The Comparison of Milk Composition and Quality of Dairy Crossbred Simmental and Holstein Cows for One Year

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Abstract. *The research was conducted to ascertain the positive benefts of crossbreeding for the quantitative and qualitative indicators of livestock production. The aim of the research was to perform a comparative analysis of the composition and quality rate of the milk produced by dairy Simmental crossbreeds and Holstein cows during the year.*

The experiment involved the purebred Holstein cows of dairy breed and F1 generation crossbred Holstein x Simmental cows of dual purpose. Twenty cows of each breed were observed for one year. The research revealed that the yield (Simmental crossbreeds: 8,951 l, Holstein 8,665.7 l) during the year was similar in both breeds, but the average annual fat content in the milk (0.32 percent) and protein (0.2percent) was higher in crossbred Simmentals' milk. The lactose content in the milk of both cow breeds differed by 0.075 percent, and no essential differences during the year were observed. The average amount of urea in Holstein cows' milk was 2.65 mg/100 mL, i.e., higher compared with crossbred Simmentals. The quantity of somatic cells in Holstein cows' milk during the year was by 97.85 thousand/mL higher than in the milk of crossbred Simmentals (P < 0.05).

Introduction

The period, when rapid freezing of bull semen was introduced 50 years ago, during that period, a new sire was evaluated taking into account the genetic progress of the first lactation daughters. Negative consequences of such an evaluation have long been known; however, it was only in recent years that this fact was taken seriously. It was during that period that the Holstein breed of livestock (Schonmuth, 1963; Malchiodi, 2014) was developed; thus, all the mistakes made during such breeding are best seen and analyzed while studying this particular breed population (Herinngstad et al., 2001). Looking for a way out of the situation (Fleischer at al., 2001), two strategies are currently being discussed and used: one suggests including "the functional values of the animal (such as the exterior, life expectancy, hoof wellness, etc.)" into the evaluation of breeding and taking them into account while executing the selection of purebred Holsteins. Another strategy is to exploit the heterosis effect while crossbreeding cattle with other breeds, which has long been known and used for breeding pigs and hens (Hein's et al., 2012; Karamfilov and Nikolov, 2019).

Cattle crossbreeding is of great significance (Konig et al., 2005; Simianer et al., 2006) in Lithuanian dairy farms. The positive effects of crossbreeding make farmers expect higher economic cost-effectiveness by improving cattle health, reproductive characteristics and calf survival rates. In recent years, such problems (cattle health, reproductive characteristic, calf survival rates and so on) have been increasing in the herds of Holstein cows.

Simmental breed of dairy cows ranks second in Europe (taking into account the number of livestock as well as the amount of milk and meat produced) after Holstein (SGG, 2018; Perišić et al., 2009). The Global Dairy Simmental Association states that, in some European countries, dairy Simmental breed is dominant, with Germany (about 3.5 million cattle, which accounts for slightly less than 30 percent of all dairy cow population in Germany), Austria (1.6–1.7 million, i.e., about 80 percent of all dairy cow population in Austria) and Serbia (850 thousand, i.e., about 80 percent of all dairy cow population in Serbia) taking the lead. A similar situation also occurs in the Czech Republic, Switzerland and Slovenia (Perišić et al., 2009).

The milk production and milk quality of crossbred cows has been extensively characterized (Heins et al., 2006; Dechow et al., 2007; Prendiville et al., 2010). The aim of the research was to perform a comparative analysis of the composition and quality rate of milk produced by dairy Simmental crossbreeds and Holstein cows during one year of production.

Material and Methods

Twenty Holstein cows and 20 F1 generation crossbred Simmental-Holstein cows were used for the research. All of the cattle were from the second lactation and were calved in November 2017. Livestock was observed and the productivity data were registered and evaluated for one year: from 1 January to 31 December 2018. The cow milk was analyzed once

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per month, during the morning and evening milking. The milk quantity was checked and written down during both milkings. Milk samples were taken in an alternating pattern: one month they were taken during the morning, and the following month –they were taken during the evening. Milk indicators were rated using the records accounts of a controlled herd of cattle from 2016–2018. The contents of the milk (fat, protein, lactose and urea) and the indicators somatic cell count in the milk were graded by PE "Pieno tyrimai". Fat, protein, lactose and urea amounts were analyzed using the mid-infrared detector LactoScopeFTIR. The somatic cell count was rated using a Somascope detector, which operates using the flow cytometry principle. The influence of different breeds on profitableness was evaluated using the checks for meat sales/purchases and milk price statistical indexes, which are announced every month on the website of the Ministry of Agriculture of the Republic of Lithuania.

The primary collected information was categorized, grouped, analyzed, and presented in the Microsoft Excel 20 program. Mathematical statistics were used to process the obtained research results and interpretation of the obtained data. The paper presents the following statistical indicators: arithmetic mean and its error (SE, standard deviation, minimum (Min), maximum (Max) and statistical reliability indicator – Student's t criterion with a significance level $P < 0.05$: when $P < 0.05$, the differences between the two comparator groups are considered statistically significant at a 95.0% reliability level; when $P > 0.05$, the differences between the groups are considered statistically unreliable (not statistically significant).

Results

In December, second lactation cows that were selected for the research were dry (Fig. 1). Most dairy crossbred Simmentals and Holsteins calved in January, and the rest did it at the beginning of February. In January, the cows of both breeds produced on the average a similar amount of milk ($P = 0.652$; $P > 0.05$), i.e., dairy crossbred Simmentals produced 17.8 ± 5.62 L, and Holsteins produced 15.5 ± 4.47 L (Fig. 1). In February, the average quantity of milk per cow was a few liters greater than in January, i.e., dairy crossbred Simmentals produced 21.1 ± 6.66 L, and Holsteins produced 18.4 ± 5.31 L.

In 6 weeks after calving, the productivity of most cows becomes the highest. This has also been observed during the research. In March, dairy crossbred Simmental cattle produced an average of 33.5 ± 0.60 L of milk (min = 28.4; max = 40.8;), and Holsteins produced an average of 11.1 L less than dairy crossbred Simmentals (i.e., average 24.4 ± 7.04, min = 6.5; max = 40.8;). However, statistically significant differences were not observed ($P = 0.139$; $P > 0.05$). At the end of April, the grazing period was commenced, which helped maintain high yields of livestock. Both breeds produced more than 33 L per cow. Due to prevailing hot weather in May of 2018, the yield per cow decreased significantly and reached a little more than 27 L per cow. Such an average yield remained until August. Most of the observed cows were successfully inseminated at the beginning of lactation; thus, the milk yield decreased. From October to December, the average yield of the dairy crossbred Simmental cows declined, and the lowest was in November, i.e., 17.4 ± 5.52 L. A similar trend was typical of the yield of Holstein cows. However, the lowest amounts of

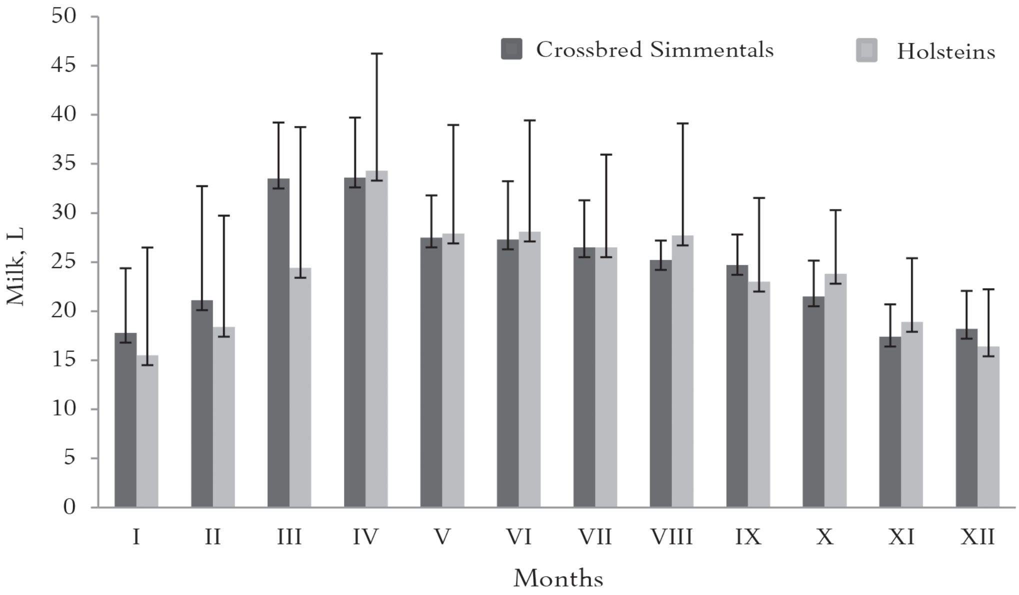

Fig. 1. Milk yield of dairy crossbred Simmental and Holstein cows

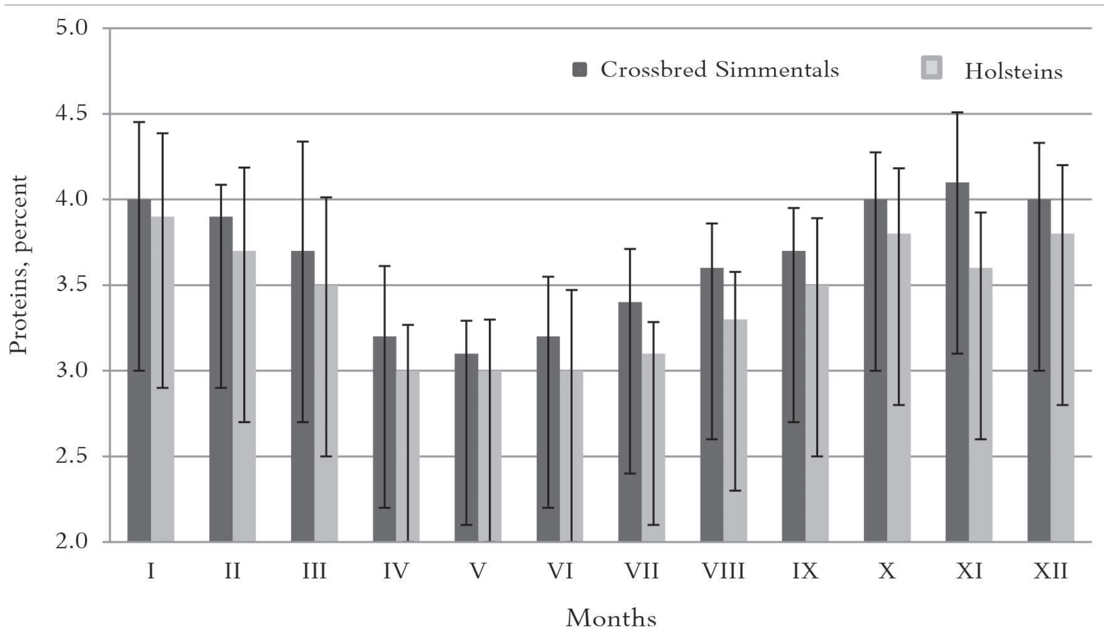

Fig. 2. The protein content in the milk of dairy crossbred Simmental and Holstein cows

milk were produced in December, i.e., an average of 16.4 ± 4.73 L.

The higher protein content in the milk of dairy crossbred Simmental cows, as compared with other varieties, is inherited from generation to generation, and this is one of the reasons for choosing these cows. During the entire period of the research, the protein content in the milk of dairy crossbred Simmental cows was higher than that of Holsteins (Fig. 2). However, statistically significant differences were observed only in November ($P = 0.006$; $P < 0.05$), when the protein content in the milk of dairy crossbred Simmentals was statistically significantly higher by 0.5 percent: for dairy crossbred Simmentals, it was 4.1± 0.41 percent, and for Holsteins, it was 3.6 ± 1.04 percent. During other months, the difference in the protein content in the milk of the two breeds was 0.1–0.3 percent. However, statistically the protein content in the milk of dairy crossbred Simmentals was not higher ($P < 0.05$). The comparison of the tendencies of variation of protein content in the milk of crossbred Simmentals and Holstein cows reveals that the changes in the protein content in the milk of both breeds of cows were very similar, i.e., from January (dairy crossbred Simmentals', with an average of 4.0 ± 0.45 percent, and Holsteins' - 39 ± 0.49 percent) it gradually decreased, while between April and June, it reached the lowest rates (an average of 3.1% to 3.2% in dairy crossbred Simmentals, of, and 3.0% in Holsteins). This was due to the commencement of the grazing period and adaptation to different forage. In June, having stabilized and balanced the changes of forage, the protein content started to grow again, and in October through December it reached the highest average values again, i.e., dairy crossbred Simmentals ranged from 4.0 to 4.1 percent, and Holsteins from 3.6 to 3.8 percent.

The fat content in the milk of the observed cows of both breeds ranged and varied throughout the study unevenly (Fig. 3). The highest average fat content in the milk of dairy crossbred Simmental cows was 5.7 ± 1.01 percent (min = 4.45; max = 7) in March; 5.4 ± 0.75 percent (min = 4.45; max = 6.43) in April; and 5.4 ± 0.86 percent (min = 4.02; max = 6.75) in November. The highest average fat content in the milk of Holstein cows was in January, 5.4 ± 0.90 percent (min = 4.31; max = 6.62) (Fig. 3). The lowest average fat content in the milk of dairy crossbred Simmental cows was observed in October, 4.2 ± 1.19 percent (min = 2.05; max = 6.57), and that of Holsteins in September, 3.9 ± 0.84 percent (min = 2.60; max = 5.43) and 4.2 ± 0.77 percent (min = 2.96; max = 5.20), respectively.

The comparison of the average fat content in the milk of the observed cows of both breeds reveals that throughout the study, except for a few months (January, February and December), the milk fat content of dairy crossbred Simmentals was higher. Key differences were observed in June and July, when the average fat content in the milk of Simmentals was 0.5 percent per piece ($P = 0.017$, $P < 0.05$) and 0.8 percent per piece higher ($P = 0.001$, $P < 0.05$) than in the milk of Holsteins. In March, the average fat content in the milk of dairy crossbred Simmentals was 5.7 ± 1.01 percent (min = 4.45; max = 7.24), and 4.7 ± 1.63 percent in the milk of Holsteins (min = 1.68; max = 6.52), i.e., 1.0 percent higher. However, the difference was not statistically significant.

The amount of lactose in the milk of dairy crossbred Simmentals reached the highest values (4.6 percent) in January through March and December, while in the milk of Holsteins (4.6 ± 1.27 percent), it was highest in December (Fig. 4). The lowest aver-

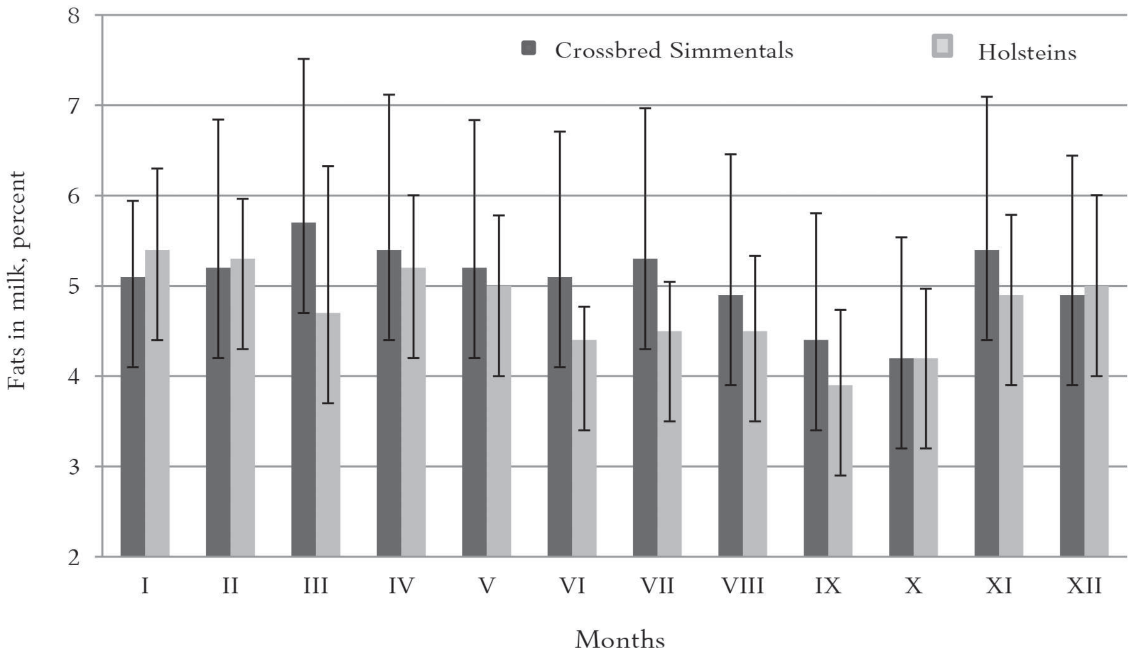

Fig. 3. The fat content in the milk of dairy crossbred Simmental and Holstein cows

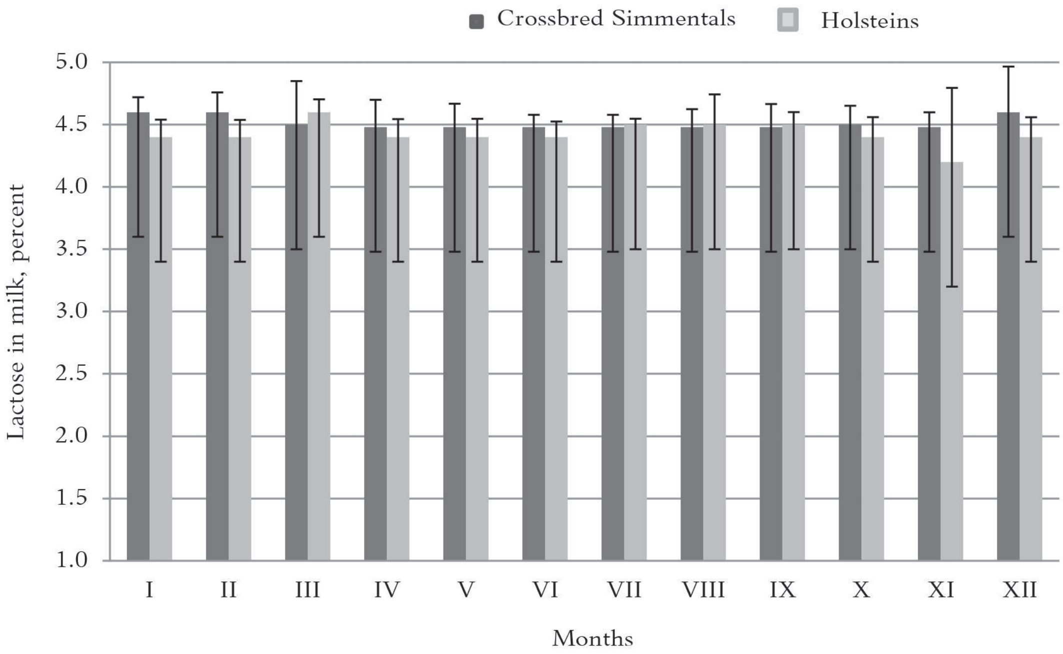

Fig. 4. The amount of lactose in the milk of dairy crossbred Simmental and Holstein cows

age amount of lactose was observed in the milk of Holstein cows in November, i.e., 4.2 ± 1.22 percent (min = 2.48; max = 4.65).

During the entire period of research, the difference in the average amount of lactose in the milk of dairy crossbred Simmental and Holstein cows varied negligibly (0.1–0.3 percent), except in June, when the average lactose content in Simmentals' milk was statistically significantly higher by 0.1 percent than in Holsteins' milk ($P = 0.023$; $P < 0.05$).

The comparison of the amount of urea in the milk throughout the study reveals that usually the average amount of urea in the milk of the Holstein breed was higher than that in the milk of dairy crossbred Simmentals, with the exception of a few months, i.e., January, April and August (Fig. 5). In January, the amount of urea in the milk of dairy crossbred Simmental cows reached 23.2 mg/100 mL, or was statistically significantly greater by 2.1 mg/100 mL than that of Holsteins ($P = 0.049$; $P < 0.05$). In February,

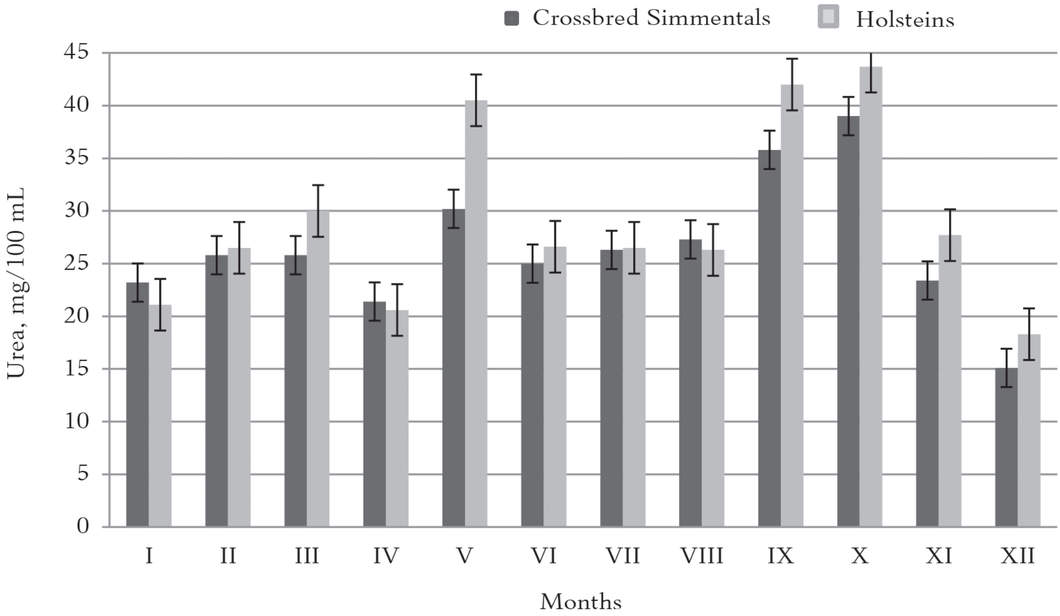

Fig. 5. The amount of urea in the milk of dairy crossbred Simmental and Holstein cows

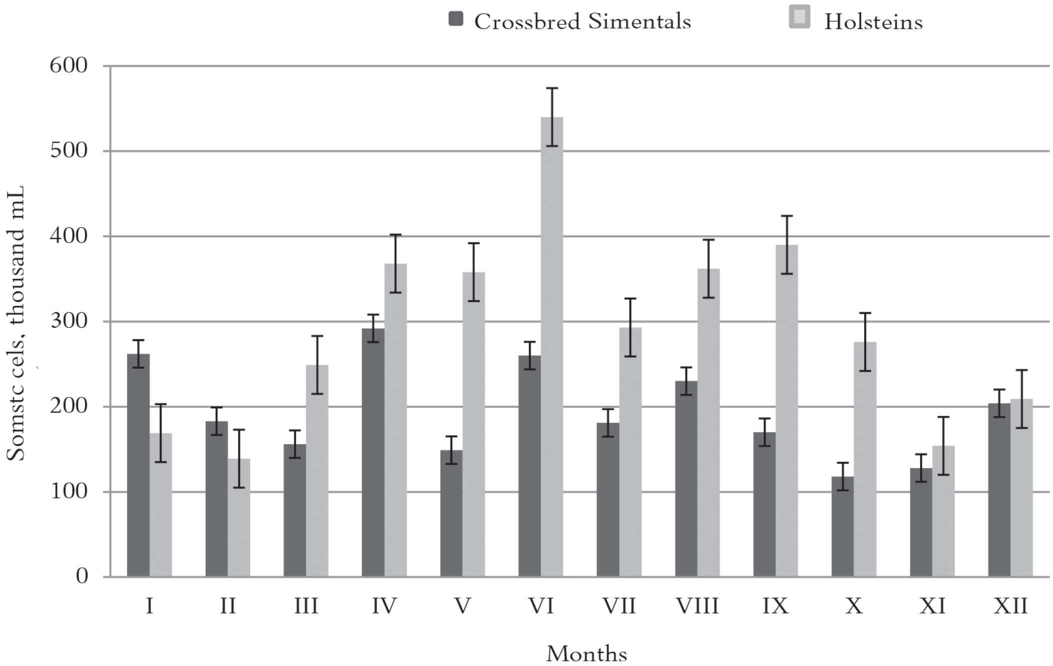

Fig. 6. The somatic cell count in the milk of dairy crossbred Simmental and Holstein cows

the average urea amount in the milk of dairy crossbred Simmentals was 0.7 mg/100 mL, i.e., statistically significantly lower ($P = 0.023$; $P < 0.05$), and in March, it was 4.2 mg/100 mL ($P = 0.028$; $P < 0.05$) lower than in the milk of Holsteins. However, in April, the urea amount in the milk of dairy crossbred Simmental cows was statistically significantly higher by 0.8 mg/100 mL in comparison with the average urea amount in the milk of Holstein cows in the same month ($P = 0.042$; $P < 0.05$).

The study of the established maximal indicators of urea throughout the entire research reveals that the average urea content, more than 40 mg/100 mL, was observed in May, September and October in the milk of Holstein cows, 40.5 ± 8.00 mg/100 mL, 42.0 ± 9.53 mg/100 mL and 43.7 ± 7.98 mg/100 mL, respectively. In comparison with dairy crossbred Simmental cows' milk, urea rates in Holsteins' milk during these months were significantly higher (10.3, 4.2 and 4.7 mg/100 mL, respectively), but the differences were not statistically significant ($P > 0.05$).

The comparison of the average somatic cell counts (SCC) in the milk of dairy crossbred Simmental and Holstein cows reveals that only in January and February the SCC in the milk of dairy crossbred Simmentals was higher than that in Holsteins' milk by 93 and 44 thousand/mL (Fig. 6). During other months, a higher SCC, 5 thousand/mL (December) up to

280 thousand/mL (June) was observed in the milk of Holstein cows. However, during the entire period, the differences in the SCC in the milk of the two breeds of cows were not statistically significant, with the exception of September, when the SCC in the milk of dairy crossbred Simmental cows was significantly lower than that in Holsteins' milk by 220 thousand/mL ($P = 0.034$; $P < 0.05$).

Discussion

During all months, the protein content in the milk of dairy crossbred Simmental cows was by 0.2 percent higher than that in the milk of Holstein cows. The quantity of cow milk depends on many factors: the time of lactation, intensity of feeding, animals' health, genetics, keeping conditions, etc. The research revealed that the milk yields of both breeds were very similar, and no statistically significant differences were observed. The milk yield of Holstein cows averaged 24.5 L per day per cow, while dairy crossbred Simmental cows produced 23.7 L per day per cow ($P > 0.001$). The lowest milk yield of Holstein cows was 8.9 L per cow, and the largest was 59.9 L per cow. The lowest milk yield of dairy crossbred Simmental cows was 12.3 L per cow, the largest was 50.8 L per cow. Similar results were also found in the research conducted by Muller et al. (2005), where the quantity of milk produced by Holstein and dairy crossbred Simmental cows was not significantly different ($P > 0.05$). In Toledo-Alvarado et al. (2017) studies, lower average milk yield of dairy crossbred Simmental cows was observed.

Lower average milk yield of Holstein cows was observed by Pintić et al. (2007), and Abdouli et al. (2008). In the research conducted by Marenjak et al. (2004), the cows of Simmental breed produced more milk than Holstein cows.

During all months, the protein content (3.6 percent) in the milk of dairy crossbred Simmental cows was higher than that in the milk of Holstein cows (3.4 percent). However, substantial differences were observed in November only ($P = 0.006$; $P < 0.05$). Significant differences in milk fat content were observed in June and July, when the average fat content in the milk of dairy crossbred Simmental cows was 0.5 percent ($P = 0.017$, $P < 0.05$) and 0.8 percent respectively higher ($P = 0.001$, $P < 0.05$) than in the milk of Holstein cows. During the year, the average fat content was 4.75 percent in the milk of Holstein cows, and 5.0 percent in the milk of dairy crossbred Simmental cows. In the research conducted by Muller et al. (2005), lower quantities of protein and fat were observed in the milk of Holstein cows than in the milk of dairy crossbred Simmental cows. In the study conducted by Toledo-Alvarado et al (2017), among dairy crossbred Simmental cows, the difference in protein and fat content in the milk has not been established. The study conducted by Pintić et al. (2007) also revealed that no substantial differences in fat and protein content in the milk of Holstein and Simmental breeds were identified. Johnson and Young (2003) as well as Abdouli et al. (2008) estimated that fat and protein content in the milk of Holstein cows was substantially lower as compared with that in the milk of cows of the Simmental breed.

There was no significant difference in the amount of lactose in the milk of both breeds; it ranged from 3.86 percent to 5.59 percent. The lactose content in the milk of dairy crossbred Simmental cows varied little, and the average yearly amount was 4.5 percent, whereas the amount of lactose in the milk of Holstein cows varied greater, with the average of 4.4 percent. Similar results were also obtained in the study conducted by Bendelja et al. (2011).

The average urea amount in Holstein cows' milk was 29.15 mg/100 mL, while in the milk of dairy crossbred Simmental cows it was 26.5 mg/100 mL. Such results fall within the recommended amount of urea in milk defined by most authors (Marenjak et al., 2004). Lower concentration of urea (15.5 mg/100 mL) was found in the milk of Holstein cows in the study conducted by Johnson and Young (2001). However, a 40 percent higher urea amount was observed in Holstein cows' milk as compared with Jersey cows' milk (Rodriguez et al., 1979).

In this study, the quantity of somatic cells in the milk of Holstein cows was statistically significantly higher ($P < 0.001$). The average somatic cell count is 307 thousand/mL. Such an SCC is close to the average somatic cell count characteristic to the breed, which reaches 316 thousand/mL (Hojman et al., 2005). The average SCC in the milk of dairy crossbred Simmental cows was 234 thousand/mL. The study conducted by Toledo-Alvarado et al. (2017) revealed that the somatic cell count was higher in the milk of Holstein cows as compared with the milk of dairy crossbred Simmental cows.

Conclusions

Milk yield during the year was similar in both breeds: Simmental crossbreeds produced 8,951 L, and Holstein cows produced 8,665.7 L. Average annual fat and protein content, 0.32 and 0.2 percent, respectively, was higher in crossbred Simmentals' milk, while the average amount of urea in Holstein cows' milk was 2.65 mg/100 mL, i.e., higher in comparison with crossbred Simmentals. Significant differences were found in November – Simmental crossbreeds: 4.1 ± 0.41 percent, Holstein 3.6 ± 1.04 percent ($P < 0.05$)). Average annual fat content in the milk (0.32 percent) was higher in crossbred Simmentals' milk. Significant differences were found in June and July (Simmental crossbreeds' 0.5 percent ($P = 0.017$; $P < 0.05$) and 0.8 percent higher ($P = 0.001$; $P < 0.05$) some Holstein cows). Lactose content in the milk of both cow breeds differed by 0.075 percent, and no essential differences during the year were observed ($P > 0.05$). The average amount of urea in Holstein cows' milk was 2.65 mg/100 mL, i.e., higher in comparison with crossbred Simmentals (both stocks were fed the same). Statistically significant differences were found in January (23.2 mg /100 mL) ($P = 0.049$; $P < 0.05$) and April (0.8 mg/100 mL) ($P = 0.042$; $P < 0.05$), the milk urea content was higher in the milk of dairy Simental crossbred cows than in Holstein cows. The mean urea levels in milk of Simmental crossbreeds in February (0.7 mg/100 mL) ($P = 0.023$; $P < 0.05$) and March (4.2 mg/100 mL) ($P = 0.028$; $P < 0.05$), the quantity was significantly lower than that of the Holstein. These results suggest a conclusion that dairy crossbred Simmentals use nutrients better for production. The quantity of SCC in Holstein cows' milk during the year was by about 100 thousand/mL higher than in the milk of crossbred Simmentals. In September, the somatic cell count in milk of crossbreed Simmentals was 220 thousand/mL, statistically lower than in Holsteins' milk ($P = 0.034$; $P < 0.05$).

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