostar, Čapljina, Tuzla, Goražde, Jablanica, Konjic, Stolac, Žepče, Neum, Livno, Bugojno, Velika Kladuša, Cazin, Travnik, Donji Vakuf, Jajce, Rudo, Trebinje, Foča, Višegrad, Gacko, Bileća, Banja Luka i Brčko (Sl. 1.), autori su radili na prikupljanju ličnih zabilješki i snimljenih fotografskih ili video zapisa pomoću tehničkih

uređaja kako bi se došlo do podataka o distribuciji lokalnih populacija vrste *Columba domestica* Linnaeus, 1758 (Aves: Columbiformes: Columbidae) iz Bosne i Hercegovine.

Sl. 1. Prikaz lokaliteta na kojima su konstatovani pripadnici vrste *Columba domestica* Linnaeus, 1758 u Bosni i Hercegovini u periodu od maja do oktobra mjeseca 2019. godine

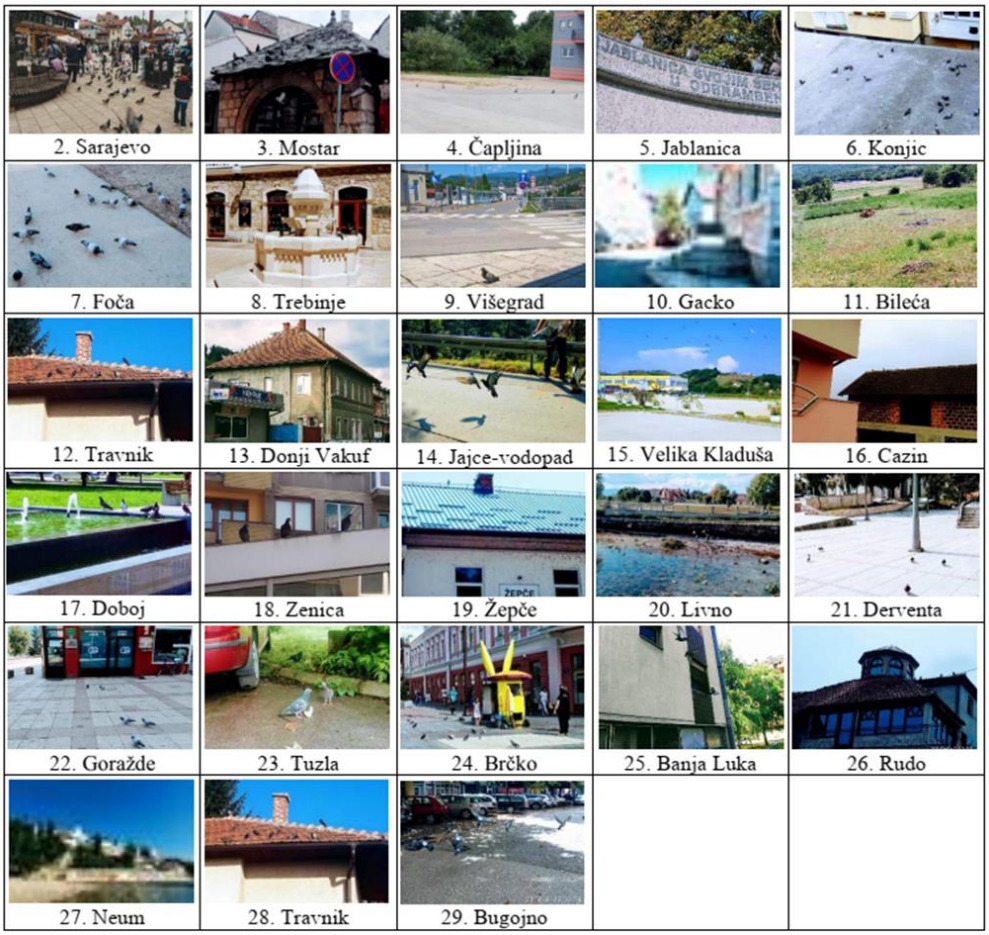
Tab. 1. Podaci o općinama/opštinama BiH (nadmorska visina, vrijeme i dnevna temperatura, koordinate, površina i broj stanovnika)

Općina	Nadmorska visina, m	GPS koordinate	Vrijeme, Dan/sat	Temperatura, C^0	Površina općine, km^2	Broj stanovnika, 2013. god.
Sarajevo	518	43°39'55.2"N 18°58'39.2"E	26.5.2019. 16:30	21	141,5	275.524
Zenica	316	44°12'01.6"N 17°54'26.0"E	15.06.2019. 11:15	30	558.5	110.663
Doboj	146	44°44'05.5"N 18°05'03.3"E	15.06.2019. 14:55	33	648	68.514
Derventa	103-215	44°58'35.1"N 17°54'25.4"E	15.06.2019. 14:25	32	516.84	56.489
Mostar	60	43°20'37.6"N 17°48'27.9"E	01.06.2019. 13:10	20	1.175	113.169
Čapljina	10	43°06'42.6"N 17°42'19.7"E	01.06.2019. 14:42	20	274	28.122
Tuzla	231	44°32′21.9″N 18°40′30.1″E	11.07.2019. 13:40	23	302.35	110.979
Goražde	345	43°39'54.9"N 18°58'39.1"E	06.07.2019. 17:25	26	252	22.080
Jablanica	202	43°39'27.8"N 17°45'37.4"E	18.10.2019. 10:50	16	301	10.111
Konjic	268	43°39'19.5"N 17°57'17.7"E	26.07.2019. 11:52	29	1.169	25.148
Stolac	252	43°05'09.7"N 17°57'32.7"E	18.10.2019. 13:00	24	331	14.502
Žepče	219	44°25'34.1"N 18°01'46.8"E	15.06.2019. 13:50	30	395	31.582
Neum	0	42°55′29.1″N 17° 37′ 0″ E	18.10.2019. 15:08	26	225	4.960
Livno	722	43°49′39.5″N 17°0′13.2″ E	29.09.2019. 14:50	24	994	37.487
Bugojno	569	44°03'09.3"N 17°26'58.4"E	29.09.2019. 12:10	20	366	34.559
Velika Kladuša	160	45°10'59.2"N 15°48'42.7"E	31.8.2019. 16:00	32	331,56	44.770
Travnik	514	44°13'06.0"N 17°41'34.4"E	31.8.2019. 8:17	18	529	57.543
Donji Vakuf	500	44°08'44.6"N 17°23'34.0"E	31.8.2019. 9:23	19	320	14.739
Jajce	362,5 vodopad	44°20'13.9"N 17°16'06.0"E	31.8.2019. 11:20	24	339	30.758
Rudo	390	43°37'01.4"N 19°22'03.0"E	07.09.2019. 12:05	30	347.63	8.834
Trebinje	207	42°42'38.8"N 18°20'47.3"E	28.06.2019. 14:30	35	854.5	31.433
Foča	370	43°30'19.7"N 18°46'38.2"E	28.06.2019. 18:55	25	1.134.58	19.811
Višegrad	389	43°46'58.4"N 19°17'41.0"E	6.7.2019. 13:15	32	448.14	11.774

Općina	Nadmorska visina, m	GPS koordinate	Vrijeme, Dan/sat	Temperatura, C^0	Površina općine, km^2	Broj stanovnika, 2013. god.
Gacko	940	43°10'02.1"N 18°32'09.8"E	28.06.2019. 17:05	33	735.88	9.734
Bileća	476	42°52'32.4"N 18°25'45.2"E	28.06.2019. 16:07	35	632,33	11.536
Banja Luka	164	44°46′ 0″ N, 17° 11′ 0″ E	22.08.2019. 16:30	29	1.239	185.042
Brčko	92	44°52′22.″ N, 18° 48′ 38″ E	17.07.2019. 13:30	26	493	93. 028

REZULTATI I DISKUSIJA

Istraživanjem distribucije običnog goluba ili goluba lutalice – *Columba domestica* (Linnaeus, 1758, u Bosni i Hercegovini u periodu mart-oktobar 2019. godine konstatovano je da individue naseljavaju svako urbano i suburbano područje izuzev naselja Neum. U nizu naselja koje smo obišli konstatujemo da smo obezbijedili fotodokumentaciju sa lokaliteta: Sarajevo, Zenica, Doboj, Derventa, Mostar, Čapljina, Tuzla, Goražde, Jablanica, Konjic, Stolac, Žepče, Neum, Livno, Bugojno, Velika Kladuša, Cazin, Travnik, Donji Vakuf, Jajce, Rudo, Trebinje, Foča, Višegrad, Gacko, Bileća, Banja Luka i Brčko (Sl. 2-29).

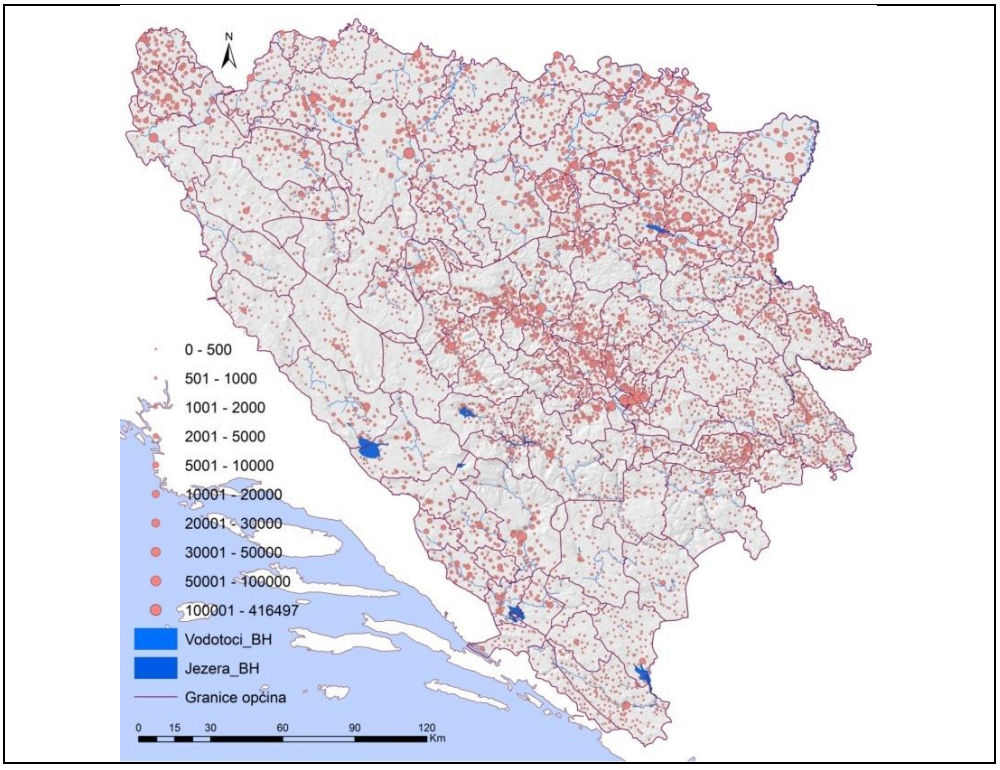


Sl. 2-29 Prikaz dijela fotodokumentacije o nalazima predstavnika vrste *Columba domestica* Linnaeus, 1758 sa istraživanja provedenih u periodu maj-oktobar 2019. godine u Bosni i Hercegovini.

Zanimljivo je da su obični golubovi na području Bileće zabilježeni samo u predgrađu, a u gradskoj zoni nisu uočeni.

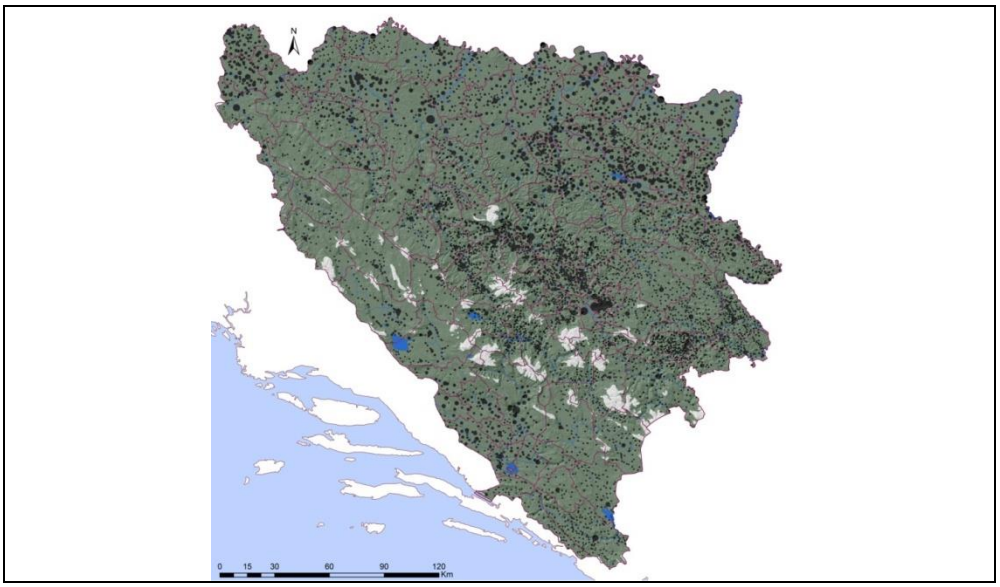
Pored prikupljenih podataka o distribuciji običnog goluba u Bosni i Hercegovini postoji i niz podataka u publiciranim tekstovima o istraživanoj problematici koji su preobimni da bi svi bili navedeni, zato izdvajamo neke zanimljive ili navode za rijetko navođene lokalitete: BiH (Reiser, 1888); Kanton Sarajevo (Kotrošan *et al*., 2010); Ilijaš (Lelo *et al*., 2007, 2008, 2009; Sarajevo (Aganović & Lelo, 2017a, 2017b, 2018); Blagaj (Bem, 1990).

Prije svega dužni smo pojasniti da iz dugogodišnjeg iskustva i rada Ornitološkog udruženja „Naše ptice“, Sarajevo pouzdano znamo da se obični golub može naći u skoro svakom naseljenom mjestu u Bosni i Hercegovini (Sl. 30).



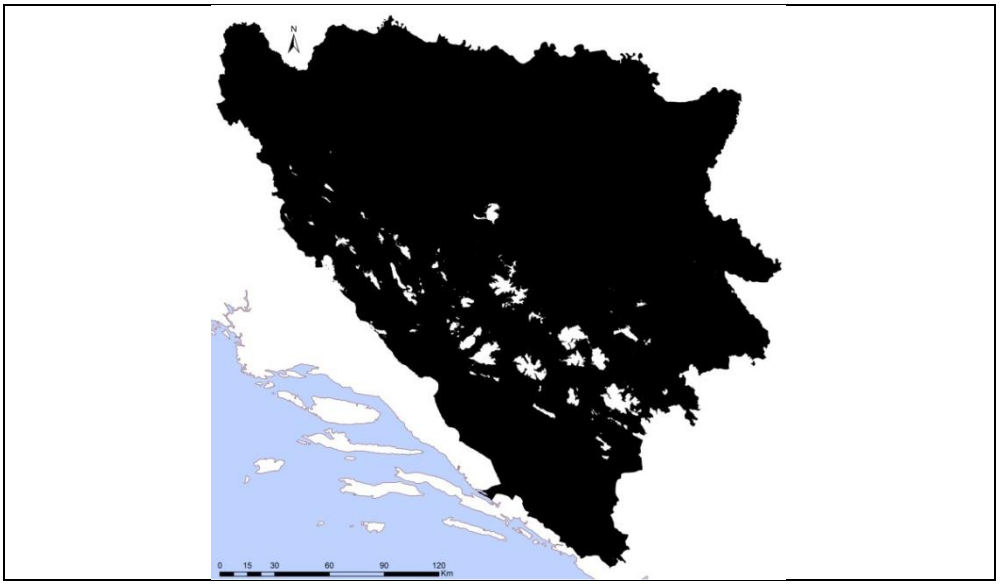
Sl. 30. Prikaz naseljenih mjesta (sa legendom procjene broja stanovnika) u Bosni i Hercegovini (Na GIS platformi izradio N. Drešković)

Na osnovi prikupljenih podataka izrađene su i originalne geografske karte o distribuciji vrste *Columba domestica* Linnaeus, 1758 u Bosni i Hercegovini (Sl. 31-32).
Dalje, pouzdano je utvrđeno da je veličina lokalne populacije direktno proporcionalna veličini naseljenog mjesta iz čega je izvedena karta sa prikazom veličine lokalne populacije *Columba domestica* Linnaeus, 1758 u Bosni i Hercegovini (Sl. 31).



Sl. 31. Prikaz zabilježene distribucije te veličine lokalnih populacija vrste *Columba domestica* Linnaeus, 1758 u Bosni i Hercegovini.

Iz svega izvedenog izrađena je karta stvarnog areala meta populacije vrste *Columba domestica* Linnaeus, 1758 u Bosni i Hercegovini (Sl. 32).



Sl. 32. Prikaz rasprostranjenja vrste *Columba domestica* Linnaeus, 1758 u Bosni i Hercegovini (bijele zone označavaju područja bez golubova).

ZAKLJUČCI

Na temelju dobivenih podataka o distrubuciji vrste *Columba domestica* Linnaeus, 1758 iz Bosne i Hercegovine u periodu od maja do oktobra mjeseca 2019. godine mogu se donijeti sljedeći zaključci:

- pripadnici vrste *Columba domestica* Linnaeus, 1758 uočeni su u svim općinama/opštinama Bosne i Hercegovine, izuzev na lokalitetu općine Neum;

- na području općine/opštine Bileća prisustvo vrste je zabilježeno samo u predgrađu, dok u gradskoj zoni nije uočeno;

- na osnovu dobivenih nalaza može se konstatovati da je populacija vrste *Columba domestica* Linnaeus, 1758 široko rasprostranjena u BiH.

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DISTRIBUTION OF LOCAL POPULATIONS OF THE SPECIES *Columba domestica* Linnaeus, 1758 (Aves: Columbiformes: Columbidae) IN BOSNIA AND HERZEGOVINA

Summary

The aim of the study was to determine the presence of local populations of *Columba domestica* Linnaeus, 1758 in Bosnia and Herzegovina, and based on the results, to map their distribution. In order to gain the results, notes, photographs and video recordings were performed using appropriate technical devices on the field. The results indicate that members of the species *Columba domestica* Linnaeus, 1758 were distributed in all investigated and visited locations of Bosnia and Herzegovina, except the municipality of Neum. Population presence in the municipality of Bileća was recorded only in the suburbs, and not observed in the urban area. Based on the findings, it was concluded that the population of *Columba domestica* Linnaeus, 1758 is relatively widespread in Bosnia and Herzegovina.

Keywords: *Columba, domestica, distribution, Bosnia and Herzegovina*

DEVELOPMENT AND SELECTION OF OPTIMAL STATISTICAL MODELS TO EVALUATE THE EFFECT OF MICROCLIMATE PARAMETERS ON THE VARIABILITY OF PRODUCTION TRAITS IN DAIRY COWS

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Original scientific paper

Summary

Currently we are living and producing in the world characterized by a climate change. For agriculture and livestock production, this change means, in most cases, deterioration of the environmental effect in numerous regions globally and consequently significant effect on livestock production in the world. Modern livestock production, most frequently implies high production per animal, meaning high milk production per cow in terms of dairy cattle production. The increase of production makes cows more susceptible to heat stress, meaning that heat stress will become an acute problem regardless of climate changes, that will only further emphasize this problem. High-producing dairy cows lose the ability to regulate their body temperature when the ambient temperatures reach 25-29°C. Furthermore, the intensive genetic selection for high milk production resulted in changed thermoregulation physiology meaning that the high-producing cows have larger frames and consequently larger gastrointestinal tracts that enable them to digest more feed. This creates more metabolic heat and reduces the ability of cows to regulate normal temperature at heat stress conditions. Finally, by increase of milk yield, feed intake and metabolic heat, the thermoneutrality of animal shifts to lower temperatures. Accordingly, to many researches, heat stress environment induces reduction in dry matter intake, milk production and reproductive performances. Also, heat stress conditions affect milk composition, somatic cell counts (SCC) and mastitis frequencies.

Since Pannonian region is characterized by the high prevalence of heat stress days, mostly during the summer season, the aim of this paper was to develop and select optimal models for evaluation of the effect of microclimate parameters on the variability of production traits in dairy cows.

Key words: *statistical modelling, microclimate, production traits, dairy cattle*

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INTRODUCTION

Today's cattle milk production is characterized by high cattle productivity requirements and increasingly pronounced unfavourable (micro)climate conditions. Accordingly, to the forecasts of the IPCC (2007) changes in climate will significantly affect agricultural, and especially animal production worldwide. Accordingly, Battisti and Naylor (2009) forecasted that by year 2050, most of the world will be exposed to median temperatures in the summer that will be higher than the highest recorded temperatures. In continuation, Reiczigel *et al.* (2009) in Hungary, as well as Dunn *et al*. (2014) in UK indicated an increase of heat stress days per year. Stated implies that the heat stress of high productive dairy cows will cause growing concern in dairy production in Europe (Gauly *et al*., 2013). In the light of the anticipated changes, Segnalini *et al.* (2013) pointed out the necessity of adequate adaptation strategies in order to decrease negative effects of climate change on domestic animals. Since, high production makes cows more susceptible to heat stress, heat stress will become, and already is, a problem in intensive dairy breeding systems regardless the climate changes (Hansen, 2013). Bohmanova (2006) and Collier *et al.* (2006) pointed out that the level of milk production significantly alters the animal response to heat stress making high production animals more sensitive to heat stress than low production ones. Furthermore, Kadzere *et al.* (2002) emphasized that the intensive genetic selection for high milk production resulted in changes in the thermoregulation physiology of dairy cattle. Larger frames and larger gastrointestinal tracts in high production animals enable them to digest more feed, but also creates more metabolic heat and reduces the animal's ability to regulate temperature at heat stress environment meaning that increased milk yield, feed intake and metabolic heat shifts the thermoneutrality to lower temperatures. Accordingly, to many studies, heat stress conditions in dairy cattle reduce dry matter intake, milk production (West *et al.*, 1999; Casa and Ravelo, 2003; Gantner *et al.*, 2011) as well as reproductive performances (Bohmanova *et al*., 2007; Ravagnolo *et al.*, 2000). Furthermore, heat stress alters the milk composition, somatic cell counts (SCC) and prevalence of mastitis (Bouraoui *et al.*, 2002; Collier *et al.*, 2012; Correa-Calderon *et al.*, 2004; Gantner *et al.*, 2011, 2017; Ravagnolo *et al.*, 2000; St-Pierre *et al.*, 2003; West 2003; Hammami *et al.*, 2013; Smith *et al.*, 2013). Finally, heat stress induces considerable profit loss (St-Pierre *et al.*, 2003). The most common measure of heat stress when dairy cattle are analysed is temperature-humidity index (THI). Temperature-humidity index is a measure that includes ambient temperature and relative humidity (Kibler, 1964). The THI threshold value at which heat stress affects milk production and feed intake vary, depending on study, from 68 to 72 (Du Preez *et al.*, 1990a, b; Bouraoui *et al.*, 2002; Bernabucci *et al.*, 2010; Gantner *et al.*, 2011; Collier and Hall, 2012). Finally, Vitali *et al.* (2009) emphasised the increased risk of animals' death in the environment characterised by THI = 80. Furthermore, the acclimatization to long-term stress results in proteomic changes indicated by expression of proteins related to inflammation (Balfoussia *et al.*, 2014). Min *et al.* (2016) concluded that long-term moderate heat stress may lead to

an inflammatory response in dairy cows with significantly pro-inflammatory factors. Those changes lead to increase of operating expenses of dairy farm that is to decrease of profitability of the dairy business.

Since Pannonian region is characterized by the high prevalence of heat stress days, mostly during the summer season, the aim of this paper was to develop and select optimal models for evaluation of the effect of microclimate parameters on the variability of production traits in dairy cows. Application of optimal statistical model in routine genetic evaluation and selection of more resistant animals will certainly contribute to realization of profitable and sustainable dairy farm.

MATERIALS AND METHODS

Test-day records of Holstein and dairy Simmental cows collected in the period from January 2005 to December 2013 provided by the Croatian Agricultural Agency were used for the statistical analysis. Test-day records were collected during the regular milk recording performed monthly in accordance to the alternative milk recording method (AT4 / BT4) on dairy cattle farms in Croatia. At each recording, measuring and sampling of milk were performed during the evening or morning milkings. Additionally, at each milk recording, ambient temperature and relative humidity were recorded. Based on measured ambient parameters, daily values of temperature-humidity index (THI) was calculated using the Kibler equation (1964):

$$\mathbf{THI = 1.8 * Ta – (1 – RH) * (Ta – 14.3) + 32}$$

Where Ta is average temperature in degrees Celsius and RH is relative humidity as a fraction of the unit.

Test-day records with lactation stage in (< 5 days and > 500 days), age at first calving in (< 21 and > 36 months), missing parity, missing breed, and missing or nonsense daily milk traits (ICAR standards, 2017), Ta and RH value were deleted from the dataset. After logical control dataset consisted of 1,636,192 test-day records from 117,659 Simmentals (10,599 farms) and 1,275,713 test-day records from 90,159 Holsteins (6,701 farms).

Accordingly, to the parity, cows were divided into four classes: I., II., III., and IV. (animals in fourth and higher lactations). Furthermore, accordingly to location of farm, test day records were divided into three breeding regions: Eastern, Central, and Mediterranean. While, in accordance to the recording date, test day records were divided into 108 classes: 1/2005 to 12/2013. Basic statistical parameters of daily milk traits and microclimate parameters is presented in Table 1 and Table 2.

Tab. 1. Basic statistical parameters of analysed traits (daily milk traits and microclimate parameters, n = 1,275,713) for Holstein breed

Trait	mean	SD	CV	Min	Max
DMY	21.16	8.85	41.80	3.00	87.60
DFY	4.17	0.95	22.76	1.50	9.00
DPC	3.41	0.47	13.83	1.04	6.99
DLC	4.45	0.23	3.13	3.00	5.65
UREA	22.06	9.89	44.85	0.50	60.00
logSCC	16.88	2.12	12.58	12.29	22.25
T	15.07	7.97	52.89	-9.00	40.00
RH	68.66	12.39	18.04	30.00	99.00
THI	58.71	11.86	20.20	17.66	101.21

* DMY – daily milk yield (kg); DFC – daily fat content (%); DPC – daily protein content (%); DLC – daily lactose content (%); UREA – daily lactose content (mg/ml); logSCC – log transformed somatic cell count; T – ambient temperature (°C); RH – relative humidity; THI – temperature humidity index

Tab. 2. Basic statistical parameters of analysed traits (daily milk traits and microclimate parameters, n = 1,636,192) for Simmental breed

Trait	mean	SD	CV	Min	Max
DMY	15.56	8.85	38.17	3.00	94.00
DFY	4.17	0.95	21.46	1.50	9.00
DPC	3.46	0.47	13.38	1.12	7.00
DLC	4.48	0.23	5.12	3.00	5.83
UREA	19.90	9.89	53.56	0.50	60.00
logSCC	16.58	2.12	12.93	12.29	22.25
T	15.73	7.97	47.47	-9.00	40.00
RH	70.82	12.39	14.87	30.00	99.00
THI	59.77	11.86	20.20	16.03	101.21

* DMY – daily milk yield (kg); DFC – daily fat content (%); DPC – daily protein content (%); DLC – daily lactose content (%); UREA – daily lactose content (mg/ml); logSCC – log transformed somatic cell count; T – ambient temperature (°C); RH – relative humidity; THI – temperature humidity index

For the evaluation of the effect of microclimate parameters (T, RH, and THI) on the variability of production traits (daily milk yield and contents) in dairy cows several statistical models were developed and tested. Based on evaluation parameters (R^2, CV and Root MSE of model) two models were selected as optimal for further analysis.
The relationship between daily milk traits (yields and contents) and microclimate parameters (T, RH, and THI) was analysed using PROC GLM procedure in SAS (SAS Institute Inc., 2000) in accordance to following model 1:

$$y_{ijklmn} = \mu + b_1(d_i/305) + b_2(d_i/305)^2 + b_3 \ln(305/d_i) + b_4 \ln^2(305/d_i) + S_j + A_k + R_l + x_{ijklm} + e_{ijklm}$$

Furthermore, the variation in daily milk traits (yields and contents) due to heat stress was tested by least square analyses of variance for set THI values (68, 72) using PROC GLM / SAS accordingly to following model 2:

$$y_{ijklmn} = \mu + b_1(d_i/305) + b_2(d_i/305)^2 + b_3 \ln(305/d_i) + b_4 \ln^2(305/d_i) + S_j + A_k + R_l + T_m + x_{ijklm} + e_{ijklm}$$

where y_{ijklm} = estimated daily milk trait;
μ = intercept;
b_1, b_2, b_3, b_4 = regression coefficients;
d_i = days in milk (i = 5 to 500 day);
S_j = fixed effect of recording season class j (j = 1/2005 to 12/2012);
A_k = fixed effect of age at calving class k (k = 21 to 36 month);
R_l = fixed effect of breeding region l (l = Eastern, Central, and Mediterranean Croatia);
x_{ijklm} = fixed effect of microclimate parameter as linear regression – model 1;
T_m = fixed effect of THI class (m = 0 *(normal condition – values under the given threshold)* or m = 1 *(heat stress condition – values equal and above the given threshold)*) – model 2;
e_{ijklm} = residual.
The significance of the differences between the THI classes in model 2 was tested by t-test. The statistical analysis was performed separately for each breed (Holstein, and Simmental).

RESULTS AND DISCUSSION

The coefficients of linear regression between analysed daily milk traits (daily milk yield, daily fat, protein, lactose and urea content, and somatic cell count) and microclimate parameters (ambient temperature, relative humidity and temperature-humidity index – THI) in accordance to breed is presented in the Table 3. A statistically significant ($p < 0.05$) decrease in daily milk yield (DMY) and daily fat and protein content (DFC, and DPC) caused by the increase in ambient temperature (T) and THI was observed in both breeds. Furthermore, by increase of relative humidity (RH), in Holstein cows DMY, DFC and DPC increased, while in Simmental breed those traits decreased. The daily lactose content (DLC) showed very low variability due to variations in microclimate conditions. While the daily urea content (UREA), and somatic cell count (logSCC) increased in terms of increased daily T, RH and THI in both analysed breeds.

Tab. 3. The coefficients of linear regression between daily milk traits and microclimate parameters accordingly to breed

	Holstein			Simmental		
Trait	T	RH	THI	T	RH	THI
DMY	-0.0463	0.0023	-0.0315	-0.0483	-0.0068	-0.0320
DFC	-0.0004	0.0012	-0.0004	-0.0006	-0.0010	-0.0004
DPC	-0.0018	0.0003	-0.0011	-0.0011	-0.0001	-0.0007
DLC	-0.0005	0.0000	-0.0003	0.0001	0.0000	0.0001
UREA	0.0158	-0.0047	0.0102	0.0257	0.0050	0.0175
logSCC	0.0045	0.0019	0.0032	0.0003	0.0028	0.0002

* DMY – daily milk yield (kg); DFC – daily fat content (%); DPC – daily protein content (%); DLC – daily lactose content (%); UREA – daily lactose content (mg/ml); logSCC – log transformed somatic cell count; T – ambient temperature (°C); RH – relative humidity; THI – temperature humidity index; all coefficients of linear regression were statistically highly significant ($p < 0.05$)

Statistically significant ($p < 0.05$) difference in all analysed daily milk traits, with exception of log SCC, due to heat stress condition at THI = 68 was determined in both breeds (Table 4). Higher difference between the daily milk yield produced in normal condition compering to heat stress condition in amount of 314 g of milk / day was determined in Holstein cows, while lower difference in amount of 296 g of milk / day was determined in Simmental cows. Furthermore, the amount of variation in daily fat/protein/lactose content and logSCC due to heat stress was similar in all cows. Daily urea content showed significant ($p < 0.05$) increase in all cows in terms of heat stress.

Tab. 4. LSmeans of daily milk traits regarding the heat stress (HS-0/HS-1) when threshold THI = 68 accordingly to breed

	Holstein		Simmental	
Trait	HS-0	HS-1	HS-0	HS-1
DMY	19.908^{a}	19.594^{b}	13.867^{A}	13.571^{B}
DFY	4.322^{a}	4.333^{b}	4.076^{a}	4.070^{b}
DPC	3.547^{a}	3.542^{b}	3.374^{a}	3.364^{b}
DLC	4.465^{a}	4.459^{b}	4.465^{a}	4.463^{b}
UREA	20.196^{a}	20.578^{b}	20.622^{a}	21.070^{b}
logSCC	15.947^{a}	15.955^{a}	16.306^{a}	16.300^{a}

*DMY – daily milk yield (kg); DFC – daily fat content (%); DPC – daily protein content (%); DLC – daily lactose content (%); UREA – daily lactose content (mg/ml); logSCC – log transformed somatic cell count; Lsmeans within the same row and mastitis risk class marked with different letters (a, b) differ statistically significant ($p < 0.05$); HS-0: normal condition, HS-1: heat stress condition

The results of analyses of variance of daily milk traits regarding the heat stress conditions (HS-0/HS-1) when threshold THI = 72 according to breed is presented in the

Table 5. Similar trends as at lower THI value (68) was determined for all analysed traits in both breed while the determined differences were higher comparing to lower THI value. The daily milk yield, in Holstein breed, drop almost 0.5 kg per day due to increased heat stress, while Simmental cows exposed to heat stress at THI = 72 produced around 0.3 kg of milk per day less comparing to ones in normal conditions.

Tab. 5. LSmeans of daily milk traits regarding the heat stress (HS-0/HS-1) when threshold THI = 72 accordingly to breed

	Holstein		Simmental	
Trait	HS-0	HS-1	HS-0	HS-1
DMY	19.908^{a}	19.424^{b}	13.841^{A}	13.543^{B}
DFY	4.321^{a}	4.344^{b}	4.076^{a}	4.065^{b}
DPC	3.548^{a}	3.538^{b}	3.373^{a}	3.363^{b}
DLC	4.465^{a}	4.457^{b}	4.465^{a}	4.462^{b}
UREA	20.231^{a}	20.541^{b}	20.641^{a}	21.258^{b}
logSCC	15.946^{a}	15.967^{a}	16.305^{a}	16.301^{a}

*DMY – daily milk yield (kg); DFC – daily fat content (%); DPC – daily protein content (%); DLC – daily lactose content (%); UREA – daily lactose content (mg/ml); logSCC – log transformed somatic cell count; Lsmeans within the same row and mastitis risk class marked with different letters (a, b) differ statistically significant ($p < 0.05$); HS-0: normal condition, HS-1: heat stress condition

The negative effect of increase of temperature and temperature humidity index on daily milk production was determined in all cows. The increase of ambient temperature for one degree, in both breeds, induces decrease of around 50 g of milk / day (with slightly higher decrease determined in Simmentals (-0.0483, vs -0.0463). Furthermore, the negative effect of high relative humidity in the barns was pronounced in Simmental than Holstein cows. Accordingly, to many studies, highly productive dairy cows lose their ability to regulate body temperature at an air temperature of 25 to 29°C. For instance, the increase in daily production from 35 to 45 kg results in a higher sensitivity to thermal stress and reduces the threshold temperature for intermediate heat stress by 5°C (Berman, 2005). Furthermore, the heat stress condition may occur even in periods with lower temperatures when problems could be caused by high relative humidity (Gantner *et al*., 2011). The negative effect of high humidity on milk production was also confirmed by Bianca (1965). She determined that at 29°C and 40% RH milk yield of Holstein, Jersey and Brown Swiss cows produced 97, 93, and 98% of normal production, but when relative humidity increased to 90% milk production dropped to 69, 75, and 83% of normal level. Du Preez *et al*. (1990a) in dairy cows bred in South Africa, determined the decrease of milk yield at THI higher than 72 meaning at 22°C at 100% RH, 25°C at 50% RH, or 28°C at 20% RH. Significant decrease in milk production, in amount of 6% (9%) depending on the region, during the warmer months in Argentina was also determined by Casa and Ravelo (2003). Similarly, to results of this research, Bouraoui *et al*. (2002) reported decrease of 0.41 kg of milk / day for

each point increase of THI above 69. Accordingly, to many researches (Kadzere *et al*., 2002; Bohmanova, 2006; Collier *et al*., 2006; Hansen, 2013; Gantner *et al*., 2017), the threshold value of THI depend on a many effect, for instance, lactation stage, parity, level of milk production, breed, breeding region, individual susceptibility to heat stress, etc. For instance, Bouraoui *et al*. (2002) put the threshold on 65-69, Bernabucci *et al.* (2010) as well as Collier end Hall (2012) on 68, Du Preez *et al.* (1990a, b) on 72, while Bohmanova *et al.* (2007) depending on region defined threshold THI value 72 in Georgia, and 74 in Arizona. Lambertz *et al.* (2014) pointed out that the difference in defined threshold values could be due to better adapted cows, farm management or housing.

CONCLUSIONS

In this research, application of selected optimal models for evaluation showed statistically highly significant ($p < 0.05$) effect of microclimate parameters (ambient temperature, T; relative humidity, RH and temperature-humidity index, THI) on the variability of analysed production traits in dairy cows (daily milk yield, daily fat, protein, lactose and urea content, and somatic cell count). Determined decrease in daily milk yield and daily fat and protein content caused by the increase in T and THI in both breeds showed to be statistically significant ($p < 0.05$). Furthermore, the daily urea content, and somatic cell count increased in terms of increased daily T, RH and THI in both analysed breeds. The daily lactose content showed very low variability due to variations in microclimate conditions.

The analyses of variance of daily milk traits regarding the heat stress conditions (normal or stressed: HS-0 / HS-1) at different threshold THI (68, and 72) showed statistically significant ($p < 0.05$) difference in all analysed daily milk traits, with exception of log SCC. Higher difference between the daily milk yield produced in normal condition compering to heat stress condition was determined in Holstein cows, as well as at higher tested THI threshold value (72 vs. 68). Furthermore, the amount of variation in daily fat/protein/lactose content and logSCC due to heat stress was similar in all cows. Finally, daily urea content showed significant ($p < 0.05$) increase in all cows in heat stress environment with higher increase in Simmental breed and at more pronounced heat stress (higher THI threshold value, THI = 72).

Based on the obtained results, it could be emphasised that selected optimal statistical model could be used as the basis for further research aiming estimations of genetic parameters as well as breeding value for heat resistance.

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RAZVOJ I ODABIR OPTIMALNIH STATISTIČKIH MODELA ZA PROCJENU ZNAČAJNOSTI UTJECAJA MIKROKLIMATSKIH PARAMETARA NA VARIJABILNOST PROIZVODNIH SVOJSTAVA MLIJEČNIH KRAVA

Rezime

Trenutno živimo i proizvodimo u svijetu koji karakteriziraju klimatske promjene. Za poljoprivredu, a osobito stočarstvo, ove promjene u većini slučajeva znače pogoršanje okolišnih uvjeta u brojnim regijama, te na globalnoj razini i posljedično značajan utjecaj na stočarsku proizvodnju u cijelom svijetu. Suvremena stočarska proizvodnja najčešće podrazumijeva visoku produktivnost po životinji, što u mliječnom govedarstvu znači visoku proizvodnju mlijeka po kravi. Povećanje proizvodnje čini krave osjetljivijim na toplinski stres, što znači da će toplinski stres postati akutni problem bez obzira na klimatske promjene, koje će ovaj problem samo još više naglasiti. Visoko proizvodne mliječne krave gube sposobnost regulacije tjelesne temperature kada temperatura okoline dosegne 25-29°C. Nadalje, intenzivna genetska selekcija usmjerena na visoku proizvodnju mlijeka rezultirala je izmijenjenom fiziologijom termoregulacije što znači da krave koje proizvode više imaju veće okvire i posljedično veće gastrointestinalne sustave koji im omogućuju probavu više hrane. Navedeno stvara više metaboličke topline i smanjuje sposobnost krava da reguliraju normalnu temperaturu u uvjetima toplinskog stresa. Naposljetku, povećanjem količine mlijeka, unosa hrane te metaboličke topline, termoneutralnost životinja prelazi na niže temperature. Sukladno brojnim istraživanjima, toplinski stres u krava inducira smanjenje unosa suhe tvari, proizvodnju mlijeka i reproduktivne performanse. Također, uvjeti toplinskog stresa utječu na sastav mlijeka, broj somatskih stanica (SCC) i učestalost mastitisa.
Budući da se Panonska regija odlikuje velikom prevalencijom dana sa toplinskim stresom, uglavnom tijekom ljetne sezone, cilj ovog rada bio je razviti i odabrati optimalne modele za procjenu utjecaja mikroklimatskih parametara na varijabilnost proizvodnih svojstava u mliječnih krava.

Ključne riječi: *statističko modeliranje, mikroklima, proizvodna svojstva, mliječna goveda*

UTJECAJ NAČINA PROIZVODNJE NA KVALITET MARINIRANOG BIJELOG LUKA (*ALLIUM SATIVUM* L.)

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Orginalni naučni rad – *Orginal scientific paper*

Rezime

Bijeli luk je posebno cijenjen proizvod u svijetu kako u svježem tako i u prerađenom obliku. Međutim, neposredno nakon prerade mariniranog bijelog luka dolazi do promjene boje u zelenu. Nastala promjena nema negativan utjecaj na zdravlje potrošača ali ograničava njegovu komercijalnu upotrebu i smanjuje ekonomsku vrijednost. Stoga je cilj rada bio analizirati utjecaj predtretmana (kombinacija 0,2% limunske i 0,3% askorbinske kiseline; blanširanja pri 75°C tri minute, te salamurenja sa 16, 20 i 24% koncentracije NaCl), vrste sječiva (keramički i metalni), i koncentracije sirćetne kiseline (0,8, 1,0 i 1,5%) u nalivu, na parametre kvaliteta mariniranog bijelog luka. Analizirani su sadržaj ukupnih fenola (spektrofotometrijski *Folin-Cicalteu* reagensom), tvrdoća (teksturometrom *Stable Micro System, Surrey* UK) i senzorne karakteristike (okus, miris, boja i tekstura) od strane 10 ocjenjivača. Nije utvrđen značajan utjecaj predtretmana na analizirana senzorna svojstva dok su na tvrdoću proizvoda i sadržaj fenola značajan utjecaj ispoljili tretmani blanširanjem i kombinacija limunske i askorbinske kiseline. Veći sadržaj ukupnih fenola je zabilježen kod uzoraka koji su pripremljeni keramičkim sječivom u odnosu na metalno, izuzev kod uzoraka prethodno salamurenih sa 20% soli. Zbog važnosti fenolnih komponenti na zdravlje potrošača, te boje i teksture na marinirane proizvode, preporučuje se mariniranje bijelog luka u nalivu sa 1,5% sirćetnom kiselinom, prethodno salamurenog sa 16% soli i pripremljenog keramičkim nožem.

Ključne riječi: *predtretmani, mariniranje, senzorna analiza, sadržaj ukupnih fenola, tekstura*

UVOD

Bijeli luk su još u davna vremena koristili Egipćani, Vikinzi, Kinezi, Grci, Rimljani i dr. kao lijek za intestinalna oboljenja, nadutost, respiratorne infekcije, kožne bolesti, rane, i sl. (Block, 1985). Tradicionalno prepoznate zdravstvene efekte bijelog luka potvrdile su i novije studije navodeći da konzumiranje bijelog luka smanjuje rizik od kardiovaskularnih i kancerogenih oboljenja, jača imunitet, vrši detoksikaciju

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organizma, jača otpornost organizma na stres, te da ima pozitivan utjecaj u borbi protiv starenja (Bongiorno *et al*., 2008; Tsai *et al*., 2012; Shang *et al*., 2019). Uglavnom su organofosforna jedinjenja bijelog luka zaslužna za antimikrobno, antiinflamatorno i antiaterosklerotično dejstvo, kao i za smanjenje nivoa masti u krvi i krvnog pritiska (Popić i Vujičić, 2009; Gebreyohannes i Gebreyohannes, 2013). Osim u svježem stanju bijeli luk se koristi i prerađen u niz nutritivno vrijednih proizvoda (Casado *et al*., 2004). Međutim, tokom prerade dolazi do promjene boje koja je generalno nepoželjna osim kod kineskog delikatesa, biološki konzervisanog bijelog luka „Lab", kod kojeg se zelena boja iznimno cijeni. Tako npr. preradom bijelog luka pod određenim uslovima, kao što su kisela sredina i skladištenje pri sobnoj temperaturi, stvara se žad zelena boja koja ograničava komercijalno korištenje a smanjuje ekonomsku vrijednost prerađevinama (Lukes, 1986; Kim *et al*., 1999; Jedelska *et al*., 2008). U integralnom česnu ne dolazi do promjene boje. Međutim, tokom prerade, dolazi do kontakta enzima alinaze smještenog u vakuolama sa substratom, S-alk(en)ilcistein sulfoksidom, pri čemu nastaju različiti tiosulfati. Nastali tiosulfati zatim, reaguju sa prisutnim aminokiselinama u bijelom luku stvarajući pigmentne prekursore, koji dalje reaguju sa di(2-propenil) tiosulfinatom stvarajući plavi pigment. Istovremeno, pigmentni prekursori reaguju sa pirogrožđanom kiselinom, proizvodeći žuti pigment. Kombinacijom žutih i plavih pigmenata formira se zelena boja (Zeng *et al*., 2013). S obzirom da je ova promjena boje prerađenog bijelog luka uglavnom nepoželjna i da uzrokuje velike finansijske gubitke, to se pokušavaju iznaći načini koji će je prevenirati. Tako su istraživači Kim *et al*. (1999) ispitivali utjecaj različitih koncentracija natrijum metabisulfita, askorbinske kiseline, cisteina i trinatrijum fosfata na promjenu boje prerađenog bijelog luka i utvrdili da je natrijum metabisulfit najefikasniji u očuvanju boje. Promjena boje se također može inhibirati ukoliko je pH vrijednost medija ispod 4 (Bai *et al*., 2006; Imai *et al*., 2006; Kubec *et al*., 2004) te primjenom visokog pritiska (Hong i Kim, 2004). Nadalje, Lukes (1986) iznosi da je bijeli luk skladišten prije prerade pri temperaturi od 3°C tokom 2-4 sedmice podložniji promjeni boje.
Imajući u vidu naprijed izneseno cilj ovog rada bio je analizirati utjecaj predtretmana, vrste sječiva, te koncentracije sirćetne kiseline na kvalitet mariniranog bijelog luka.

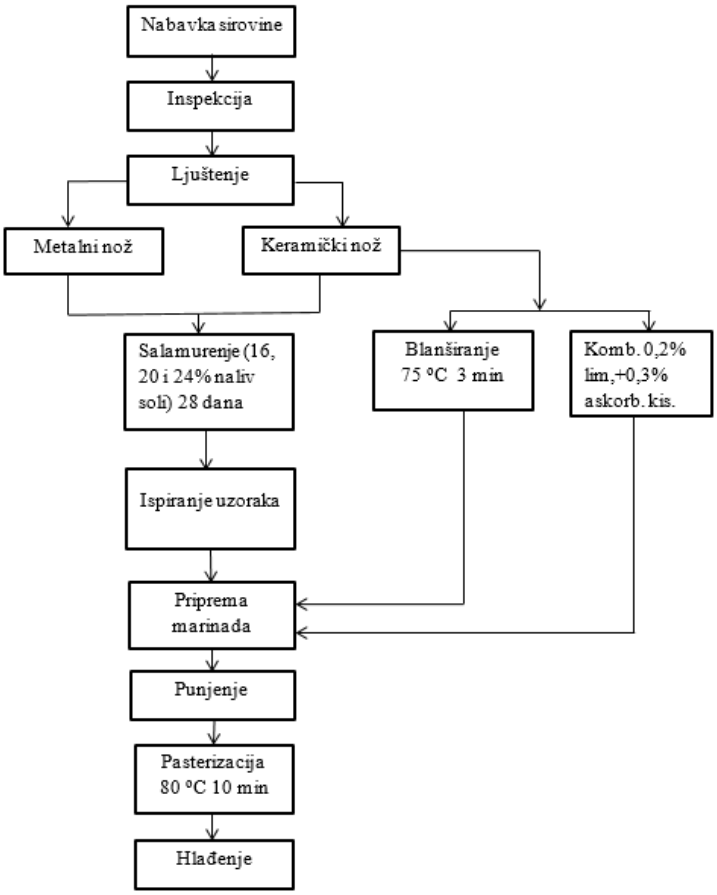
MATERIJAL I METOD RADA

Bijeli luk koji je poslužio kao materijal u radu nabavljen je u količini od 5 kg na otvorenoj tržnici. Lukovice su bile bez vidljivih oštećenja, zdrave sa sitnim češnjevima i bijele ovojnice. Pored osnovne sirovine za proizvodnju mariniranog bijelog luka korištene su askorbinska, limunska i sirćetna kiselina karakteristika u skladu sa važećim Pravilnikom[2]. Nakon inspekcije vršeno je manuelno ljuštenje lukovice i česna bijelog luka i to keramičkim nožem dok je za predtretman slamurenjem ova operacija vršena i metalnim nožem. Uzorci su zatim podvrgnuti predtretmanima (blanširanje, tretman kombinacijom limunske i askorbinske kiseline i salamurenje). Blanširanje uzoraka je

[2] Pravilnik o prehrambenim aditivima, Službeni glasnik BiH, broj 33/18 dostupno na: http://www.fsa.gov.ba/fsa/images/pravni-propisi/hr_Pravilnik_o_prehrambenim_aditivima_33-18.pdf preuzeto 15.07.2019.

vršeno pri temperaturi od 75°C tokom tri minute, zatim je slijedilo punjenje i zatvaranje u prethodno oprane i sterilisane tegle, dodavanje naliva, pasterizacija pri temperaturi 80°C 10 minuta te naglo hlađenje. Predtretman potapanjem u rastvoru organskih kiselina proveden je tako što su oljušteni uzorci potapani u rastvor kombinacije 0,2% limunske i 0,3% askorbinske kiseline tokom pet minuta dok su ostale operacije provedene po prethodno opisanom postupku. Naliv za opisane predtermane je sadržavao 1% sirćetne kiseline i 1,7% soli. Salamurenje je provedeno tako da su odvojeno oljušteni uzorci metalnim odnosno, keramičkim sječivima i potapani u rastvor soli koncentracije (16, 20 i 24% - oznake na grafikonima A, B i C) tokom 28 dana. Nakon salamurenja uzorci su ispirani i ostavljali potopljeni u vodi 24h radi uklanjanja soli. Ostale operacije su provedene po već opisanom postupku. Naliv za prethodno salmurene uzorke je pripremljen u tri varijante: I (0,8% sirćetne kiseline), II (1% sirćetne kiseline) i III (1,5% sirćetne kiseline). Tehnološka linija proizvodnje mariniranog bijelog luka prikazana je na shemi 1. Uzorci su skladišteni 14 dana da bi došlo do ujednačavanja sadržaja a zatim su vršene analize koje su podrazumijevale senzornu analizu, određivanje ukupnih fenola i određivanje tvrdoće.

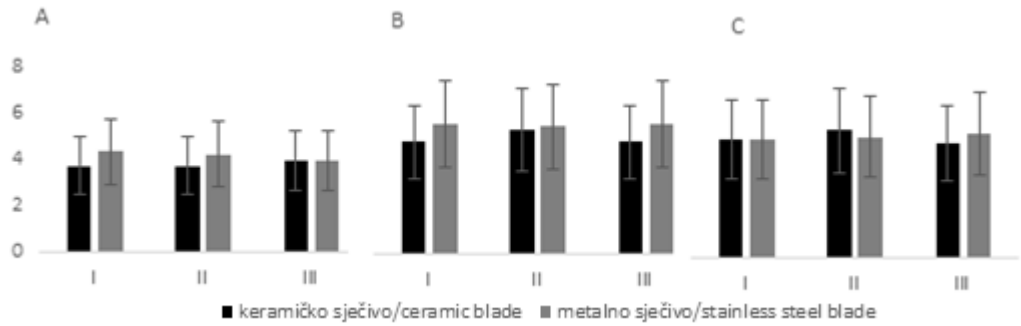
Ocjenjivanje senzornih karakteristika mariniranog bijelog luka vršilo je 10 obučenih ocjenjivača, starosne dobi od 20-50 godina. Uzorci su ocjenjivani pomoću olfaktorne, gustativne i vizuelne tehnike, pri čemu je korištena petostepena skala. Ukoliko je kriterij u potpunosti zadovoljen dodijeljena je ocjena 5, a ukoliko nije ili djelimično jeste ocjena se smanjivala, osim kod parametra teksture gdje se ocjena 1 dodijeljivala ako je kriterij u potpunosti zadovoljen, a ukoliko nije ili djelimično jeste povećavala se u skladu sa tim. Senzorne karakteristike koje su se ocjenjivale su boja, miris, okus te tekstura mariniranog bijelog luka. Određivanje ukupnih fenola vršeno je spektrofotometrijskom metodom *Folin-Ciocaltu* reagensom pri talasnoj dužini 765 nm a kao standard je korištena galna kiselina (Ough i Amerine, 1988). Tvrdoća uzoraka je mjerena na teksturometru (*Stable Micro System, Surrey* UK) a vrijednosti su izražene u njutnima (N). Primjenom jedno- i dvofaktorijalne analize varijanse te t-testa analizirani su rezultati provedenih istraživanja (SPSS 20 program).



Shema 1. Eksperimentalna proizvodnja mariniranog bijelog luka / *Experimetal production of marinated garlic*

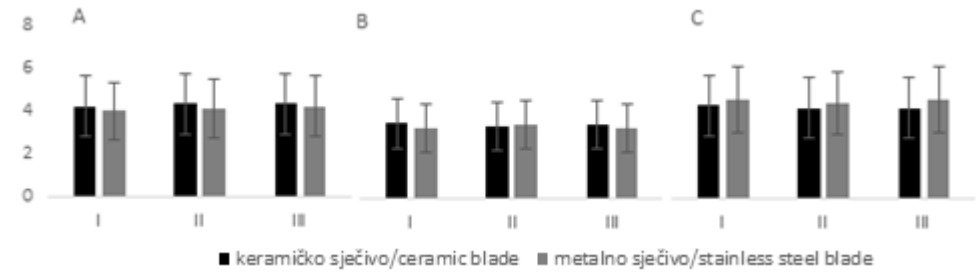
REZULTATI RADA SA DISKUSIJOM

Podaci o rezultatima senzorne analize provedenih predtretmana mariniranog bijelog luka prikazani su na grafikonima 1-5A. Statističkom obradom podataka dobijenih senzornom analizom nisu utvđene značajne razlike u ocjeni boje mariniranog bijelog luka prethodno salamurenog sa različitim koncentracijama soli (16, 20 i 24%). Također, na analizirani senzorni atribut ni vrsta sječiva nije ispoljila značajan utjecaj. Ocjene za boju su se kretale u rasponu od 3,5 do 4,5 što znači da je proizvod prethodno salamuren zadržao prirodnu boju bijelog luka tj. da nije došlo do promjene boje u smeđu odnosno žad zelenu (graf.1A-C).

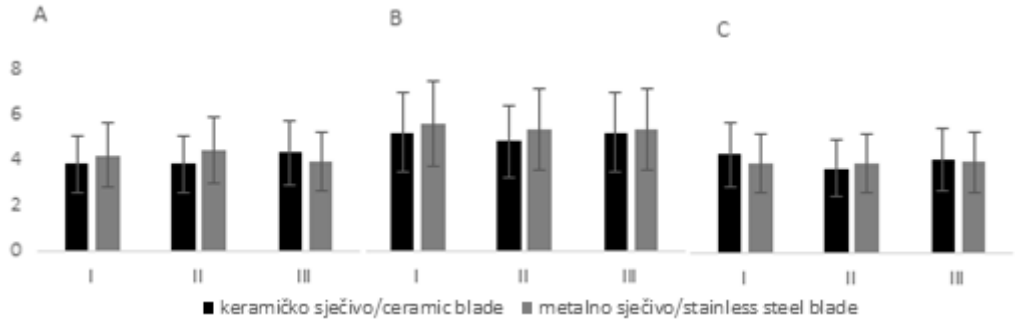


Grafikon 1 (A-C). Senzorna ocjena boje prethodno salamurenih uzoraka / *Sensory analysis of color in previously brined samples*

Može se pretpostaviti da su primijenjene koncentracije soli prilikom predtretmana salamurenjem inhibirale aktivnost enzima, koji u interakciji sa substratom uzrokuje promjenu boje (Zhang *et al*., 2013), što je rezultiralo očuvanjem boje mariniranog bijelog luka. Navedeno potvrđuju istraživanja autora Vamos Vigyazo (1995) i Luo *et al*. (2011), koji iznose da su neorganski halidi, i to najčešće kalcij i natrij hlorid u koncentraciji 2-4 % (Steiner i Riet, 1989 – prema Marchall *et al*., 2000), efikasni inhibitori polifenoloksidaze, enzima koji uzrokuje enzimsko posmeđenje voća i povrća. Također, nije utvrđen utjecaj koncentracije sirćetne kiseline, kao niti vrste sječiva na senzorne ocjene mirisa i okusa mariniranog bijelog luka (graf. 2, 3 A-C). Uzorci prethodno salamureni u koncentracije soli 24% dobili su visoke ocjene za miris u rasponu od 4,1 do 4,6, dok su za okus pri istom tretmanu ocjene bile neznatno niže (3,7-4,3). Navedeno ukazuje na činjenicu da su uzorci zadržali tipičan intenzivan miris i okus bijelog luka i nakon 28 dana koliko je trajao proces salamurenja. U prilog navedenom su i vrijednosti standardne devijacije na osnovu kojih se može vidjeti da su ocjenjivači bili usklađeni u pogledu ocjene mirisa i okusa jer nije došlo do rasipanja ocjena. Poznato je da kuhinjska so doprinosi intenziviranju arome hrane. Tako i u čokoladi intenzivira druge nezaobilazne arome, naglašava čistu hrskavu notu i reducira gorčinu, kada se dodaje u rangu između 0,06 i 0,12% na ukupnu količinu preliva (Miličević *et al*., 2015). Nadalje, prema istraživanjima Memic *et al*. (2014) dodatak soli utječe na izbalansiranost isparljivih komponenti te skraćuje vrijeme destilacije pri proizvodnji jakih alkoholnih pića. Stoga je bilo za očekivati da uzorci koji su prethodno salamureni sa većom koncentracijom soli (24%) dobiju više ocjene za miris. Međutim, s obzirom da su generalno za salamurenje korištene visoke koncentracije soli (16-24%) i da bijeli luk ima veoma jak, intenzivan miris za pretpostaviti je da ocjenjivači nisu detektovali razlike u intenzitetu.



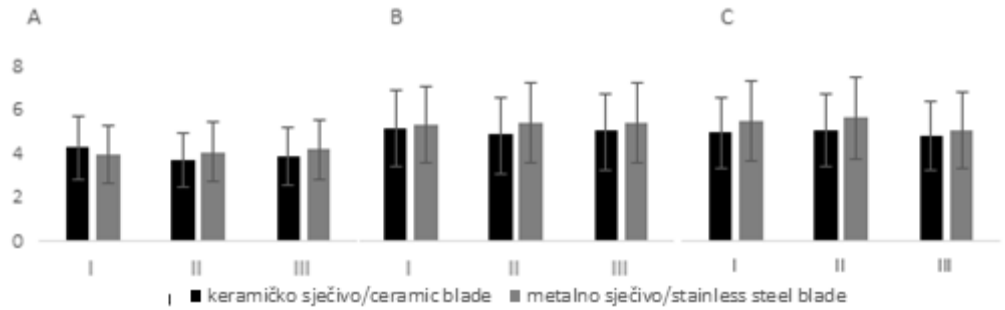
Grafikon 2 (A-C). Senzorna ocjena mirisa prethodno salamurenih uzoraka /*Sensory analysis of odour in previously brined samples*



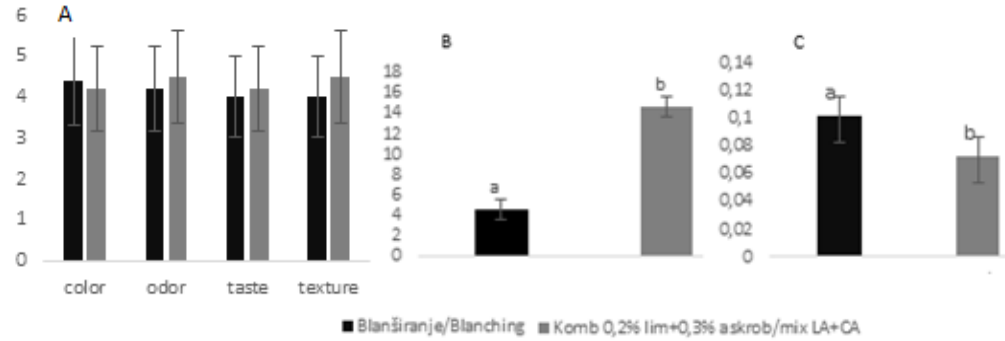
Grafikon 3 (A-C). Senzorna ocjena okusa prethodno salamurenih uzoraka/ *Sensory analysis of taste in previously brined samples*

Na osnovu rezultata provedene senzorne ocjene teksture prikazanih na grafikonu 4. (A-C) jasno se vidi da analizirani faktori (vrsta sječiva i koncentracija sirćetne kiseline) nisu ispoljili značajan utjecaj. Svi analizirani uzorci su ocjenjeni ocjenama u intervalu 3,5 – 4,3 odnosno ocjenjeni su kao srednje meki do meki. Dobijeni rezultati su u skladu sa navodima Luo *et al.* (2011) koji iznose da tretman natrijumhloridom a posebno ukoliko je dodatno zakiseljen uzrokuje omekšavanje tkiva jabuke. Stoga istraživači Mola *et al*. (2016) predlažu kombinovani tretman natrijum hloridom, kalcijum hloridom i kalcijum askorbatom svježe sječenih plodova java jabuke (*Syzygium samarangense* L.).

Predtretmani bijelog luka blanširanjem i potapanjem u rastvor limunske i askorbinske kiseline nisu ispoljili značajan utjecaj na analizirane senzorne atribute (graf. 5A). Ocjene za sve analizirane senzorne atribute kretale su se u rasponu od 4,0 do 4,5. Nešto niže ocjene, izuzev za boju, dobili su blanširani uzorci u odnosu na tretman rastvorom limunske i askorbinske kiseline što je i razumljivo uzme li se u obzir činjenica da tretman blanširanjem rezultira okusom na „kuhano" (Ioannou i Ghoul, 2013) te uzrokuje gubitak rastvorljivih komponenti (Mazzeo *et al*., 2011). Isti autori navode da je boja zamrznutog povrća (špinat, karfiol i mrkva) koje je prethodno podvrgnuto blanširanju stabilnija zbog inaktivacije enzima koji učestvuju u reakcijama posmeđenja.



Grafikon 4 (A-C). Senzorna ocjena teksture prethodno salamurenih uzoraka / *Sensory analysis of texture in previously brined samples*



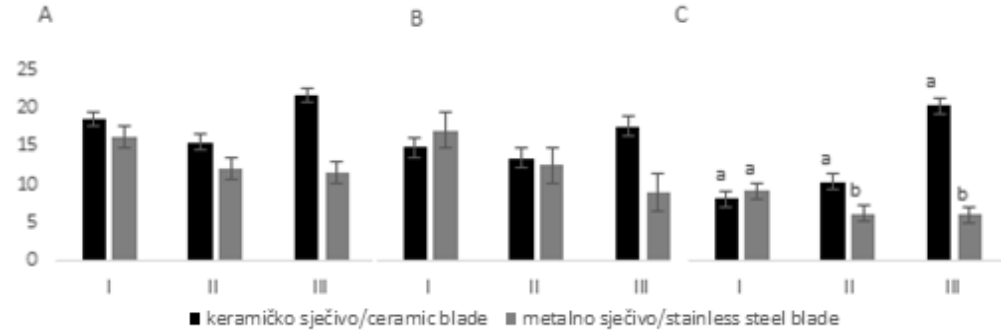
different lowercase letters (a-b) represent statistically significant differences ($t_{0,05}$) between predtreatments

Grafikon 5 (A-C). Utjecaj predtretmana na senzorne karakteriske (A), tvrdoću (B) (N) i sadržaj fenola (C) (gGAE/100g) mariniranog bijelog luka / *The influence of pretreatments on sensory characteristics, hardness and total phenol content of marinated garlic*

Na tvrdoću prethodno salamurenih uzoraka u koncentraciji soli 24% značajan utjecaj je ispoljila vrsta sječiva i to u varijantama II i III dok su između ostalih uzoraka uočene razlike posljedica slučaja (graf. 6 A-C). Generalno se može reći, izuzev salamure sa 20 i 24% koncentracije soli u varijanti I, da su uzorci pripremljeni keramičkim sječivom imali veću čvrstoću (21,65; 14,60; i 20,22 N) u odnosu na metalne (11,57; 7,08 i 5,94 N). Istraživači Mola *et al.*(2016) izdvojili su tretman kombinacijom natrijum hlorida, kalcijum hlorida i kalcijum askorbata za tretman svježe sječenih plodova java jabuke u cilju sprečavanja enzimskog posmeđenja, očuvanja čvrstoće i mikrobiološke kontaminacije. Prema istim autorima čvrstoća uzorka na početku skladištenja iznosila je 44,35 N a nakon skladištenja pri navedenom tretmanu neznatno se promijenila i iznosila je 38,68 N.

Utvrđen je utjecaj predtretmana blanširanja i potapanja u rastvoru limunske i askorbinske kiseline na tvrdoću proizvoda (graf. 5B). Statički značajno veću čvrstoću imali su uzorci tretirani u rastvoru limunske i askorbinske kiseline (14,71 N) u odnosu na blanširane (4,56 N). Dobijeni rezultati su u skladu sa navodima autora Badwik *et*

al. (2015) i Denga *et al*. (2017) koji iznose da konvencionalno blanširanje vodom utječe značajno na inaktivaciju različitih enzima, uništava mikrooganizme, ali i omekšava teksturu uzoraka.

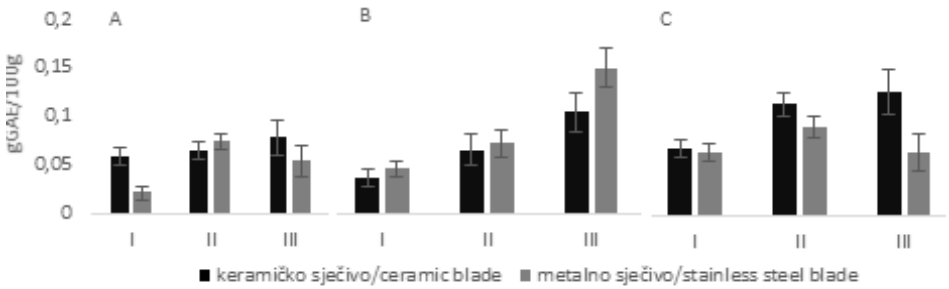


different lowercase letters (a-b) represent statistically significant differences ($t_{0,05}$) between type of the blade material

Grafikon 6 (A-C). Prosječne vrijednosti tvrdoće (N) prethodno salamurenih uzoraka/
The average value of hardness (N) in peviously brined samples

Utvrđen je statistički značajno veći sadržaj fenola u blanširanim (0,101 gGAE/100g) u odnosu na uzorke tretirane rastvorom limunske i askorbinske kiseline (0,072g/100g) (graf. 5C). Dobijeni rezultati su u skladu sa navodima autora Begić-Akagić i Piližota, 2010) koji su analizirali utjecaj termičkog tretmana (50, 60, 65 i 70°C tokom 5 minuta i 70°C tokom 3 minute) na sadržaj fenola analiziranih sorti prethodno sječenog krompira. Naime, autori su utvrdili da je degradacija polifenola usporenija pri višim temperaturama, pri čemu dolazi do inaktivacije enzima odgovornog za reakcije enzimskog posmeđenja.

Veći sadržaj fenola zabilježen je u uzorcima pripremljenim u nalivima sa većom (1,0% odnosno 1,5%) koncentracijom sirćetne kiseline (0,150 odnosno 0,127 gGAE/100g), a najniži (0,023 gGAE/100g) sa najnižom koncentracijom sirćetne kiseline (0,8%) kod prethodno salamurenih uzoraka. Također, zabilježena je i veća koncentracija fenolnih komponenti u uzorcima prethodno pripremljenim keramičkim sječivom i salamurenim u nalivima soli 16 i 24% u odnosu na metalne, osim u uzorcima salamurenim sa koncentracijom soli 20% gdje je zabilježen veći sadržaj fenola ukoliko su pripremljeni metalnim sječivom.



Grafikon 7 (A-C). Prosječan sadržaj ukupnih fenola (gGAE/100g) u prethodno salamurenim uzorcima / *The average content of total phenol (gGAE/100g) in previously brined samples*

S obzirom da nije utvrđen utjecaj analiziranih faktora na sadržaj fenola kod predhodno salamurenih uzoraka utvrđene razlike su posljedica slučaja (graf. 7 A-C). Ovi rezultati su očekivani, s obzirom da metalna sječiva uglavnom sadrže bakar i željezo te prilikom dezintegracije ćelijskog tkiva vrlo brzo dolazi do reakcije metala sa ćelijskim sadržajem uzrokujući promjenu boje i gubitak fenola. S druge strane keramička sječiva su "hemijski inertna", te se za njih smatra da inhibiraju enzimsko posmeđenja tj. usporavanju oksidaciju polifenolnih komponenti i utječu na njihovu stabilnost (Begić-Akagić, 2010). Prema rezultatima istraživanja drugih autora sadržaj fenola u bijelom luku iznosi 562,6 mg/100g (Park *et al.*, 2009) odnosno 15,61-19,69 mg/g (Lu *et al*., 2011) i uveliko zavisi od dužine skladištenja, odnosno što je bijeli luk duže čuvan koncentracija fenola je veća (Choi *et al.*, 2008). Dobijeni rezultati odstupaju od navedenih što je i očekivano s obzirom da su uzorci prethodno podvrgnuti predtretmanima te da su bili pasterizovani pri čemu je došlo do gubitka ovih vrijednih komponenti.

ZAKLJUČCI

Boja kao i ostale analizirane senzorne karakteristike mariniranog bijelog luka nisu se statistički značajnije mijenjale pod utjecajem primijenjenih predtretmana. Na tvrdoću prethodno salamurenih uzoraka sa koncentracijom soli 24% značajan utjecaj je ispoljila vrsta sječiva i to u varijantama II i III gdje su uzorci pripremljeni keramičkim sječivom imali veću čvrstoću u odnosu na metalne. Također, značajno veću čvrstoću imali su uzorci prethodno tretirani u rastvoru limunske i askorbinske kiseline u odnosu na blanširane. Sadržaj ukupnih fenola bio je značajno veći u prethodno blanširanim uzorcima u odnosu na uzorke tretirane rastvorom limunske i askorbinske kiseline. U uzorcima prethodno salamurenim sa 16 i 24% soli pripremljenim keramičkim sječivom zabilježen je veći sadržaj ukupnih fenola u odnosu na uzorke pripremljene metalnim sječivom. Imajući u obzir navedeno preporučuje se mariniranje bijelog luka u nalivu sa 1,5% sirćetne kiseline, prethodno salamurenje sa 16% soli i priprema keramičkim sječivom.

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THE IMPACT OF THE PRODUCTION METHOD ON THE QUALITY OF MARINATED GARLIC (*ALLIUM SATIVUM* L.)

Summary

Garlic is highly consumed vegetable in the world and is processed in various forms. However, after production the marinated garlic change the natural color into green without negative impact on the consumer's health, but it limits its commercial use and reduces economic value. Therefore, the aim of the paper was to analyze the influence of pretreatments (mixture of 0,2% citric acid and 0,3% ascorbic acid; blanching 75°C for 3 minutes; brined with different salt concentrations 16, 20 and 24%), type of the blade material (ceramic and stainless steel) and acetic acid concentration (0,8; 1,0 and 1.5%) on the quality parameters of marinated garlic. The total phenol content (spectrophotometric by Folin-Ciocalteu reagent), texture profile by Texture Analyzer (Stable Micro System, Surrey UK) and sensory characteristics (taste, odor, color and texture) in samples were analyzed. Sensory parameters of marinated product were not affected by pretreatment while the phenol content and texture profiles of samples were affected by blanching treatment and mixture citric and ascorbic acid. Higher content of total phenol was recorded in samples produced with ceramic in relation to metal blade with the exception of samples previously brined with 20% salt. As a result of the importance of phenolic compounds for human health and color and texture for marinated products, marinated garlic production method which includes ceramic blade for preporation, 1,5% acetic acid, previously brined with 16% salt concentration.

Key words: *pretretments; marination; sensory evaluation, total phenols, texture profile*

UTICAJ STARTER KULTURE I TEMPERATURE DOGRIJAVANJA NA KVALITET KUPREŠKOG SIRA

Edin Rizvanović[1], Zlatan Sarić[1], Tarik Dizdarević[1], Smail Žilić[2]

Originalni naučni rad – *Original scientific paper*

Rezime

Kupreški sir spada u grupu punomasnih, tvrdih sireva, a proizvodi se uglavnom od kravljeg ali takođe kozijeg i ovčijeg mlijeka ili njihovim kombiniranjem. U radu je ispitivan uticaj starter kultura i promjene temperature dogrijavanja na karakteristike Kupreškog sira. Cilj rada je proizvesti Kupreški sir uz dodatak različite termofilne starter kulture i snižene temperature dogrijavanja gruša za 10 do 12°C (37°C) u odnosu na kontrolnu proizvodnju standardnom tehnologijom (dogrijavanje do 48°C), a zatim utvrditi njihov uticaj na kvalitet Kupreškog sira. Prosječne vrijednosti hemijskog sastava Kupreškog sira su se mijenjale tokom zrenja, a nakon završetka zrenja dobijeni su sledeći rezultati za sadržaj hemijskih komponenti sira dobijenog standardnom tehnologijom: voda 31,51%, suha materija 68,48%, mast 37,16%, proteini 27,85%, mast u suhoj materiji 54,26% i voda u bezmasnoj materiji sira 50,14%. Eksperimentalni sirevi su imali slijedeći hemijski sastav: voda 29,46%, suha materija 70,53%, mast 39,00%, proteini 27,29%, mast u suhoj materiji 55,28% i voda u bezmasnoj materiji sira 48,30%. Analize su pokazale da promijenjena starter kultura i niža temperatura dogrijavanja nisu dali poboljšani kvalitet Kupreškog sira.

Ključne riječi: *kupreški sir, starter kultura, dogrijavanje, fizičko-hemjske analize sira, senzorna analiza.*

UVOD

Sirevi predstavljaju najbrojniju grupu mliječnih proizvoda, a njihova proizvodnja seže u daleku prošlost, što ih čini jednom od najstarijih životnih namirnica. Ono što posebno karakteriše sir, kao produkt nastao na bazi mlijeka, jeste raznovrsnost okusa i formi, ali i specifičan način proizvodnje. Autohtoni sirevi predstavljaju važno obilježje nekog naroda i zemlje i pokazatelj su opće i tehničke kulture. Zahvaljujući geografskom položaju i klimatskim određenjima, u bosanskohercegovačkim regijama se u velikoj mjeri razvila proizvodnja autohtonih sireva (Sarić i Bijeljac, 2003). Pored već poznatih autohtonih sireva, na BH, ali i regionalnom tržištu već dvije dekade egzistira Kupreški sir, koji je vrlo brzo doživio ekspanziju na tržištu.

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Kupreški sir spada u tvrde punomasne sireve i tradicionalno se proizvodi od kravljeg mlijeka, zatim ovčijeg i kozijeg ili njihove mješavine u mljekari „Kupres Milch“ d.o.o. Naziv je dobio po mjestu u kojem se proizvodi, te on spada u autohtone vrste sira. Cilindričnog je oblika, težine od 1,8 do 2,0 kg. Kupreški sir ima čvrstu i glatku koru, slamnato-rumene boje. Tijesto Kupreškog sira je svijetlo žute boje i zrnaste strukture. Sir se obično proizvodi od pasterizovanog kravljeg mlijeka (10–15 sekundi/ 72 - 73ºC). U tehnologiji Kupreškog sira se prije zasiravanja dodaju termofilna starter kultura bakterija mliječne kiseline i kalcijev hlorid ($CaCl_2$). Nakon rezanja gruša, dogrijavanje se odvija na temperaturi od 48°C (Rizvanović *et al*., 2018). Upotreba starter kultura (često jednostavno nazvanih starteri), koje sadrže bakterije mliječne kiseline obavezan je preduslov u savremenoj proizvodnji većine sireva. Ove kulture se zovu starteri zbog toga što one iniciraju ili "startaju" proizvodnju mliječne kiseline, što je njihova primarna uloga u proizvodnji sira. Oni uzrokuju biohemijske promjene tokom zrenja sira koje pomažu da se razvije karakteristična aroma sira (Parente i Cogan, 2004). Međunarodna mljekarska federacija (IDF) daje definiciju starter kultura: "Starter kulture LAB su pripremljene kulture mezofilnih ili termofilnih LAB. One se prvenstveno koriste zbog svoje sposobnosti da previru laktozu rezultirajući proizvodnjom mliječne kiseline, ali i zbog drugih metaboličkih aktivnosti koje imaju direktnu vezu sa posebnim svojstvima proizvoda" (IDF Standard, 1997). U osnovi, postoje dva tipa starter kultura bakterija mliječne kiseline: **mezofilne**, sa optimalnom temperaturom od oko 30°C i **termofilne**, sa optimalnom temperaturom od oko 40°C. Dok se prve upotrebljavaju za veći broj sireva (meki i polutvrdi) druge se koriste za sireve sa višom temperaturom dogrijavanja (tvrdi) koju starter bakterije moraju izdržati. Sastavljene su Korespood vrsta *Lactobacillus* i *Streptococcus*. Za izdvajanje surutke se kod tvrdih i polutvrdih sireva, pored mehaničke i kiselinske sinereze primjenjuje toplinska sinereza odnosno dogrijavanje gruša kojim se postiže veća čvrstoća što se naziva još i sušenje zrna. Dogrijavanje se za većinu polutvrdih sireva vrši na 35-40°C dok se za tvrde sireve primjenjuju temperature iznad 40°C i one mogu ići do 56°C (Bijeljac i Sarić, 2005).

Cilj rada je bio proizvesti Kupreški sir uz dodatak različite termofilne starter kulture i snižene temperature dogrijavanja gruša za 10 do 12°C (37°C) u odnosu na kontrolnu proizvodnju standardnom tehnologijom (uobičajena termofilna starter kultura bakterija mliječne kiseline i dogrijavanje do 48°C), a zatim utvrditi njihov uticaj na kvalitet Kupreškog sira.

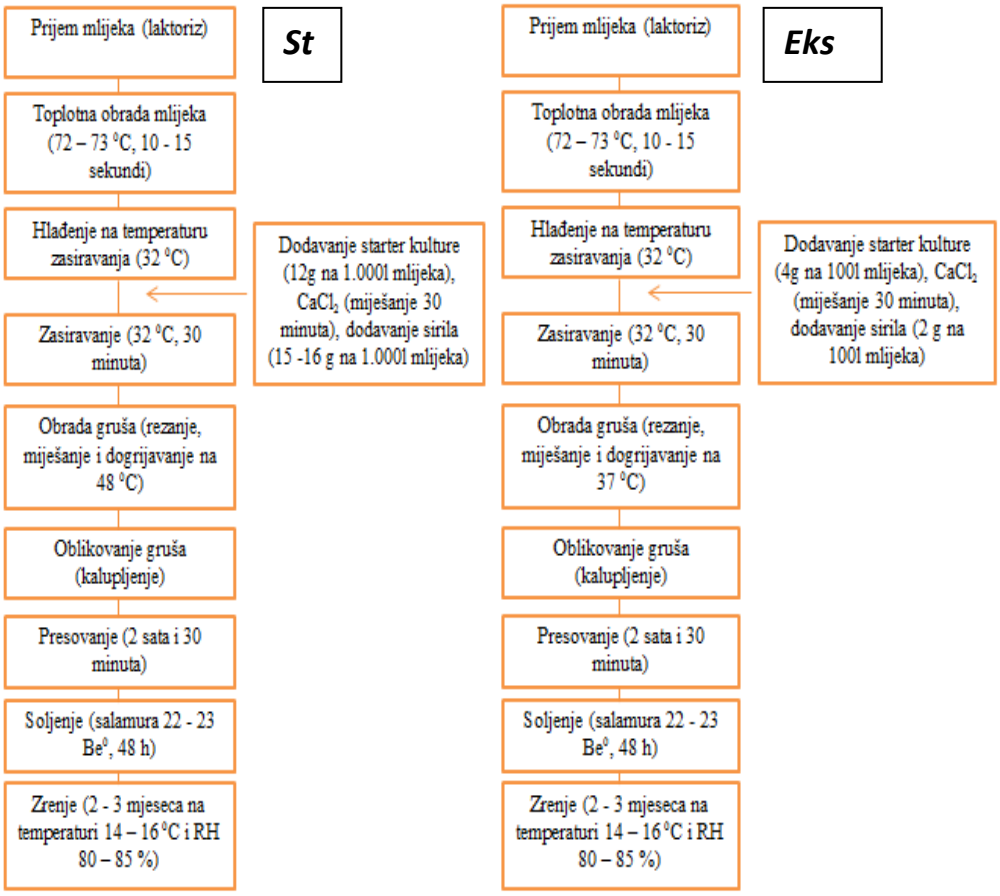
MATERIJAL I METODE

Za proizvodnju Kupreškog sira koristilo se identično mlijeko za obje proizvodnje. U mljekari „Kupres Milch“ d.o.o. u tri proizvodna dana izvršene su tri serije *standardne (a)* i *eksperimentalne (b)* proizvodnje Kupreškog sira. Praćena je tehnologija, hemijski sastav, pH i senzorne osobine Kupreškog sira tokom zrenja. Proizvodnja Kupreškog sira odvijala se u dva sirarska kazana kapaciteta 1.000 l *(St)* i 150 l *(Eks)*. Kazan kapaciteta

1.000 l se koristio za *standardnu* proizvodnju *(St)* Kupreškog sira, dok se kazan kapaciteta 150 l koristio za proizvodnju *eksperimentalnog (Eks)* Kupreškog sira.

Standardna proizvodnja *(a)* je obavljana po tehnologiji opisanoj od strane Rizvanović *et al.* (2018), od pasterizovanog kravljeg mlijeka uz upotrebu termofilne starter kulture bakterija mliječne kiseline (Chr. Hansen, TCC – 20) u količini od 12 g na 1.000 litara mlijeka i temperaturi dogrijavanja od 48-49°C. Tehnologija kod *eksperimentalne* proizvodnje razlikovala se od *standardne* po tome što se koristila drugačija termofilna starter kultura. Na 100 l mlijeka dodavalo se 4 g starter kulture (duboko zamrznuta, koncentrovana kultura, CSL PS IDC 11) odnosno 40 g na 1.000 litara mlijeka, a dogrijavanje se odvijalo na temperaturi od 37°C. Korišteno je isto sirilo za obje varijante (Chy-Max, Chr. Hansen) u količinama 15-20g/1.000 litara mlijeka i $CaCl_2$ (0,02%). Tehnološki proces proizvodnje Kupreškog sira *standardnom* i *eksperimentalnom* tehnologijom prikazan je u shemi 1.

Nakon 30, 70 i 100 dana dana zrenja izvršene su fizičko-hemijske analize sireva *standardne* i *eksperimentalne* proizvodnje gdje su određivani sadržaj suhe materije sušenjem u sušnici - Heraeus (Pravilnik o metodama uzimanja uzoraka i metodama hemijskih i fizičkih analiza mlijeka i proizvoda od mlijeka, 1983), sadržaj masti, Van Gulik metodom (ISO 3433:2008), masti u suhoj materiji (SM) i vode u bezmasnoj materiji sira (vode u BMS) računskim putem (Spreer, 1995), sadržaj proteina metodom po Kjeldahl – u (ISO 8968:2004) i pH vrijednost sira pomoću pH-metra (Metrohm 632) i elektrode WTW-SenTix Sp.



Shema 1. Tehnološki proces *standardne (St)* i *eksperimentalne (Eks)* proizvodnje sira u sirani „Kupres Milch“ d.o.o.

Scheme 1. Technology proces of standard (St) and experimental (Ex) cheese manufacture in Dairy „Kupres Milch“ d.o.o.

Senzorna analiza Kupreškog sira je izvršena nakon 30, 70 i 100 dana zrenja sira. Senzorna ocjena urađena je od strane ocjenjivačkog tima koji je sastavljen od 5 ocjenjivača-eksperata. U rezultatima su prikazane prosječne ocjene svih ocjenjivača. Ocjenjivanje je vršeno metodom bodovanja, a različite karakteristike sira su nosile različit broj bodova ovisno od njihove značajnosti. Svojstva sira koja su ocjenjivana od strane ocjenivača su slijedeća: vanjski izgled, boja, konzistencija, izgled na presjeku, miris i okus. Maksimalan broj bodova koji je sir mogao dobiti je 20,00. Svi rezultati su prikazani kao prosječne vrijednosti tri ponavljanja. Dvofaktorijalna ANOVA urađena je za sve fizičko-hemijske parametre i ukupnu senzornu ocjenu Kupreškog sira. Pomoću LSD testa ($p<0.05$) izvršeno je poređenje aritmetičkih sredina između vremena zrenja i tretmana da bi se ustanovilo gdje postoje statistički značajne razlike. ANOVA je

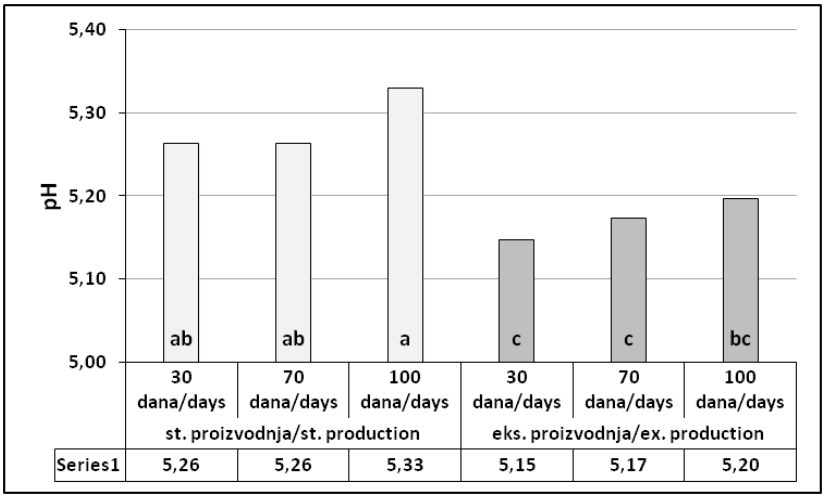
rađena u programu MS Excel, a post hoc LSD test ($p<0.05$) prema Kurtović i Jarebica (1997).

REZULTATI I DISKUSIJA

Nakon što je proizveden Kupreški sir standardnom i eksperimentalnom tehnologijom u tri uzastopna proizvodna dana od istoga mlijeka urađena je fizičko-hemijska analiza i senzorna ocjena dobivenog sira.

Fizičko-hemijski parametri Kupreškog sira

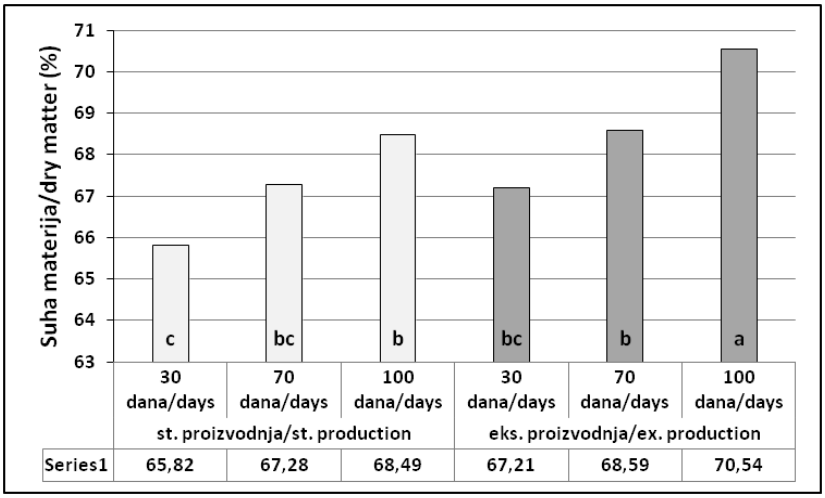
Nakon 30, 70 i 100 dana zrenja sira izvršene su analize pH vrijednosti i hemijskog sastava Kupreškog sira. Prosječne vrijednosti i rezultati analize statističke značajnosti srednjih vrijednosti su prikazani u grafikonima 1-6.



Grafikon 1. pH vrijednost Kupreškog sira proizvedenog *standardnom* i *eksperimentalnom* tehnologijom tokom zrenja

Figure 1. pH value of Kupres cheese produced by standard and experimental technology during ripening

Podaci predstavljaju srednje vrijednosti tri ponavljanja. Različita slova na stupcima ukazuju na statistički značajnu razliku (($p<0.05$, LSD test);. Data represents mean values of three replicates. Different letters means statistically significant difference (($p<0.05$, LSD test).



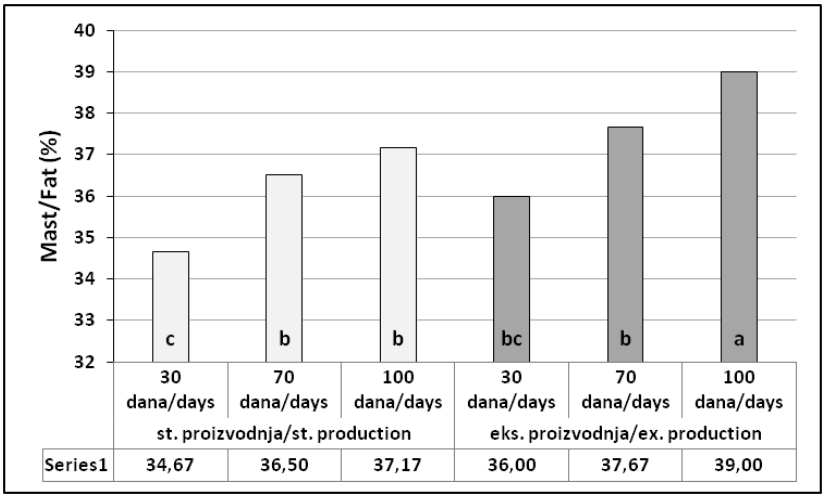
Grafikon 2. Sadržaj suhe materije Kupreškog sira proizvedenog *standardnom* i *eksperimentalnom* tehnologijom tokom zrenja

Figure 2. Dry matter content of Kupres cheese produced by standard and experimental technology during ripening

Podaci predstavljaju srednje vrijednosti tri ponavljanja. Različita slova na stupcima ukazuju na statistički značajnu razliku ((p<0.05, LSD test);. Data represents mean values of three replicates. Different letters means statistically significant difference ((p<0.05, LSD test).

Prosječna pH vrijednost tvrdog Kupreškog sira nakon završetka zrenja (100 dana) kod *standardne* proizvodnje iznosila je 5,33 što odgovara vrijednostima većine tvrdih sireva prema Hill (1995) i Fox *et al.* (2000). Kod *eksperimentalne* proizvodnje pH nakon završetka zrenja iznosila je 5,20 što je nešto niže od vrijednosti koje su dobili navedeni autori. Postepeno povećanje pH vrijednosti tokom zrenja sira je rezultat proteolize. Alkić (2007) navodi da je razlog povećanja pH sira tokom zrenja upravo proteoliza kada dolazi do oslobađanja polipeptida i aminokiselina koje imaju bazni karakter, posebno kada se sir nalazi na zrenju s povišenom temperaturom ako sadrži veliki broj kvasaca i plijesni koji ubrzavaju lipolitičke i proteolitičke promjene sira. Može se konstatovati da je pH *eksperimentalnih* sireva bio statistički niži cijelim tokom zrenja u odnosu na sireve iste starosti dobivene *standardnom* tehnologijom.

Prosječan sadržaj suhe materije nakon trideset dana zrenja kod *standardne* proizvodnje iznosio je 65,82%, a kod *eksperimentalne* proizvodnje 67,21%. Nakon 70 dana zrenja došlo je do značajnog povećanja sadržaja suhe materije koja je iznosila 67,28% kod *standardne* proizvodnje, a kod *eksperimentalne* 68,59%. Nakon završetka zrenja (100 dana) sira prosječan sadržaj suhe materije u siru je iznosio 68,49% kod *standardne* proizvodnje i bio je statistički niži u odnosu na sadržaj suhe materije sira iste starosti *eksperimentalne* proizvodnje (70,54%). Statistička značajnost postoji i između sireva na početku i kraju zrenja kod obje proizvodnje.

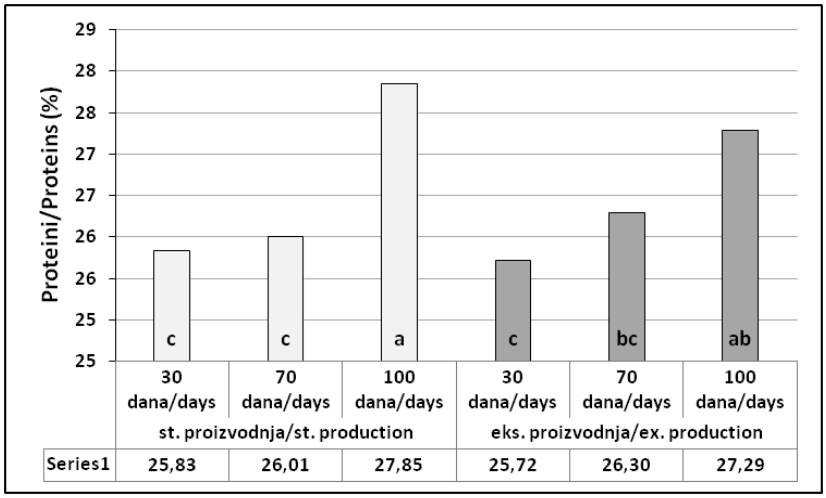


Grafikon 3. Sadržaj masti Kupreškog sira proizvedenog *standardnom* i *eksperimentalnom* tehnologijom tokom zrenja

Figure 3. Fat content of Kupres cheese produced by standard and experimental technology during ripening

Podaci predstavljaju srednje vrijednosti tri ponavljanja. Različita slova na stupcima ukazuju na statistički značajnu razliku ((p<0.05, LSD test);. Data represents mean values of three replicates. Different letters means statistically significant difference ((p<0.05, LSD test).

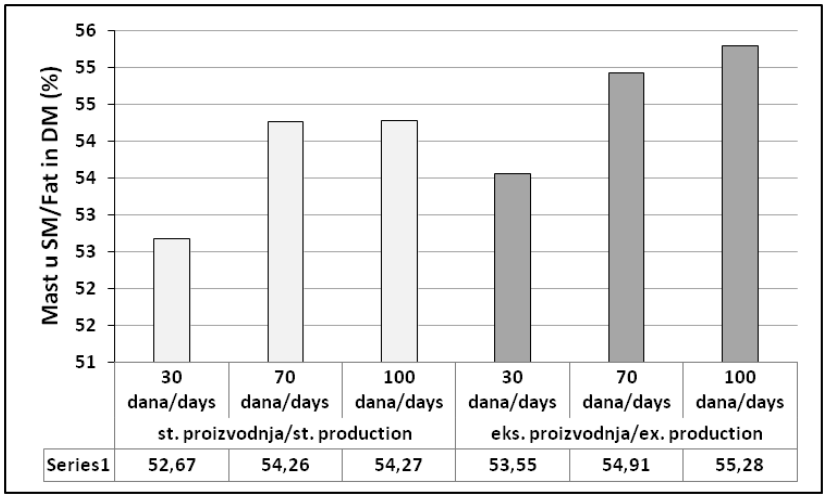
Prema istraživanju Kutle (1996) koje je proveo na industrijskom Livanjskom siru sadržaj suhe materije sira iz *standardne* proizvodnje Kupreškog sira odgovara vrijednostima suhe materije u Livanjskom siru koja je iznosila 68,53%. Količina masti u Kupreškom siru se povećavala tokom zrenja kod obje proizvodnje. Prosječan sadržaj masti nakon 100 dana zrenja kod *standardne* proizvodnje iznosio je 37,17%, dok je kod *eksperimentalne* proizvodnje došlo do povećanja masti za 1,43% u odnosu na prethodni period, te je sadržaj masti iznosio 39,00%. Iz navedenog se može vidjeti da je sadržaj masti nakon završetka zrenja sira statistički niži kod *standardne* proizvodnje u odnosu na *eksperimentalnu* proizvodnju. Razlog ovakvog odnosa se može objasniti činjenicom da je temperatura dogrijavanja gruša kod *eksperimentalne* proizvodnje niža za 10–12 ^{0}C u odnosu na *standardnu* proizvodnju. Sadržaj masti kod obje varijante Kupreškog sira se razlikuje od podataka koje navode Gallowey i Crawford (1985) za različite vrste tvrdih sireva gdje je sadržaj masti iznosio 33,00%. Prosječan sadržaj proteina nakon trideset dana zrenja kod *standardne* proizvodnje iznosio je 25,83%, a kod *eksperimentalne* proizvodnje 25,72%. Nakon 70 dana zrenja došlo je do povećanja sadržaja proteina za 0,18% kod *standardne* proizvodnje, a kod *eksperimentalne* za 0,58%. Završetkom procesa zrenja sira (100 dana) prosječan sadržaj proteina u siru je iznosio 27,85% kod *standardne* proizvodnje, a kod *eksperimentalne* 27,29% i bio je statistički značajno viši u odnosu na početak zrenja.



Grafikon 4. Sadržaj proteina Kupreškog sira proizvedenog standardnom i eksperimentalnom tehnologijom tokom zrenja

Figure 4. Protein content of Kupres cheese produced by standard and experimental technology during ripening

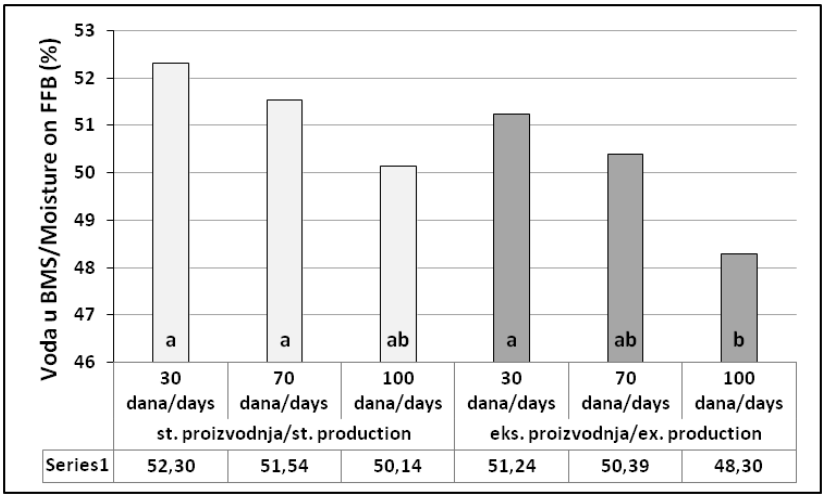
Podaci predstavljaju srednje vrijednosti tri ponavljanja. Različita slova na stupcima ukazuju na statistički značajnu razliku ((p<0.05, LSD test);. Data represents mean values of three replicates. Different letters means statistically significant difference ((p<0.05, LSD test).



Grafikon 5. Sadržaj masti u suhoj materiji (SM) Kupreškog sira proizvedenog standardnom i eksperimentalnom tehnologijom tokom zrenja

Figure 5. Fat in dry matter content of Kupres cheese produced by experimental and standard technology during ripening

Podaci predstavljaju srednje vrijednosti tri ponavljanja. Različita slova na stupcima ukazuju na statistički značajnu razliku ((p<0.05, LSD test);. Data represents mean values of three replicates. Different letters means statistically significant difference ((p<0.05, LSD test).



Grafikon 6. Sadržaj vode u bezmasnoj materiji sira (BMS) Kupreškog sira proizvedenog standardnom i eksperimentalnom tehnologijom tokom zrenja

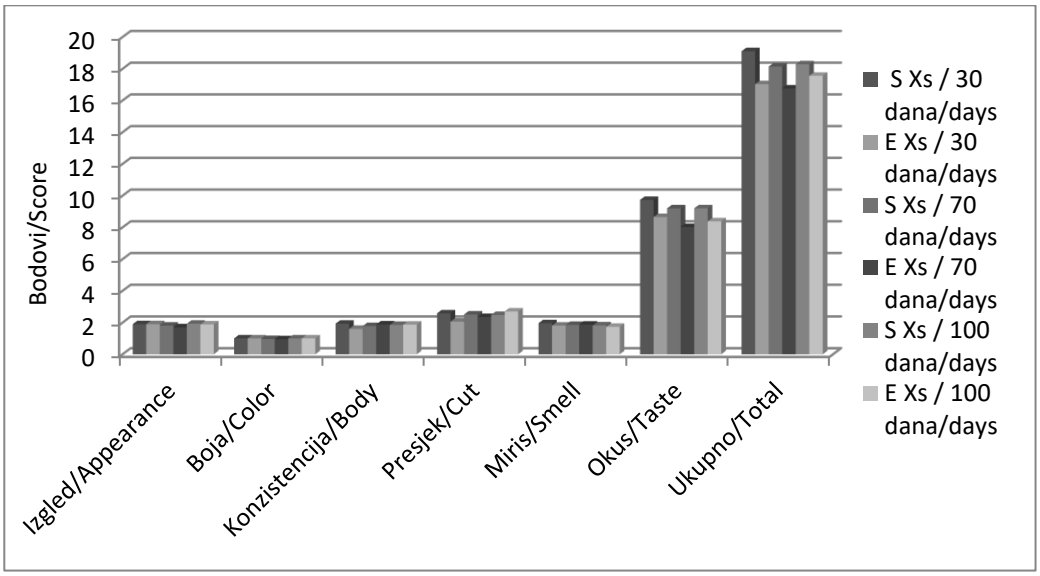
Figure 6. Moisture on fat-free basis content (FFB) of Kupres cheese produced by standard and experimental technology during ripening

Podaci predstavljaju srednje vrijednosti tri ponavljanja. Različita slova na stupcima ukazuju na statistički značajnu razliku ((p<0.05, LSD test);. Data represents mean values of three replicates. Different letters means statistically significant difference ((p<0.05, LSD test).

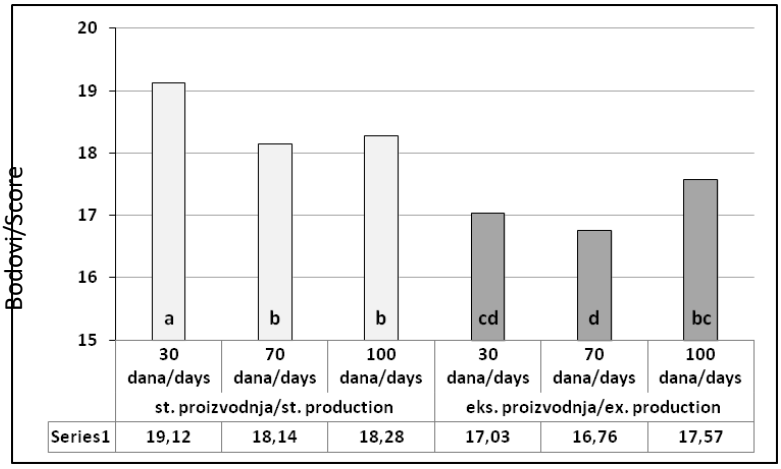
Sadržaj proteina je tipičan za tvrde sireve kao što navode Gallowey i Crawford (1985) gdje je sadržaj proteina različitih tvrdih sireva iznosio 26,00%. Sadržaj masti u suhoj materiji se postepeno povećavao tokom zrenja, da bi završetkom procesa zrenja sira (100 dana) bio značajno viši kod sireva iz *eksperimentalne* proizvodnje. Hill (1995) i Fox *et al.* (2000) su kod Cheddar sira ustanovili sadržaj masti u suhoj materiji nešto niži u odnosu na Kupreški sir. Na osnovu Pravilnika o proizvodima od mlijeka i starter kulturama (2011) sirevi iz *standardne* i *eksperimentalne* proizvodnje svrstavaju se u grupu punomasnih. Vidljivo je iz grafikona 6., da je prosječna vrijednost sadržaja vode u BMS tokom sva tri perioda zrenja u opadanju. Prema Pravilniku o proizvodima od mlijeka i starter kulturama (2011) sirevi iz *standardne proizvodnje* su na prelazu ali pripadaju prije grupi tvrdih sireva nego ekstra tvrdih dok sirevi iz *eksperimentalne proizvodnje* nedvojbeno pripadaju grupi ekstra tvrdih sireva. Pored toga prema istom Pravilniku (2011) ekstra tvrdi sirevi moraju imati period zrenja najmanje 6 mjeseci što nijedna varijanta od proizvedenih sireva nema.

Senzorna ocjena Kupreškog sira

Senzone karakteristike sira su one koje opredjeljuju potrošače i čine nezaobilazni dio procjene kvaliteta nekog sira. Da bi se lakše uočile razlike i sličnosti između senzornih ocjena nakon 30, 70 i 100 dana zrenja, rezultati senzorne ocjene svojstava sireva iz *standardne* i *eksperimentalne* proizvodnje predstavljeni su u grafikonima 7. i 8.



Grafikon 7. Srednje vrijednosti svih senzornih karakteristika sireva
Figure 7. Mean values of all sensory characteristics of cheeses
S-standardna proizvodnja/ standard production; E-eksperimentalnaproizvodnja/experimental production



Grafikon 8. Ukupna senzorna ocjena Kupreškog sira proizvedenog *standardnom* i *eksperimentalnom* tehnologijom tokom zrenja
Figure 8. Total sensory evaluation of Kupres cheese produced by standard and experimental technology during ripening
Podaci predstavljaju srednje vrijednosti tri ponavljanja. Različita slova na stupcima ukazuju na statistički značajnu razliku ((p<0.05, LSD test);. Data represents mean values of three replicates. Different letters means statistically significant difference ((p<0.05, LSD test).

Na grafikonu 7. su prikazane srednje vrijednosti senzorne ocjene svih ocjenjivača-eksperata. Može se primjetiti da je prosječna senzorna ocjena vanjskog izgleda nakon

30 dana identična kod obje proizvodnje te iznosi 1,90. Nakon završetka zrenja nešto bolju ocjenu imali su sirevi iz *standardne* proizvodnje 1,93 naspram 1,88. Prosječna senzorna ocjena za boju iznosila je 1,00 kod obje proizvodnje posle 30 dana zrenja, a također i nakon završetka zrenja. Nakon 30 dana zrenja senzorne ocjene konzistencije i izgleda na presjeku su bile veće kod *standardne proizvodnje*, ali nakon završetka zrenja *eksperimentalni sirevi* imali su bolju prosječnu ocjenu ova dva svojstva. Sirevi iz *standardne* proizvodnje su imali bolje prosječne ocjene za miris i okus. Sirevi iz *standardne* proizvodnje su statistički značajno bolje ocijenjeni nakon 30 i 60 dana u odnosu na sireve iste starosti iz eksperimentalne proizvodnje. Najbolje ocijenjeni je bio sir zrelosti 30 dana iz *standardne* proizvodnje i on se statistički značajno razlikovao od svih ostalih sireva.

ZAKLJUČAK

U radu je ispitivan uticaj starter kulture i temperature dogrijavanja na kvalitet Kupreškog sira. U tu svrhu Kupreški sir je proizveden *standardnom* i *eksperimentalnom* tehnologijom, uz promjenu starter kulture i nižu temperaturu dogrijavanja. Izvršena je fizičko-hemijska analiza i senzorna analiza *standardnih* i *eksperimentalnih* sireva. pH *eksperimentalnih* sireva je bio značajno niži u odnosu na *standardnu* tehnologiju i generalno raste tokom zrenja. Sadržaj suhe materije, masti i proteina raste tokom zrenja. Dok su prva dva parametra viša kod *eksperimentalnih* sireva sadržaj proteina je niži. Sadržaj masti u suhoj materiji je viši cijelim tokom zrenja, a sadržaj vode u BMS niži kod *eksperimentalnih* sireva u odnosu na one proizvedene *standardnom* tehnologijom. Sirevi proizvedeni *standardnom* tehnologijom su dobili bolje ocjene za miris i okus, te ukupne ocjene. Na osnovu ovoga može se zaključiti da se uvođenje nove starter kulture i niže temperature dogrijavanja u tehnologiju Kupreškog sira nije pokazalo opravdanim.

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THE IMPACT OF THE STARTER CULTURE AND SCALDING TEMPERATURE TO THE QUALITY OF KUPRES CHEESE

Summary

Kupres cheese belongs to a group of full-fat, hard cheeses and is made mainly from cow's but also from goat's and sheep's milk or by combination of them. This paper describes the influence of the starter culture and the change of scalding temperature on the Kupres cheese. The aim of the work was to produce the Kupres cheese with the addition of a different thermophilic starter culture and a reduced temperature of scalding for 10 to 12°C (37°C) compared to the control production with standard tehnology (up to 48°C), and then determine their impact to the quality of Kupres cheese. The average values of the chemical composition changed during ripening, and after the ripening, the following results for the chemical composition were obtained for the standard tehnology cheese: water 31.51%, dry matter 68,48%, fat 37.16%, proteins 27.85%, fat in dry matter 54.26%, moisture on fat-free basis 50.14%. Experimental cheeses had the following chemical composition: water 29.46%, dry matter 70.53%, fat 39.00%, proteins 27.29%, fat in dry matter 55.28%, moisture on fat-free basis 48.30%. Analyzes have shown that changed starter culture and lower scalding temperature did not gave improved quality of Kupres cheese.

Key words: *Kupres cheese, technology, technological-production parameters, chemical composition, sensory analysis.*

THE ROLE OF INTERNATIONAL TRADE IN THE CREATION OF THE SUSTAINABILITY OF AGRICULTURAL PRODUCTION - COMPARATIVE PRESENTATION OF THE FORMER YUGOSLAVIA

Dragan Dokić[1], Maja Gregić[2], Muhamed Brka[3], Vesna Gantner[2]

Original scientific paper

Summary

Modern aspects of the business do not exclusively concern the manufacturers themselves, and today they are much more complex than before. The total quantity of agricultural products produced is placed on the market by producers if they do not use it for further reproduction. Trade enables the exchange of goods and thus makes goods widely available. International trade flows are of great importance in terms of economic and regional development. No economy can base its growth on the self-sufficiency of real and financial resources, and is therefore directed to international trade, whose final balance reflects the degree of growth and macroeconomic variables of a particular economy. The aim of the paper was to point out the importance of trade and its positive aspects to which it contributes to society. Furthermore, the example of the countries of the former Yugoslavia will show how much international trade in agricultural products contributes to economic development. An analytical model for analysing the volume of production and trade in goods through the components of imports and exports will show the value of trade between countries and how this reflects on the overall economic situation. Furthermore, the gravity model will analyse the overall geographical environment and show which multilateral factors affect the commodity exchange process.

Key words: *agricultural production, trade, commodity exchange, gravity model, export, import*

INTRODUCTION

International trade flows are of great importance in terms of economic development. No economy can base its growth on the self-sufficiency of real and financial resources, and is therefore directed to international trade, whose final balance reflects the degree of growth and macroeconomic variables of a particular economy (Krueger, 2009). Therefore, the import of certain products and services into the state has a negative impact on the foreign trade balance, which then requires the engagement of financial

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resources to cover it, causes the increase of debt, changes the foreign exchange rate of the state, and through the prices of imported products, also affects the inflation in the state (Bjelic, 2008). Conversely, the export of products and services raises the level of resource engagement in the country, securing financial resources without increasing indebtedness, along with a number of other benefits that subsequently arise within the domicile economy (Blanchard, 2005). The role and importance of foreign trade is reflected in the following (Stojadinović Jovanović, 2012): allows external markets to place surplus products and buy deficits, enables the achievement of favorable price than if it sold only on the domestic market, complements the range of products and services and enables better quality satisfaction of human needs, directs manufacturers to apply world production criteria and standards and state-of-the-art technological processes and allows constant communication with the world, which has a positive effect on staff training, as well as the broadening of knowledge and exploring the culture and customs of other people. The standard trade model is based on four key relationships (Krugman, 2009): on the relation between the production potential frontier and the relative demand curve, relation between relative prices and relative demand, determining the world equilibrium based on world relative supply and world relative demand and the effect of the exchange ratio (the export price of one country divided by the import price of that country) on national well-being. Furthermore, agriculture is an economic activity that includes livestock and plant production and other related services. Agriculture can be viewed through two prisms: as the principle of subsistence through agriculture, that is, the production of enough food to meet the needs of the farmer himself and his family, and as commercial agricultural production that consists in acquiring monetary profits through cultivation of the land. Also, agriculture is extremely important for developing economies because it lays the foundation for sustainable economic growth (Bašić *et al*., 2002). The development of agriculture, apart from the agricultural sector itself, encourages growth in the non-agricultural sectors, which results in increased employment and improved standards of living. Maintaining agricultural activity in rural areas is of the great importance as agriculture remains the main beneficiary of available land, a food producer as a strategic resource, and a source of livelihood for a considerable proportion of the rural population. Therefore, agriculture has a dominant influence on the management options for sustainable rural development, environmental protection and biodiversity conservation. Furthermore, rural development policy must ensure an integrated approach to the problems and offer appropriate solutions to the issues and needs of agricultural sector development in rural areas. Respecting the above, the state's development strategy must start from the local level. Taking care of rural areas as a whole is reflected in investing in innovation, modernizing technology and equipment and investments, strengthening local producer associations to improve the marketing of agricultural products (Defilippis, 2005). Such measures should be of benefit to producers and consumers alike, since they have an impact on farmers' competitiveness and consequently on the quality of life in rural areas, while raising the level of food security and contributing to consumer protection.

The importance that trade flows have on the state of the economy indicates the importance that quantitative measurements of international trade flows may have, the results of which may provide useful information to economic decision makers (Kovacević, 2002). Opportunities for making quantitative measurements of trade flows and their implications on other economic variables can be found within certain multivariable statistical tools. The basic premise of the gravitational trade model is that trade flows between two countries can be explained by their size and distance (proximity). The gravity model of international exchange uses variables: exports and imports (total trade), demand and supply in partner countries (usually their GDPs), distance indicates ease of access to a foreign market (transportation costs), and the gravity constant is a variable that does not depend either on one partner state (eg. the level of liberalization of world trade) (Shepherd, 2013). The aim of the paper was to analyse, on the example of the countries of the former Yugoslavia, how much international trade in agricultural products contributes to economic development and to point out the importance of trade and its positive aspects to which it contributes to society.

MATERIALS AND METHODS

For the countries of the former Yugoslavia's rural development policy is very important, given the fact that almost 40% of the population lives in rural areas, compared to the EU average of 24%. At the same time, the ratio of population over 60 and under 20 years in rural areas is less favourable than in urban and transitional areas, and apart from natural extinction, migration of young people to cities due to lack of professional opportunities worsen the demographic, economic and developmental characteristics of rural areas. In addition to the negative consequences of the war, a special problem in the countries of former Yugoslavia is the gap between the very small farms and large agricultural producers. For the statistical analysis the data from the Central Bureau of Statistics of the Republic of Croatia, the Central Bureau of Statistics of Serbia, the Agency for Statistics of Bosnia and Hercegovina, the Statistical Office of the Republic of Slovenia, the Central Bureau of Statistics of Macedonia, the Statistical Office of Montenegro and Eurostat. The total volume of agricultural production was analysed, namely: crop production (corn, wheat, sunflower and soybeans) and meat (pigs and cattle) production (as slaughtering weight), hereinafter referred to as agricultural production. Comparative overview of agricultural production in the period from year 2016 – 2018 is presented in Table 1.

Tab. 1. The comparative overview of agricultural (crop and meat) production in the period from year 2016 – 2018 (in 000 t)
(Source: Author's calculation on the basis of statistical data)

State / year	2016		2017		2018	
	Crop	Meat	Crop	Meat	Crop	Meat
Croatia	9550	586	9710	535	9660	535
Serbia	11370	660	11280	625	11200	570
Bosnia and Hercegovina	4080	325	4180	315	4110	311
Montenegro	1996	114	1980	101	1920	96
Macedonia	6120	405	6006	389	5980	370
Slovenia	3114	421	2930	399	2870	390

According to statistics of the volume of agricultural production presented in Table 1, a state puts a certain amount into international traffic, that is, it exports the produced surplus goods. Trade volume, measured by the average share of imports and exports in GDP, is one indicator of the openness of a particular economy, although it is not always a good indicator of openness.

RESULTS AND DISCUSSION

The value of agricultural production in total GDP in the analysed states is shown in the Figure 1. The highest percent of agricultural production in total GDP in amount of 5.1% was recorded in Bosnia and Hercegovina, while the lowest percent was recorded in Macedonia (3.6%).

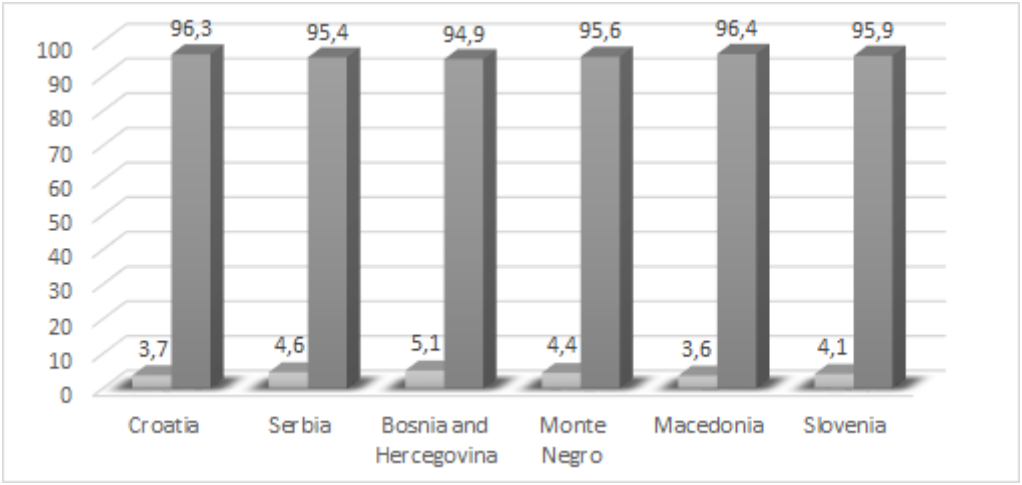

Fig. 1. The value of agricultural production in total GDP per state
(Source: Author's calculation on the basis of statistical data)

The comparative overview of export of agricultural production in the period from year 2016 – 2018 (the average) is presented in Table 2. The share of exported crop products in total crop production ranged from 14.03% to 35.27%, while the share of exported meat production ranged in interval from 10.53% to 26.15%. The lowest export of crop production was reported in Montenegro while Serbia had the highest percentage of exported crop products. Similarly, the lowest percentage of exported meat products was also determined in Montenegro, while the highest value was in Bosnia and Hercegovina.

Tab. 2. The comparative overview of export of agricultural (crop and meat) production in the period from year 2016 – 2018 (in 000 t)
(Source: Author's calculation on the basis of statistical data)

State / Production	Crop production		Meat production	
	000 t	%	000 t	%
Croatia	2940	30.79	115	19.62
Serbia	4010	35.27	160	24.24
Bosnia and Hercegovina	1020	25.00	85	26.15
Montenegro	280	14.03	12	10.53
Macedonia	1950	31.86	70	17.28
Slovenia	840	18.45	52	12.32

The empirical analysis in this paper was based on annual data on GDP, the commodity exchange of agricultural production for year 2018, and the distance between countries. The gravity model shows the movement of mutual import and export of agricultural products individually for countries: Bosnia and Herzegovina, Croatia, Montenegro, Northern Macedonia, Serbia, and Slovenia (Figure 2).

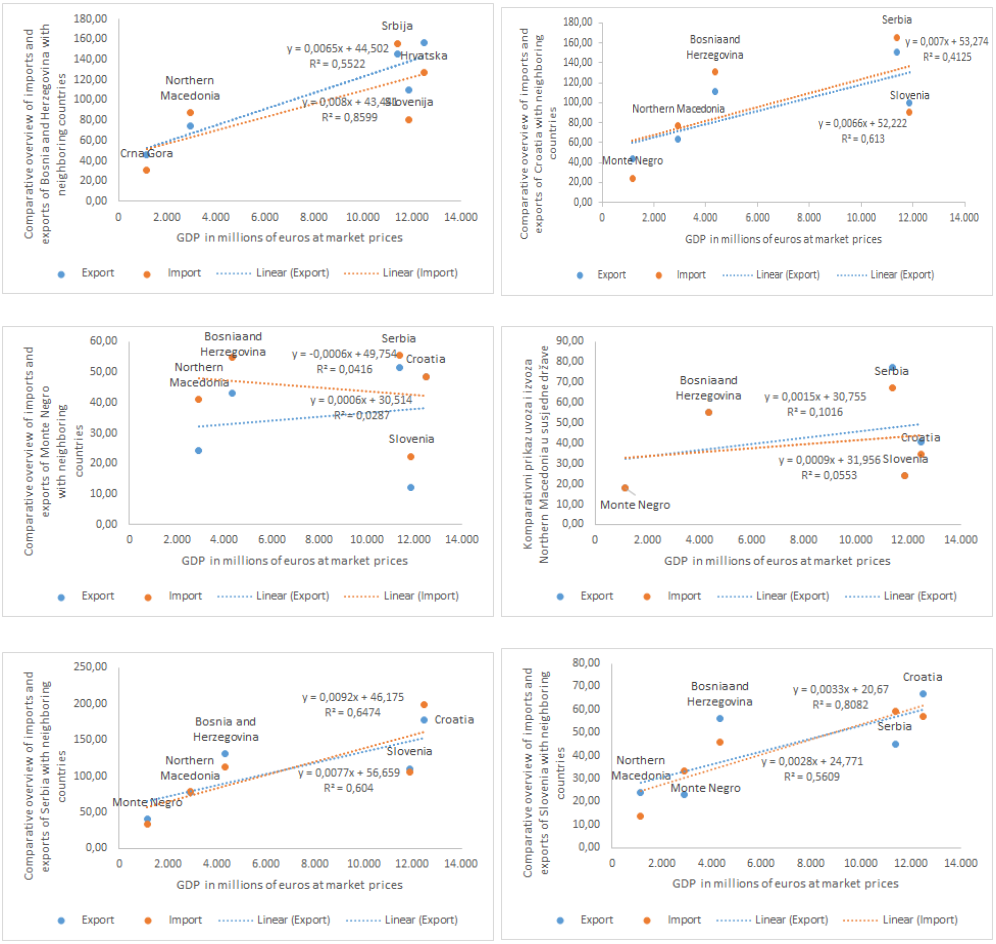

Fig. 2. The analysis of trade of agricultural products in year 2018 through the gravity model - comparative overview of imports and exports of analysed states (Bosnia and Herzegovina, Croatia, Montenegro, Northern Macedonia, Serbia, and Slovenia) with neighbouring countries
(Source: Author's calculation on the basis of statistical data)

Imports and exports of agricultural production with neighbouring states are shown individually for each country. The value on the abscissa represents the value of the GDP of the state, expressed in market prices, while the ordinate shows imports (on the charts left) and exports of the state (on the charts on the right). The Figure 2 also shows the linear regression of imports and exports of goods showing the dependence of imports and exports of agricultural products on GDP. From this view it is also noticeable that the value of trade between distant countries is smaller, that is, increasing geographical distance has the effect of reducing bilateral trade.

Results obtained in this research are in agreement with those obtained by Ranilović (2017) and Balšić (2014).

CONCLUSIONS

The main purpose of the paper was to analyse the trade between the countries of the former Yugoslavia as trading partners. In this context, the gravity model of international trade was applied. The obtained results indicate that trade is very important because it enables the exchange of surplus goods produced, and thus meets the needs of other markets. Furthermore, according to the results, goods traffic intensifies between countries that are geographically closer and between countries with higher income levels. The greater distance of the trading partner weakens the value of the exchange, which indicates that, for example, products from northern Macedonia are less available on the Slovenian market. Despite the violent breakup of Yugoslavia, all model ratings suggest a strong trade bias with the former Yugoslav republics, revealing strong inertia of existing trade relations that have retained their role since Yugoslavia's existence. Furthermore, the following studies will analyse issues commonly associated with gravity models. One of the major criticisms of the gravity model is the definition of the distance variable, which cannot adequately replace the average cost of transportation from one country to another. Therefore, improving this variable is crucial for further research.

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ULOGA MEĐUNARODNE TRGOVINE U STVARANJU ODRŽIVOSTI POLJOPRIVREDNE PROIZVODNJE – KOMPARATIVNI PRIKAZ PROSTORA BIVŠE JUGOSLAVIJE

Rezime

Suvremeni aspekti poslovanja ne dotiču se isključivo samih proizvođača, te su oni danas znatno kompleksniji nego ranije. Ukupno proizvedenu količinu poljoprivrednih proizvoda proizvođači ukoliko ne koriste za dalji proces reprodukcije plasiraju na tržište. Trgovina omogućava razmjenu dobara i tako omogućava da dobra budu širom dostupna. Međunarodni trgovinski tokovi imaju veliki značaj sa aspekta razvoja gospodarstva i regije. Nijedna ekonomija svoj rast ne može zasnivati na samodostatnosti realnih i financijskih resursa, pa je stoga i upućena na međunarodnu trgovinu, čiji se konačni saldo odražava na stupanj rasta i makroekonomske varijable određene ekonomije. Cilj ovoga rada jeste ukazati na važnost trgovine i njezinih pozitivnih strana kojima ona pridonosi društvu. Nadalje, na primjeru država bivše Jugoslavije prezentirat će se koliko međunarodna razmjena poljoprivrednih proizvoda doprinosi ekonomskom razvoju. Analitičkim modelom analize obima proizvodnje i prometa roba kroz komponente uvoza i izvoza prikazat će se kolika je vrijednost razmjene između država i kako se to odražava na ukupnu gospodarsku situaciju. Nadalje, gravitacijskim modelom analizirati će se ukupno geografsko okruženje i pokazati koji multilateralni faktori utječu proces robne razmjene.

Ključne riječi: *poljoprivredna proizvodnja, trgovina, robna razmjena, gravitacijski model, izvoz, uvoz*

ENTREPRENEURIAL EDUCATION SKILLS IN URBAN AGRICULTURE OF BOSNIA AND HERZEGOVINA

Alen Mujčinović[1], Sabrija Čadro[1], Mirza Uzunović[1], Merima Makaš[1], Petar Glamočlija[1], Pakeza Drkenda[1]

Preliminary communication

Summary

Agriculture has always been an important element of the economic development of Bosnia and Herzegovina (B&H). With noteworthy trend of urbanization, urban and peri-urban areas become more important and represent a huge opportunity for business development, production of high-value products, products for niches markets, development of short supply chains, *Alternative Food Networks*, and the provision of services connected with agriculture. Although it has been in some form a part of the long-time tradition, urban agriculture as a viable socio-economic initiative has only begun to expand recently in B&H. Currently, there are a few incentives to stimulate the development of this field of agriculture and they are mostly driven by foreign investment, so the foundation for future development is missing. Sustainable development of this sector is based on knowledge about key skills (hard and soft) necessary to successfully run such initiatives. The aim of this paper is to identify a set of entrepreneurial skills (soft and hard) that can help to perform, develop and upgrade this relatively new agro-business practice in B&H.
In order to achieve such aim, the questionnaires, previously developed and tested, in the *Training Needs Analysis* within the course of the *Erasmus+* project *Urban Green Education for Enterprising Agricultural Innovation* were used. The four considered key stakeholder groups are Higher Education Institutes, Small and Medium-sized Enterprises, Non-Governmental Organizations, and Public Authorities. The results showed that capacity for teamwork, communication, self-confidence from a group of soft skills are most important, while among the hard skills, plant production, communication and networking, and project planning are found to be the most important.

Keyword: *urban agriculture, entrepreneurial skills, education, Bosnia and Herzegovina*

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INTRODUCTION

Urban agriculture (UA) development recently become a worldwide trend, but it started since the 1990s (Yang *et al.*, 2010). There is no common definition of a concept of urban agriculture, detailed definition provided by FAO defines UA as "a permanent and dynamic part of the urban socio-economic and ecological system, using typical urban resources, competing for land and water with other urban functions, influenced by urban policies and plans, and contributing to urban social and economic development" (FAO, 2007), while simplified definition would be "urban agriculture generally refers to food and fuel grown within a city or peri-urban area, produced directly for the market and/or household use." (Smit *et al.*, 1996). The concept of UA gains noteworthy attention recently with population bloom and ongoing urbanization process and it can be regarded as a reaction to a crisis in the industrial food system. More than 50% of the world's population lives in cities (Martine, 2007), while it is predicted that agglomerations in cities will continue and in 2050 two thirds of the overall population will live urban (United Nations, 2014; 2015; Wiskerke, 2015). As the world's cities growing rapidly, farming in urban areas is going to play a bigger role. However, UA already supplies food to about one-quarter of the world's urban population (FAO, 2011). Gained attention resulted in the increasing number of studies investigating challenges, opportunities and potentials of urban agriculture concepts (Pearson *et al.*, 2010; Zasada, 2011; Ackerman, 2014; Lin *et al.*, 2015; Pulighe *et al.*, 2016). The UN's Sustainable Development Goals and the New Urban Agenda explicitly name urban agriculture as an important building block for sustainable and resilient cities and agglomerations (United Nations, 2016; United Nations, 2017).

Agricultural production in cities is an activity with a long history in Bosnia and Herzegovina and it is integral to cultural landscapes and a long-standing traditional practice. "Modern" Urban agriculture in B&H took place in recent years, there are few incentives to stimulate the development of this field of agriculture. Mostly driven by foreign investment, but official data is missing.

UA development within the B&H requires a transition in attitude and behaviour of all involved actors especially people living in the cities and local policymakers; which can be promoted by enabling policies and conducive regulations. Furthermore, it is necessary to develop a well-performing pluralistic, participatory, bottom-up, and decentralized advisory system working as a training and learning tool and aiming also at organizing and empowering urban gardeners (El Bilali *et al.*, 2012). Consumer perception toward products of urban agriculture in B&H is also a field that needs special attention in the following period. It is well known that the population in B&H highly appreciate value-added products, such as organic and traditional products (Nikolić *et al.*, 2014, Mujčinović *et al.*, 2017). Also, same research identifies that consumers are environmentally conscious and if we take into the consideration positive effect of urban agricultural practice on the environment, it may be a good sign for a stronger development of this subsector in B&H. Governmental activities to support development of UA still lay on objectives defined in Midterm agricultural sector development

strategy in Federation of Bosnia and Herzegovina for the 2015-2020 period, Strategic plan for the development of agriculture and rural areas of Republic of Srpska, 2016-2020, and in Strategic Plan for Rural Development of Bosnia and Herzegovina 2018-2021, while there is no actual funding nor support programs. It remains to see what would be the path of development of urban agriculture, but its inevitable urbanization process will continue followed by new trends in the production of food in Bosnia and Herzegovina. UA can bring sustainable social, economic and environmental benefits, therefore, for ensuring its long-term development, legal, legislative and regulatory framework, as well as governance, should be improved (El Bilali *et al*., 2012). In order to achieve this, it is necessary to support empowerment of skills that are necessary to be successful in this area. So, one of the key questions of UA future development is what kind of skills (soft and hard) are necessary to possess to start doing Urban agriculture? Therefore, the aim of this study is to identify a set of entrepreneurial skills (soft and hard) that can help to perform, develop and upgrade this relatively new agro-business practice in Bosnia and Herzegovina.

MATERIALS AND METHOD

This study is done as a part of the Erasmus + project named "Western Balkan Urban Agriculture Initiative", Erasmus + Programme - Strategic Partnership Project Nr: 586304-EPP-1-2017-BA-EPPKA2-CBHE-JP with the objective to provide more information about necessary skills that should be highlighted and focused on during future Master program development, as well as to serve policymakers/decision-makers and other stakeholders involved in a development of Urban Agriculture in Bosnia and Herzegovina. Primary data for this study were collected using the questionnaire that had been developed, tested, in the Training Needs Analysis within the course of the Erasmus+ project URBAN GREEN TRAIN (Urban Green Education for Enterprising Agricultural Innovation). The survey was done among the key stakeholder groups of Higher Education Institutions (HEIs), Small and Medium-sized Enterprises (SMEs), Non-Governmental Organizations (NGOs), and Public Authorities (PAs). In total, 20 interviews were done, eleven PAs, six NGOs, three SMEs, while no HEIs survey interviews were done. So, it was not possible to create random sample which is main limitation of this study.

RESULTS AND DISCUSSION

The results of this study identify that global interest in urban agriculture is also present in B&H, where 93,33% of respondents say they are interested in UA entrepreneurial education. These results are in line with previous findings from the URBAN GREEN TRAIN countries France, Germany, Italy, and the Netherlands with a summarizing interest share of 80% (Italy 93%, Germany 87%; The Netherlands 67%; and France 65%).

The non-formal life-long learning (LLL) and formal master university course are highlighted as the most suitable levels of education (see Figure 1). Contrarily, the Ph.D. course is named by less than 25%. Computer-supported training is third-highest graded, followed by technical/vocational school and formal bachelor educational programs. URBAN GREEN TRAIN's Training Needs Analysis shows a similar picture, in which LLL and technical/vocational schools result is certainly higher shares (58%; 51%) compared to university levels (< 40%). Some comments regarding the level and kind of education emphasize formal university education, but goes also behind by including in-formal LLL, practical skills, and offers for people with special needs; e. g. "*Ph.D. and Master for development of new products, training and webinars for continuous education*", "*we think that the Master is needed but that other levels of education should not be excluded*", "*we work with people with disabilities*", "*education is at the same time a rehabilitation tool for social entrepreneurship for people with disabilities*", "*possibility of scientific improvement, experimental work*", and "*practical work*".

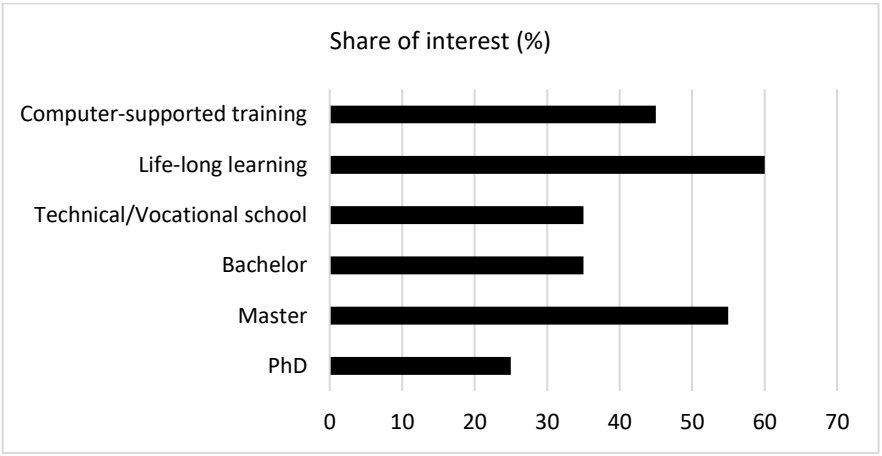

Figure 1. Which level and kind of education is from your point of view suitable for UA entrepreneurial education

More in detail, the importance of specific skills named "hard" and "soft" were also assessed and results were presented in next figure.

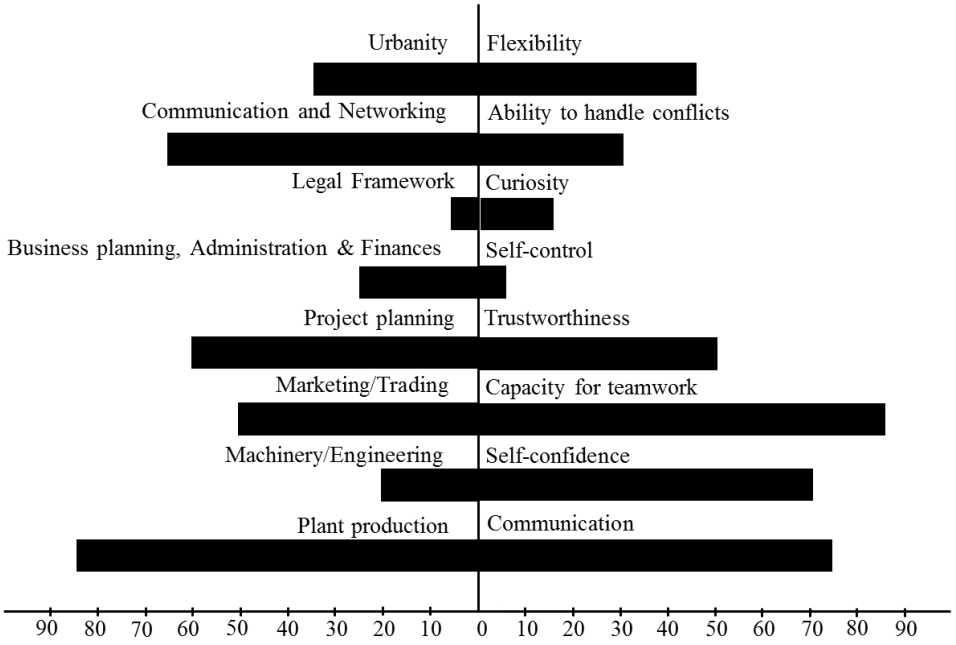

Figure 2. Required hard (left side) and soft (right side) skills for Urban agriculture entrepreneurial education

From the following figure, it can be seen that majority of respondents name capacity for teamwork, communication and self-confidence as a required soft skill for UA entrepreneurship and it clearly highlight the importance of working on these issues. In a group of highly-rated soft skills also belongs "*team management*", "*creativity*" and "*trustworthiness*", all emphasized as important by 50% and more respondents. Additional skills that are highlighted as important are "*innovation", "ability to think in different directions",* and "*desire for learning"*, while of the lowest importance are graded "*self-control*", "*curiosity*" and "*ability to handle conflicts*". Those answers may imply respondents believe that crucial elements in being successful urban agriculture entrepreneur lay in his ability to work in a team, communicate in an effective way as well as have self-confidence as this is a new, modern, innovative business practice in B&H society. Creativity and flexibility were also highly graded, which implies an awareness of the market situation and ever-present seek for market niches or desire to create unique and value-added products.

When it comes to hard skills, respondents identify *"Plant productions"* as the most important type of hard skills (85%). It is followed by *"Communication and Networking"* and *"Project planning"*. There is a slight difference compared to the result from the URBAN GREEN TRAIN findings, where in France, Germany, Italy, and The Netherlands plant production is also highlighted as the most important skill, but not followed by project planning. While results of URBAN GREEN TRAIN findings, as well as results from this study, identify communication/networking as the second most

important hard skill. The group of less important hard skills consists of *"Legal framework", "Machinery/engineering"* and *"Business planning, administration and finances".*

If we go more in detail, the following table identifies what respondents believe to be the most important elements (areas of study) of each above-identified hard skills.

For **plant production** hard skills, almost all elements are identified as important, crop production, plant nutrition and manure management, cultivation as well as ecology and resource management. Biology was the element identified as less important. For **machinery/engineering** hard skills there are several important elements named "Precision agriculture", "Harvest technology", "Greenhouse technology", while less important were identified "Post-harvest technology/logistics", "Planting, drilling and cultivation machinery", "Tractor". Interestingly, **marketing/trading** hard skills, all elements were identified as important. Lowest graded were "Market and trade mechanisms", while highest-graded were "Sales and purchase organization, negotiation and contracts", followed by "Quality management", "Certification" and "Customer relations". When it comes to **business and project planning, administration and finances**, there is a wide range of answers, from "Business and project planning" and "Project management" identified as important to "Documentation" and "Business administration" identified as less important. Hard skill **legal framework** consists of three elements, where "Subsidies" were graded as most important, followed by "Laws and Regulations", while "Taxation" is identified as less important. It may imply that as a new business/agricultural model, people are not aware of the available subsidies nor about laws and regulations that are present in this field. Therefore, they are looking for that type of information. For taxation, they identify this element as less important probably as initially they are looking for urban agriculture as a hobby, to produce food for own use. Or it may imply they are aware of the current taxation system in agriculture and they do not believe some changes will happen regarding public policies that can stimulate doing urban agriculture as a profitable business. Interestingly, **communication and networking** were highly rated hard skills in B&H as well as in countries analyzed under URBAN GREEN TRAIN study. Both elements are important, while off the highest importance were identified public relations and advertisement which is normal for doing something brand new and not familiar on a market. While information technology - IT skills education is also identified as important and it is closely related to aforementioned, as respondents are aware of benefits that come with this type of knowledge and especially using them to develop urban agriculture business in the right direction. Similar results are observed with **urbanity** hard skills, where all elements were graded as important (more than 50%). Highest graded was "Urban demands and trends" and "Urban green", while lowest graded in this group were "Urbanisation and urban sociology" and "Urban economy", but both were identified as important by 50% of respondents.

Table 1. Importance of different elements (areas of study) for Urban agricultural entrepreneurial education

PLANT PRODUCTION								
Crop protection		Plant nutrition & manure management		Cultivation		Ecology & resource management		Biology	
MACHINERY/ENGINEERING								
Tractor, planting, drilling and cultivation machinery		Harvest technology		Precision agriculture		Irrigation		Post-harvest technology/logistics	
MARKETING/TRADING								
Sales & purchase organization, negotiations and contracts		Customer relations		Market and trade mechanisms		Quality management		Certification	
BUSINESS AND PROJECT PLANNING, ADMINISTRATION AND FINANCES								
Business and project planning		Project management		Business administration		Personnel management		Documentation	
LEGAL FRAMEWORK								
Laws and regulations				Taxation				Subsidies	
COMMUNICATION AND NETWORKING								
Public relations and advertisement						IT skills			
URBANITY								
Urbanization and urban sociology		Urban demands and trends		Urban economy		Urban planning		Urban prerequisites (pros and cons)	

Legend:

 - most important (>50% of respondents);  - important (30-50% of respondents);  - less important (<30% of respondents)

Further statements with regard to individual subjects name further issues of relevance for UA entrepreneurial education; sometimes these comments confirm subjects the survey asks for, but some comments introduce also new ideas and issues (BUGI report):

- *"knowledge of agrochemical operations*", "*creating micro-gardens in small areas*", "*production in greenhouses is characteristic for this area*", "*variety of plants and animals*", "*herbal production*", "*beekeeping (school)",* "*increasing the cultivation of vegetables in urban areas*", "*plant protection with new system of herbicides*", "*urban education should focus on horticulture, urban farming of poultry and livestock, where the potential for food production is high*", "pesticides consequences of improper use" (Plant production),
- "*handling of agricultural mechanization*", "*new technologies*", "*precise farming enables each step to be made better and safer*", "*harvesting technologies*" (Machinery/Engineering),
- "*knowledge of the market*", "*marketing is a very important part*", "*marketing strategies*", "*specialized micro-enterprises*", "*helps to promote the sustainable commercialization of commercial market gardening in urban areas*" (Market/Trading),
- "*project planning - is considered as the most important skill for the realization of urban agriculture*", "we believe that especially young people need to be able to write projects and apply them to different funds" (Project planning),
- "*how a business is created and how it works*", "*it helps in business planning, risk management, land access, land quality, water use, capital use, etc*." (Business Planning, Administration, and Finances),
- "*political and institutional support facilitates the necessary legal measures for land security for urban agriculture*" (Legal Framework),
- "*direct contact with producers and customers*" (Communication and Networking), and
- "*urban agriculture mitigation of unemployment*", "*the physical, social, economic characteristics of the respective cities*", "*it contributes to the reduction of urban poverty, the creation of employment and food security, to stimulate the governance with the participation of the city and the improvement of urban management*", "*urban planning*", "*urban sociology*", "*landscape architecture*", "urban spaces", and "green spaces" (Urbanity).

Furthermore, links between the topics are named "*we should cultivate for urban marketing agriculture*" and "*the most difficult skills to learn are: project planning, business planning, administration and finances, legal frameworks, and so on*."

Moreover other comments emphasize the interdisciplinary and versatile character of UA: "*knowing everything listed is essential for successful commercial production*", "*economic development is achieved through urban agriculture where residents gain the ability to cultivate and sell their food*", "*urban agriculture is indispensable and*

applicable", "…all are needed for […] urban agriculture", "*urban education is interested in promoting partnership and collective action for the development of horticulture, training coordination and capacity building*", and "*everything has to be taken into account to succeed and to have a good impact on Urban Agriculture in the designated place*".

CONCLUSION

Urbanization is a prominent trend while urban agriculture is necessary to mitigate the negative effects that come together with urbanizations, agglomerations, aging population, etc. Chance to offer something new to a large number of potential consumers as well as land-related constraints on the other side present development opportunity for urban agriculture business practice. The proximity of farms (and all benefits that come together) should be used as a key element in the further development of urban agriculture adjustment and growth strategies. What appears to be a prominent conclusion from this study is the variety and diversity of both hard and soft skills that are necessary to do urban agriculture. From a group of soft skills, it appears "*capacity fo teamwork*", "*communication*", "*self-confidence*" are highest-graded skills. It may be understood that respondents believe as it is new business practice, dealing with obstacles and issues that possibly arise from doing urban agriculture is easier to solve as a group, using existing competence of several people instead of individual appearance. Its followed by communication, also related to the application of new practice where sharing ideas, knowledge transfer, best practice examples used to be winning combination to achieve success. Self-confidence is another important skill that every entrepreneur should possess. Especially for a business such as agriculture, where you create something unique and different from present products on the market, where customers' reaction is potentially unknow and results can vary and clearly depend on a personal/team abilities. The second group of skills, hard skills are led by "*plant production*", "*communication and networking*" and "*project planning*". It is obvious communication and networking are again highlighted therefore further strategic programs should pay special attention to this type of soft skill and future educational/vocational programs. Plant production as a highest-graded soft skill may imply the desire of future urban agriculture entrepreneurs to get specific knowledge of how to grown best types of plants that are suitable for a specific location, weather conditions, etc. Project management is also graded as a very important element, which clearly implies that future entrepreneurs also should possess specific knowledge how to develop good urban agriculture projects in order to achieve success and contribute to the development of urban agriculture business practice in Bosnia and Herzegovina.

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EDUKACIJSKE PODUZETNIČKE VJEŠTINE U URBANOJ POLJOPRIVREDI BOSNE I HERCEGOVINE

Sažetak

Poljoprivreda je oduvijek bila važan element ekonomskog razvoja Bosne i Hercegovine. Uz prisustvo značajnog trenda urbanizacije, urbane i peri-urbane sredine dobivaju na značaju i predstavljaju veliku priliku za poslovni razvoj, proizvodnju proizvoda sa dodatnom vrijednošću, proizvoda za tržišne niše, razvoj kratkih lanaca vrijednosti, "Alternative Food Networks", kao i pružanje dodatnih usluga vezanih za poloprivredni sektor. Urbana poljoprivreda u Bosni i Hercegovini ima dugu tradiciju, međutim do značajnijeg razvoja kao prepoznate socio-ekonomske inicijative dolazi tek u zadnjih nekoliko godina. Trenutno je nekoliko inicijativa usmjereno ka razvoju ovog tipa poljoprivrede, uglavnom stranih investicija, što ukazuje na nedostatak temelja za daljni razvoj. Održivi razvoj sektora se temelji na poznavanju ključnih vještina („hard" i „soft") neophodnih za uspješno bavljenje ovom poslovnom praksom. Cilj rada je identifikovati set poduzetničkih vještina ("soft" i "hard") koji treba da omoguće bavljenje, razvoj i unapređenje ove relativno nove poslovne prakse u Bosni i Hercegovini.
Kako bi postigli navedeno, anketni upitnik, ranije razvijen i testiran u okviru programa "T*raining Needs Analysis, Erasmus+* project *Urban Green Education for Enterprising Agricultural Innovation"* je korišten. Posmatrane su četiri ključne zainteresirane strane, visokoškolske institucije, mala i srednja preduzeća, nevladine organizacije i vladine institucije. Rezultati su pokazali da su najznačajnije iz grupe "soft" vještina kapacitet za timski rad, komunikacija i samopouzdanje, dok u grupi "hard" vještina ispitanici smatraju da su najznačajnije vještine biljna proizvodnja, komunikacija i umrežavanje, te planiranje projekata.

Ključne riječi: *urbana poljoprivreda, poduzetničke vještine, edukacija, Bosna i Hercegovina*

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IN MEMORIAM

Doc. dr. Bedrija Alić (1952-2019)

Bedrija Alić je rođena 1952. godine u Brezi. Srednju učiteljsku školu završila je 1971. godine u Sarajevu. Diplomirala je 1975. godine na Prirodno-matematičkom fakultetu u Sarajevu. Od 1977. godine počinje raditi kao pripravnik, a zatim kao stručni saradnik u Zavodu za agropedologiju u Sarajevu.

Od 1988. godine je zaposlena na Veterinarskom fakultetu, na Katedri za ishranu domaćih životinja, a zatim prelazi na Zavod za higijenu i tehnologiju namirnica, gdje je bila šef laboratorije za ispitivanje hemijskih i bioloških rezidua i kvaliteta namirnica. Naučnu karijeru je nastavila upisavši i završivši postdiplomske studije na Prirodno-matematičkom fakultetu u Sarajevu. Magistarski rad na temu „Istraživanje teških metala u nekim ribljim vrstama bosansko-hercegovačkih rijeka“, odbranila je 1998. godine.

Doktorsku disertaciju iz oblasti kvaliteta i higijene ispravnosti namirnica pod naslovom „Uticaj medonosnih biljnih vrsta, mikroklime i uslova prezimljavanja pčela na prinos i kvalitet meda“, odbranila je 2009. godine na Veterinarskom fakultetu i time stekla naučni stepen zvanja doktora veterinarskih nauka. Od 2010. godine je bila zaposlena na Poljoprivredno-prehrambenom fakultetu, Univerziteta u Sarajevu. U zvanju docenta izvodila je nastavu na predmetima „Pčelarstvo” i „Tehnologija pčelinjih proizvoda“, a tokom svoje akademske karijere bila je i mentor završnih radova studenata I i II ciklusa.

U toku svoje karijere objavila je veliki broj naučnih i stručnih radova. Bila je učesnik brojnih domaćih i međunarodnih kongresa, simpozija, konferencija i seminara sa referatima.

Obavila je više studijskih boravaka i specijalizacija u inostranstvu među kojima izdvajamo studijske boravke u Zagrebu 2007., Holandiji 2002., Francuskoj 1999. i Egiptu 1999. godine. Bila je saradnik i istraživač na naučnim i stručnim projektima.

Na Fakultetu Zdravstvenih studija je bila angažovana na izvođenju praktične nastave na predmetu „Osnove higijene i tehnologije namirnica“.

Posebno treba istaći da je učestvovala u brojnim edukacijama pčelara iz oblasti kvaliteta i higijene ispravnosti meda. Kao ekspert Agencije za sigurnost hrane učestvovala je u izradi Pravilnika o medu i drugim pčelinjim proizvodima, kao i Pravilnika o metodama za kontrolu meda i drugih pčelinjih proizvoda. 2006. i 2010. godine je dobila Priznanja Saveza pčelara Federacije BiH za razvoj pčelarstva u Bosanko-podrinjskom i Unsko-sanskom kantonu. 2015. godine odlazi u penziju.

Doc. dr. Lejla Biber

IN MEMORIAM

Dr sc. Jusuf Mulić, profesor emeritus (1933-2019)

Profesor Jusuf Mulić rođen je u Konjicu službeno 19., a stvarno 21. marta 1933. godine od oca Ismaila Hamida i majke Aiše, rođene Efica.

U Konjicu je završio četverorazrednu osnovnu školu (1944) i Nižu realnu gimnaziju (1948), srednju poljoprivrednu školu u Banjoj Luci (1951) i opšti smjer poljoprivrede na Poljoprivredno-šumarskom fakultetu Univerziteta u Sarajevu i stekao zvanje *inženjera poljoprivrede* (1957).

Još kao student, počeo se baviti naučno-istraživačkim radom i objavljivati radove u stručnim časopisima. Za najbolje obrađenu temu na Konkursu Univerziteta u Sarajevu za 1955. godinu, dobio je stipendiju iz Fonda *Hasan Brkić*, uz obavezu da se po završenim studijama javi na prvi konkurs Poljoprivrednog fakulteta za izbor u zvanje asistenta na nastavnom predmetu *Računovodstvo*.

Bio je član prve Redakcije Lista studenata Univerziteta u Sarajevu Naši dani (1953-1957), a pisao je za više dnevnih i sedmičnih novina, te sarađivao sa Radio Sarajevom.

Poslije diplomiranja otišao je na dvomjesečnu studentsku praksu u Dansku, a po povratku u zemlju na jednogodišnje služenje vojnog roka (1957/1958). Po otsluženju vojnog roka izabran je u zvanje asistenta Poljoprivredno-šumarskog fakulteta Univerziteta u Sarajevu za nastavni predmet *Računovodstvo*. Kao stipendista američke *Giannini fondacije*, obavio je dvogodišnji magistarski studij iz oblasti agrarne mikroekonomije i stekao naučno zvanje *magistra agrarno-ekonomskih nauka* (1962-1964). Na magistarskom studiju ovladao je za ono vrijeme najsavremenijim ekonometrijskim metodama i metodama eksperimentalne statistike. Zajedno s pokojnim prof. dr Ljubomirom Martićem s Ekonomskog fakulteta u Zagrebu, bio je pionir

uvođenja metode linearnog programiranja na velikim poljoprivrednim kombinatima Jugoslavije, u tvornicama duhana i i tvornicama stočne hrane.

Doktorirao je na Poljoprivrednom fakultetu Univerziteta u Sarajevu iz oblasti agrarne mikroekonomike i stekao naučno zvanje *doktora poljoprivrednih nauka*. U zvanje docenta Poljoprivrednog fakulteta Univerziteta u Sarajevu izabran je 1966. godine za nastavni predmet *Troškovi i kalkulacije*. Na Odsjeku za preradu i kontrolu poljoprivrednnih proizvoda povjereno mu je 1985. godine izvođenje nastave iz dijela *Kalkulacije* nastavnog predmeta *Ekonomika prehrambene idnustrije*.

Postodoktoranske studije iz agrarne mikroekonomike obavio 1967. godine na Univerzitetu u Kilu, SR Njemačka. U zvanje vanrednog profesora izabran je 1970., a u zvanje redovnog profesora 1975. godine, na istom predmetu. Bio je gostujući docent i profesor na univerzitetima u Kilu i Bariju (Italija).

Obavljao je dužnosti šefa Katedre za mikroekonomiku, direktora Zavoda za ekonomiku poljoprivrede i prehrambene idnustrije, dekana Fakulteta (1981-1983) i rektora Univerziteta u Sarajevu (1991-1993).

Mentor je u više diplomskih, devet magistarskih i pet doktorskih radova. Napisao je i objavio preko 150 stručnih, naučnih i naučno-istraživačkih radova, dvije monografije poljoprivrednih dobara (Modriča i Nova Topola), udžbenik i praktikum iz *Kalkulacija,* te priručnik *Eksperimentalna statistika u poljoprivredi*.

Za doprinos razvoju naučne misli u oblasti poljoprivrede i prehrambene industrije dobio je više odličja i javnih priznanja, među kojima su državna *27. julska nagrada Bosne i Hercegovine,* nagrada *Veselin Masleša* i *Medalja Industrijsko-komercijalne komore Evropske unije*. Senat Univerziteta u Sarajevu dodijelio mu je 1997. godine počasno zvanje *professor emeritus*.

Kao jedan od vodećih stručnjaka Jugoslavije za projektovanje u prehrambenoj idnustriji, samostalno ili u saradnji izradio je ekonomske dijelove projekata za izgradnju više prerađivačkih kapaciteta i agroindustrijskih kombinata. Zajedno s pokojnim profesorom Aleksandrom Ličinom, rukovodio je izradom dijela koji se odnosio na prehrambenu industriju u Planu srednjoročnog razvoja agroindustrijskog kompleksa Bosne i Hercegovine 1985-2000. godine.

Govorio je italijanski, njemački, ruski i engleski, a služio se i sa nekoliko drugih jezika. Profesor Mulić je svirao harmoniku i orgulje, a bavio se brojnim hobijima. Među njima je numizmatika zauzimala vodeće mjesto. Imao je najveću zbirku papirnog novca u Jugoslaviji, koju je darovao Gradu Sarajevu. Na sreću, zbirka je u Historijskom muzeju sačuvana.

Po isteku mandata rektora Univerziteta u Sarajevu 31. oktobra 1993. godine, na vlastiti zahtjev otišao je u prijevremenu mirovinu. Poslije odlaska u mirovinu, posvetio se je svojoj staroj ljubavi - istoriji i objavio 27 monografija iz istorije Bosne, Hercegovine, numizmatike i školstva, te dvotomni *Biografski leksikon Konjićana s fakultetskim obrazovanjem*.

Prof. dr Sabahudin Bajramović

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 odbranjenih na Poljoprivredno-prehrambenom fakultetu Univerziteta u Sarajevu (Fakultet).

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"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 researches. 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. These researches can be shorter in time than the usual ones. (Scientific) Review papers contain an outline of certain problems on the basis of 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 researches.

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 also 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 in order 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. On the occasion of 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, on the basis of 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.

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

Printed copies of the "Radovi" (the "Works") are delivered to the Faculty's Library where the "Radovi" (the "Works"), that is, each published issue of the "Radovi" (the "Works") is sent from, to AGRIS and CAB Publishing – UK, both in written and electronic version, separately in PDF and Word format. The Library carries out the correspondence and exchange of the "Radovi" (the "Works") with other institutions in the country and abroad as well as sends volumes of the "Radovi" (the "Works") to the authors and co-authors.

Editorial Board