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EFFECT OF PARITY AND DAYS IN MILK ON MILK UREA CONCENTRATION AND MILK COMPONENTS IN HOLSTEIN DAIRY COWS

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ABSTRACT

The objective of this study was to assess the effects of parity and of days in milk (DIM) on milk urea (MU) and other milk components in Holstein dairy cows. Milk yield was lower ($P < 0.05$) in primiparous cows compared with multiparous cows and tended to increase until the third parity and then decrease. The MU concentration was lower ($P < 0.05$) at the first lactation than at the other lactations. Milk fat and protein contents were higher ($P < 0.05$) in the primiparous cows than that in multiparous cows and were reduced until the third parity and then increased. Lower ($P < 0.05$) milk lactose content was found in primiparous cows and tended to increase until the third parity and then decreased. Primiparous cows had lower ($P < 0.05$) daily protein and fat yields compared with multiparous cows. The lowest value of milk yield was recorded during the first lactation with a peak of lactation between 61—90 DIM and a persistence of lactation of 3 %. The highest milk yield was confirmed at the third and fourth lactations with a peak of lactation between 61—90 DIM and a persistence of lactation of 7 % and 6 %. The effect of DIM on MU confirmed a significant ($P < 0.01$) positive relationships in primiparous and multiparous cows. The lowest level of MU concentration was found between 0—30 DIM. The content of MU increased and the maximum was achieved between 271—305 DIM. It is suggested that although MU for nutritional management and measures of production or reproduction are used, non-nutritional factors should be considered.

Key words: milk yield; non-nutritional factors; urea in milk

INTRODUCTION

The content of lactose in milk and the quantity of milk are affected by the composition of the feed ration through the starch content in total mixed ration (TMR) and its rumen fermentation to produce propionic acid, which in gluconeogenesis in the liver affects blood glucose levels [25]. Precursors for milk protein synthesis in the mammary glands are metabolizable amino acids that are transported from the small intestine into the mammary glands and amino acids mobilized from the body reserves [17]. The synthesis of fat in the mammary glands are supported

by two sources. The first source is the synthesis of short and medium chain fatty acids *de novo* in the mammary glands of acetic acid and beta hydroxybutyric acid after the microbial fermentation of carbohydrates in the rumen. A second source are long chain fatty acids circulating in the blood reserves [4].

Urea as a part of the non-protein fraction of nitrogen in milk represents the final product of protein metabolism in the rumen of ruminants [9]. In dairy cows, urea can be found as a component in blood, milk, saliva and urine. The ammonia appears as a product of protein or non-protein nitrogen components digestion by the microorganisms in the rumen. The rumen microflora uses ammonia and energy for microbial proteins production. The excess of ammonia in the rumen appears when microorganisms are not supplied with a sufficient quantity of energy or when the protein component in the diet is in surplus. The excess of ammonia enters into the bloodstream and is transported into the liver, where it is transferred to urea by metabolic processes [5]. Urea is transported by the bloodstream to the kidneys and excreted from the organism or is returned to the rumen or is transported to the mammary glands, where it can easily pass through the cell membrane and increase the urea concentration in milk [16]. M a r e n j a k et al. [18] reported that the normal concentration of MU in cow's milk ranges between 10 to 30 mg.dl^{-1} and P y t l e w s k i et al. [22] reported it to be 25 mg.dl^{-1}.

The concentration of MU depends on various genetic, productive, nutritional and non-nutritional factors. Only a few researchers have investigated the effects of non-nutritional factors on milk and MU concentration [1, 23]. Non-nutritional factors explained 13.3% of the variation in MU [2] and production and environmental factors explained 37% of the MU variation in cows [11].

The aim of our study was to determine the effects of non-nutritional factors, such as parity and DIM on milk yield, milk components and MU in the milk dairy cows.

MATERIALS AND METHODS

Data collection

This study included 5838 Holstein cows from a Slovakian dairy farm from January 2018 to December 2018. Cows were selected according to parity: primiparous cows (lactation number = 1) and multiparous cows (lactation number > 1, range 2—5+). According to DIM, cows were grouped into 30 days (d) increments (0—30, 31—60, 61—90, 91—120, 121—150, 151—180, 181—210, 211—240, 241—270, 271—305 d).

The cows were maintained in free-stall housing and fed with a TMR, based on corn and alfalfa silage, supplemented with different carbohydrate's feeds (cereal grains and cereal grain by-products) and protein supplements (rapeseed meal) provided *ad libitum*. The TMR was formed monthly depending on the nutrient requirements according to the milk yield and capacity of dry matter intake (DMI) for primiparous and multiparous cows. The samples of the TMR were taken from the feed manger on the control day and were analysed for dry matter (DM), which consistent of crude protein (CP), fat, acid and neutral detergent fibre (ADF, NDF) and starch analysed by conventional methods [8]. The DM was determined by weight upon drying the sample at 105 °C under the prescribed conditions. The CP content was determined by the Kjeldahl method using a 2300 Kjeltec Analyzer Unit (Foss Tecator AB, Hoganas, Sweden). The fat was determined by the device Det-Gras (JP SELECTA, Spain). The ADF and NDF were determined using Dosi-Fiber Analyzer (JP SELECTA, Spain) and the content of starch was determined by polarimetry. The net energy of lactation (NEL) and non-fibre carbohydrates (NFC) were calculated using regression equations according to the National Research Council (NRC) [20].

The cows were milked twice a day and individual milk samples were analysed once per month. This took place in the Central Analytical Laboratory of Milk with accreditation under the registration number 096/5878/2015/2 in collaboration with The Breeding Services of Slovakia, using the breeding information system. Milk samples were analysed for the milk protein, fat, lactose and MU concentration by a near-infrared spectrophotometric assay using MilkoScan FT+ (Foss Electric, Hillerød, Denmark) and BENTLEY FTS (Bentley Instruments Inc., Chaska, USA). Daily yields of protein and fat were calculated by multiplying the percentage of milk components with milk yield per day [24].

Ethical considerations

Data used in this study were obtained with the consent of the farm in collaboration with The Breeding Services of Slovakia, using the Breeding Information System.

Statistical analysis

The data were processed by the IBM SPSS Statistics version 24.0 [12]. The results were expressed as the means ± standard deviations (SD). One-Way analysis of variance (ANOVA) for multiple comparison of means were conducted to evaluate the differences in parameters of milk yield, milk components and MU, where the parity was set as the main factor at a significance level of $P < 0.05$. Subsequently, the analysis of correlation between MU concentration (dependent variable) and DIM (independent variable) was performed during lactation in primiparous and multiparous cows using the correlation procedure IBM SPSS Statistics version 24.0 [12]. Differences between both groups were declared significant at $P < 0.01$.

RESULTS

The composition of the dairy herd according to parity is shown in Fig. 1. The dominated group was young dairy cows in the first lactation (38.4%), following the dairy cows in second (28.5%) and third (20.6%) lactation. Dairy cows in fourth, fifth and over lactation represent 6.8% and 5.7% of the herd.

The composition and average concentration of nutrients in TMR are presented in Table 1. The nutritional composition of TMR for the year fluctuated in the range, which was recommended by the nutrient requirement [20] for primiparous and multiparous cows. Separate formed TMR for primiparous and multiparous cows showed no significant differences in the analysed nutrients content.

Daily intake of nutrients in primiparous and multiparous cows are presented in Table 2. The daily intake of nutrients, on average for the year and in early lactation

Table 1. The composition and analysed nutrients content of TMR in primiparous and multiparous cows

	Primiparous cows	Multiparous cow
	Composition of TMR [kg]	
Corn silage	7.0—39.0	7.0—39.0
Clover silage	6.0—14.0	6.0—16.0
Grass silage	2.0—6.0	2.0—6.0
Alfalfa silage	13.0—22.0	13.0—22.0
Rye silage	7.0—17.0	7.0—17.0
Oat silage	2.0—17.0	2.0—17.0
Alfalfa hay	0.7—3.0	0.8—3.0
Wheat straw	0.5—1.0	0.5—1.0
Cereal grain mixture	0.8—3.7	0.5—4.5
Rapeseed meal	0.4—6.0	0.4—6.0
Wet distillers grains	4.0	4.0
Concentrate mixture	0.3—4.2	0.3—4.5
	Nutrients content of TMR [g.kg^{-1} DM]	
CP	154.0 ± 12.2	154.3 ± 11.9
Starch	222.4 ± 53.5	220.5 ± 52.2
Fat	41.4 ± 6.3	41.0 ± 5.6
NDF	379.3 ± 42.2	378.5 ± 42.9
ADF	233.5 ± 30.0	234.4 ± 29.6
NFC	351.1 ± 38.8	351.7 ± 39.2
NEL	6.4 ± 0.3	6.4 ± 0.3

DM—dry matter; CP—crude protein; NDF—neutral detergent fibre; ADF—acid detergent fibre; NFC—non-fibre carbohydrates; NEL—net energy of lactation; TMR—total mixed ration

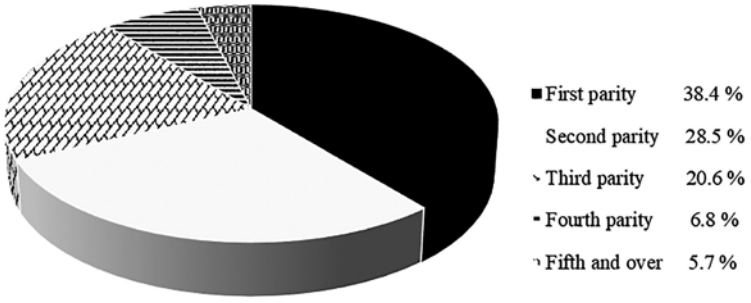


Fig. 1. Composition of dairy herd according to parity

Table 2. Daily intake of nutrients in primiparous and multiparous cows

	Daily intake of nutrients [kg.d^{-1}]			
	Primiparous cows		Multiparous cows	
	1st—3rd phase	1st phase	1st—3rd phase	1st phase
	± SD (Min—Max)		± SD (Min—Max)	
DMI	21.07 ± 1.7 17.0—24.0	22.77 ± 1.2 21.30—24.30	21.29 ± 2.1 18.00—25.30	23.68 ± 1.8 20.90—26.00
CP intake	3.20 ± 0.3 2.14—3.79	3.45 ± 0.3 2.76—3.79	3.24 ± 0.6 2.23—4.20	3.61 ± 0.4 3.00—4.08
Starch intake	4.69 ± 1.1 3.66—6.45	6.02 ± 0.4 5.30—6.72	4.71 ± 1.4 2.17—6.78	6.10 ± 0.7 4.43—6.75
NDF intake	7.72 ± 1.0 6.10—12.05	8.00 ± 0.3 7.79—8.51	7.78 ± 1.4 6.14—12.51	8.23 ± 0.6 7.79—9.11
NEL intake	132.22 ± 12.4 114.46—161.47	150.66 ± 7.1 141.24—161.47	133.67 ± 24.7 123.20—170.28	156.45 ± 10.6 138.15—170.28

DMI—dry matter intake; CP—crude protein; NDF—neutral detergent fibre; NEL—net energy of lactation

Table 3. Effect of parity on milk yield, milk components and MU

Lactation order	Milk yield [kg.d^{-1}]	MU [mg.dl^{-1}]	Fat [%]	Protein [%]	Lactose [%]	Protein yield [kg.d^{-1}]	Fat yield [mg.dl^{-1}]
1	32.5 ± 6.4^{a}	27.42 ± 6.8^{a}	3.75 ± 0.7^{a}	3.25 ± 0.3^{a}	4.75 ± 0.1^{a}	1.05 ± 0.2^{a}	1.20 ± 0.3^{a}
2	37.2 ± 9.3^{b}	27.90 ± 7.2^{b}	3.59 ± 0.7^{b}	3.23 ± 0.3^{a}	4.85 ± 0.2^{b}	1.18 ± 0.3^{b}	1.30 ±0.3^{b}
3	38.5 ± 10.3^{c}	28.30 ± 7.3^{b}	3.52 ± 0.8^{c}	3.18 ± 0.4^{b}	4.95 ± 0.2^{c}	1.20 ± 0.3^{b}	1.32 ±0.4^{b}
4	37.5 ± 10.0^{b}	28.00 ± 7.8^{b}	3.64 ± 0.7^{d}	3.20 ± 0.4^{b}	4.92 ± 0.3^{c}	1.19 ± 0.3^{b}	1.34 ±0.4^{b}
5+	34.9 ± 10.5^{d}	28.14 ± 6.8^{b}	3.73 ± 0.8^{e}	3.22 ± 0.3^{b}	4.82 ± 0.2^{d}	1.11 ± 0.3^{c}	1.28 ± 0.4^{c}

MU—milk urea; d—day; $^{a, b, c, d, e}$—Means within the same column with different superscripts are significantly different at $P < 0.05$

showed no significant differences between primiparous and multiparous cows. Differences were found between maximum and minimum nutrient intake values.

Effects of parity on milk yield, milk components and MU are presented in Table 3. Milk yield was lower ($P < 0.05$) in primiparous cows compared with multiparous cows and tended to increase until the third parity and then decrease.

The mean value of MU for the first lactation was lower ($P < 0.05$) than that of the second, third, fourth and greater parity means.

The milk fat and protein contents were higher ($P < 0.05$) in primiparous cows than that in the multiparous cows and tended to be reduced until the third parity and then increase. Lower ($P < 0.05$) milk lactose content was found in primiparous cows compared with multiparous cows and tended to increase until the third parity and then decrease.

Primiparous cows had lower ($P < 0.05$) daily protein and fat yields compared with the multiparous cows.

The dynamics of milk yield in different parities are shown in Fig. 2. Evaluation of milk yield according to parity confirmed the lowest milk yield during the first lactation (32.5 ± 6.4 kg.d^{-1}) with the lowest initial quantity of milk (29.0 ± 7.3 kg.d^{-1}) and the lowest peak of lactation (34.8 ± 6.3 kg.d^{-1}) between 61—90 DIM and persistence of lactation 3 %. The highest milk yield was confirmed in the third and fourth lactation (38.5 ± 10.3; 37.5 ± 10.0 kg.d^{-1}) with the highest initial quantity of milk

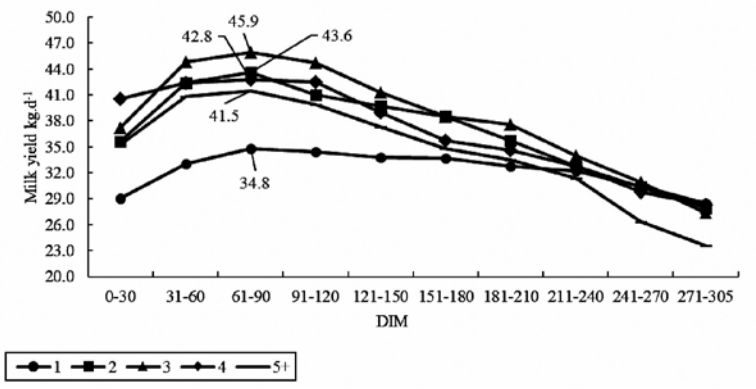


Fig. 2. Dynamics of milk yield in different parities

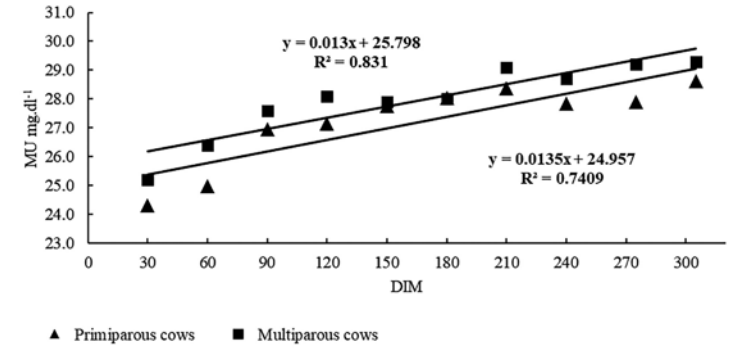


Fig. 3 Effect of DIM on MU concentration in different parities

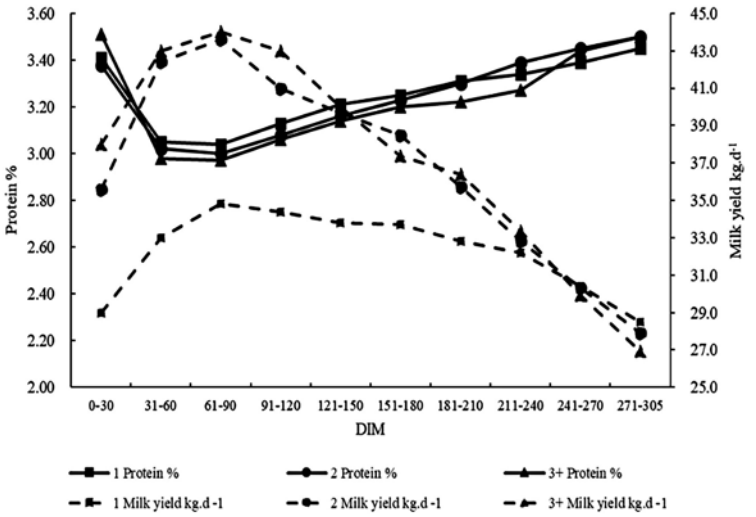


Fig. 4. Dynamics of milk yield and protein content in different parities

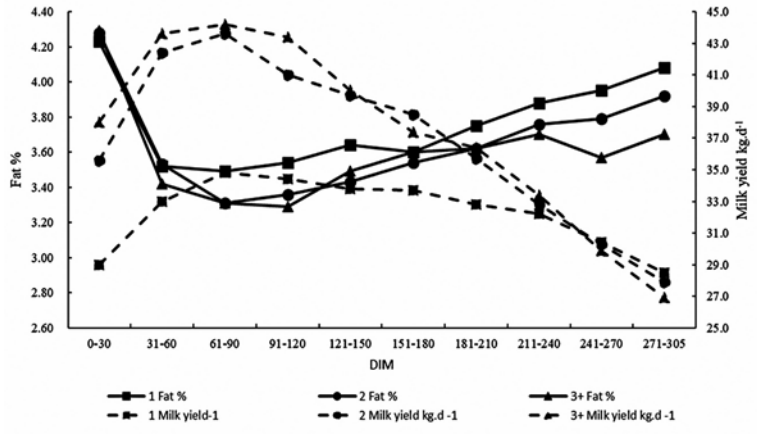


Fig. 5. Dynamics of milk yield and fat content in different parities

(37.2 ± 9.1; 40.5 ± 7.3 kg.d^{-1}) and the peak of lactation (45.9 ± 7.3; 42.8 ± 9.0 kg.d^{-1}) also between 61—90 DIM and persistence of lactation 7% and 6%. First lactation cows achieved 76% of the peak for mature cows and 79% of the peak for second lactation cows. Cows at the second lactation achieved 94% of the peak for mature cows.

The effect of the DIM on MU in different parities is shown in Fig. 3. The MU concentration was significantly ($P < 0.01$) influenced by the DIM with the coefficient of determination $R^2 = 0.74$ in primiparous cows and $R^2 = 0.83$ in multiparous cows.

The lowest levels of MU concentration (24.32 ± 7.6; 25.23 ± 9.1 mg.dl^{-1}) were found between 0—30 DIM in primiparous and multiparous cows. In the following DIM, the content of MU increased and the maximum concentration (28.63 ± 6.9; 29.13 ± 6.7 mg.dl^{-1}) was achieved between 271—305 DIM.

The dynamics of milk yield, protein and fat contents in different parities are shown in Fig. 4 and Fig. 5.

According to parities, it was confirmed that lower milk yields and higher protein and fat contents occurred in the primiparous cows, compared with the multiparous cows. According to DIM, it was confirmed that the milk yield increased proportionally with an increase of DIM into the peak of lactation and thereafter decreased. Protein and fat contents decrease into the peak of lactation and then after the peak, they tended to increase.

DISCUSSION

The lower milk yields in primiparous cows compared to multiparous cows are consistent with a previous study by Yoon et al. [27]. The lactation order is associated with the age of the cows. When the primiparous cows use nutrients from TMR for full development of tissues of the mammary gland and body frame, the milk synthesis is limited [21].

The lower MU content in primiparous cows compared to multiparous cows is conditioned by the growth of the body and higher efficiency of amino acid utilization. As a result, deamination of amino acid and urea formation in the liver are reduced [7]. While some studies [10, 16] reported that MU was lower in primiparous cows, other studies [9, 14, 15] found the highest MU concentration in primiparous cows and the lowest in multiparous cows.

Higher milk fat and protein contents in primiparous cows were connected with the lower milk yield; when the limiting milk yield associated with the growth of mammary gland and promotes a higher fat and protein contents in milk [21].

Lower milk lactose in primiparous cows compared with multiparous cows and tend to increase until the third parity and then decrease is due to increase of milk yield during the lactation, when the synthesis of lactose in the mammary gland regulates the milk secretion [19].

Increased need of nutrients for primiparous cows limits milk yield with a decrease in protein and fat yield compared to multiparous cows [21].

The confirmed results of the lowest milk yield during the first lactation with the low initial production and peak of lactation compared with cows in third and fourth lactation fully correspond to those of Baul et al. [3], who confirmed a sharper course of the lactation curve in the

group of mature cows as a consequence of a lower start of production, with a lower peak and a slower decline in milk production after the peak of lactation in primiparous cows compared to mature cows. Milk yield increases as parity proceeds because large cows produce more milk than small cows due to large body size and increased mammary gland development that comes with repeated pregnancies as well as the full development of tissues of the mammary gland. Milk yields declined in the fifth and over parity. The decline is due to the decline in body condition over the recurring pregnancies [21].

The results of the lower MU between 0—30 DIM in primiparous and multiparous cows and maximum MU concentration between 271—305 DIM correspond to those of Yoon et al. [27], who observed the highest values of MU during late lactation and the lowest during early lactation. According to Jílek et al. [14] the lower MU content in the first month of lactation is because of the inability of cows to digest a sufficient amount of feed at the beginning of the lactation. This can result in a relatively lower intake of proteins. In later lactations, as milk production declines, the protein requirement also decreases, and that MU should also decline. High of MU in the late lactations suggests the possibility that, protein is overfed in late lactations or the ration contained a different amount of rumen degradable protein than earlier in lactations [15].

The declining dynamics of milk yield during lactation is consistent with conclusions by Vijayakumar et al. [26], influenced by homeorhetic stimulation of metabolic regulation of nutrients intake for milk synthesis, as well as the synthetic capacity of mammary gland by different recovery of secretory cells at the peak and end of lactation. The increase of milk protein and fat contents during lactation is consistent with previous studies by Bondan et al. [6]. The decrease of milk yield in continuous lactation cause the protein and fat contents to remain more concentrated [13].

CONCLUSIONS

Our results confirmed the significant impact of non-nutritional factors (parity and DIM) on milk yield, milk components and MU. Results from this study show statistically significant ($P < 0.05$) impact of parity to milk yield, milk components and MU. Positive relationships ($P < 0.01$) between DIM and MU were also confirmed. These results suggest that previously mentioned non-nutritional factors should be evaluated when the relationship between MU concentration and nutritional management on dairy farms is determined.

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CONFLICT OF INTEREST

The authors declare there is no conflict of interest.

REFERENCES

1. **Abdouli, H., Rekik, B., Haddad-Boubaker, A., 2008:** Non-nutritional factors associated with milk urea concentrations under Mediterranean conditions. *World J. Agric. Sci.*, 4, 2, 183—188. DOI: 10.12691/wjar-9-3-3.
2. **Arunvipas, P., Dohoo, I. R., Vanleeuwen, J. A., Keefe, G. P., 2003:** The effect of non-nutritional factors on milk urea nitrogen levels in dairy cows in Prince Edward Island, Canada. *Prev. Vet. Med.*, 59, 1—2, 83—93. DOI: 10.1016/s0167-5877(03)00061-8.
3. **Baul, S., Cziszter, L. T., Acatincai, S., Cismas, T., Gavojdian, D., Tripon, I., Erina, S., Buzamat, G., 2013:** Effect of parity on dynamics of milk yield and composition during normal lactation in dairy cows. *J. Anim. Sci. Biotechnol.,* 46, 2, 285—289.
4. **Bauman, D. E., Griinari, J. M., 2003:** Nutritional regulation of milk fat synthesis. *Annu. Rev. Nutr.*, 23, 203—227. DOI: 10.1146/annurev.nutr.23.011702.073408.
5. **Bendelja, D., Prpić, Z., Mikulec, N., Ivkić, Z., Havranek. J., Antunac, N., 2011:** Milk urea concentration in Holstein and Simmental cows. *Mljekarstvo*, 61, 1, 45—55.
6. **Bondan, C., Folchini, J. A., Noro, M., Quadros, D. L., Machado, K. M., González, F. H. D., 2018:** Milk composition of Holstein cows: A retrospective study. *Cienc. Rural*, 48, 12, 1—8. DOI: 10.1590/0103-8478cr20180123.
7. **Cao, Z., Huang, W., Wang, T., Wang, Y., Wen, W., Ma,**

M., Li, S., 2010: Effects of parity, days in milk, milk production and milk components on milk urea nitrogen in Chinese Holstein. *J. Anim. Vet. Adv.*, 9, 4, 688—695. DOI: 10.3923/java.2010.688.695.

8. **Commission Regulation (EC) No. 691/2013, 2013:** Amending Regulation (EC) No. 152/2009 as regards methods of sampling and analysis. *OJEU*, L 197/1—L197/12.
9. **Čobanović, K., Kučević, D., Plavšić, M., Bogdanović, V., 2017:** Impact of non-nutritional factors on milk urea concentration and its relationship with production and fertility traits in Vojvodina dairy herds. *Mljekarstvo*, 67, 4, 267—276. DOI: 10.15567/mljekarstvo.2017.0404.
10. **Godden, S. M., Lissemore, K. D., Kelton, D. F., Leslie, K. E., Walton, J. S., Lumsden, J. H., 2001:** Factors associated with milk urea concentrations in Ontario dairy cows. *J. Dairy Sci.*, 84, 1, 107—114. DOI: 10.3168/jds.S0022-0302 (01)74458-X.
11. **Hojman, D., Kroll, O., Adin, G., Gips, M., Hanochi, B., Ezra, E., 2004:** Relationship between milk urea and production, nutrition and fertility trails in Israeli dairy herd. *J. Dairy Sci.*, 87, 4, 1001—1011. DOI: 10.3168/jds.S0022-0302(04)73245-2.
12. **IBM Corporation Released, 2016:** *IBM SPSS Statistics for Windows*, Version 24.0. Armonk, NY, IBM Corporation.
13. **Idamokoro, E. M., Muchenje, V., Masika, P. J., 2017:** Yield and milk composition at different stages of lactation from a small herd of Nguni, Boer, and non-descript goats raised in an extensive production system. *Sustainability*, 9, 6, 1000. DOI: 10.3390/su9061000.
14. **Jílek, F., Řehák, D., Volek, J., Štípková, M., Němcová, E., Fiedlerová, M., Rajmon, R., Švestková, D., 2006:** Effect of herd, parity, stage of lactation and milk yield on urea concentration in milk. *Czech J. Anim. Sci.*, 51, 12, 510—517. DOI: 10.17221/3971-CJAS.
15. **Johnson, R. G., Young, A. J., 2003:** The association between milk urea nitrogen and DHI production variables in western commercial dairy herds. *J. Dairy Sci.*, 86, 9, 3008—3015. DOI: 10.3168/jds.S0022-0302 (03)73899-5.
16. **Konjačić, M., Kelaval, N., Ivkić, Z., Ivanković, A., Prpi, Z., Vnučec, I., Ramljak, J., Mijić, P., 2010**: Non-nutritional factors of milk urea concentration. *Mljekarstvo*, 60, 3, 166—174.
17. **Maas, J. A., France, J., McBride, B. W., 1997:** Model of milk protein synthesis. A mechanistic model of milk protein synthesis in the lactating bovine mammary gland. *J. Theor. Biol.*, 187, 3, 363—378. DOI: 10.1006/jtbi.1997.0437.
18. **Marenjak, T., Poljičak-Milas, N., Stojević, Z., 2004:** The aim of urea determination in cows' milk (In Croatian, English abstract). *Praxis Veterinaria*, 52, 3, 233—241.
19. **Miglior, F., Sewalem, A., Jamrozik, J., Lefebvre, D. M., Moore, R. K., 2006:** Analysis of milk urea nitrogen and lactose and their effect on longevity in Canadian dairy cattle. *J. Dairy Sci.*, 89, 12, 4886—4894. DOI: 10.3168/jds.S0022-0302(06)72537-1.
20. **NRC 2001:** *Nutrient Requirements of Dairy Cattle*. 7th rev. edn., 263—265.
21. **Nyamushamba, G. B., Halimani, T. E., Imbayarwo-Chikosi, V. E., Tavirimirwa, B., 2014:** Comparative evaluation of non-genetic factors affecting milk yield and composition of Red Dane and Jersey cattle in Zimbabwe. *Springer Plus*, 3, 88. DOI: 10.1186%2F2193-1801-3-88.
22. **Pytlewski, J., A-ntkowiak, I., Skrzypek, R., 2010:** Relationships between somatic cells counts and urea level in the milk of polish Holstein-Friesian cows of black-and-white and red-white varieties. *Acta Sci. Pol.*, 9, 2, 39—50.
23. **Rajala-Schultz, P. J., Saville, W. J., 2003:** Sources of variation in milk urea nitrogen in Ohio dairy herds. *J. Dairy Sci.*, 86, 5, 1653—1661. DOI: 10.3168/jds.S0022-0302 (03)737 51-5.
24. **Stoop, W. M., Bovenhuis, H., Van Arendonk, J. A. M., 2007:** Genetic parameters for milk urea nitrogen in relation to milk production traits. *J. Dairy Sci.*, 90, 4, 1981—1986. DOI: 10.3168/jds.2006-434.
25. **Tripathi, M. K., 2014:** Effect of nutrition on production, composition, fatty acids and nutraceutical properties of milk. *J. Adv. Dairy Res.*, 2, 2, 1—11. DOI: 10.4172/2329-888X. 1000115.
26. **Vijayakumar, M., Park, J. H., Ki, K. S., Lim, D. H., Kim, S. B., Park, S. M., et al., 2017:** The effect of lactation number, stage, length, and milking frequency on milk yield in Korean Holstein dairy cows using automatic milking system. Asian-Australas. *J. Anim. Sci.*, 30, 8, 1093—1098. DOI: 10. 5713/ajas.16.0882.
27. **Yoon, J. T., Lee, J. H., Kim, C. K., Chung, Y. C., Kim, C. H., 2004:** Effects of milk production, season, parity and lactation period on variations of milk urea nitrogen concentration and milk components of Holstein dairy cows. Asian-Australas. *J. Anim. Sci.*, 17, 4, 479—484. DOI: 10.5713/ajas.2004.479.

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