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Emilia KOT, Ewa WÓJCIK, Katarzyna KRYSZAK

INFLUENCE OF THE SEASON OF THE YEAR ON THE QUALITY OF MILK PURCHASED BY DAIRIES

Institute of Bioengineering and Animal Breeding, Siedlce University of Natural Sciences and Humanities, Poland

Abstract. The aim of the study was to assess the effect of the calendar month on the quantity of milk purchased by dairies and to assess the chemical quality of milk based on analysis of its content of protein, fat, casein, and urea, as well as its SCC. Analysis of milk purchased in individual months showed that the most milk was purchased in June and the least in December. Assessment of the chemical composition of raw milk revealed that it contained on average 4.18% fat, 3.23% protein, 2.61% casein, and 222.92 mg/l urea, with a SCC of 246.67 1000/ml. The differences between means for individual months were statistically significant.

Key words: cow milk, season, composition and quality.

INTRODUCTION

For human beings, milk is a valuable raw material derived from animal production. According to the definition given by the International Dairy Federation, milk is the product of properly conducted, uninterrupted milking of a healthy, well-fed cow, free of colostrum. It is formed in the production tissue of the mammary gland, in which substances supplied from the blood are selected and processed (Barłowska 2008, 2012). It has high nutritional quality and contains complete proteins, easily digestible fat, exogenous and endogenous enzymes, carbohydrates, B-group vitamins and vitamins A, D, E and K, and minerals such as calcium, potassium, phosphorus, zinc and magnesium (Kruczyńska et al. 2006; Flaczyk et al. 2011). According to Januś and Borkowska (2011), milk and dairy products are an important component of a well-balanced human diet. High physicochemical, hygienic and microbiological quality of milk is very important in the modern dairy sector (Pilarska 2014). Its nutritional value and suitability for consumption and processing are influenced by the cattle housing system, milking hygiene and frequency, the cows' diet, the season of milking, and milk storage and transport conditions. These factors significantly affect the physicochemical, sanitary and microbiological parameters of milk. Milk composition is also influenced by the stage of lactation and the cow breed (Constantin and Csatlos 2010; Fijałkowski et al. 2017). The genotype of the cows is a very important factor (Czerniawska-Piątkowka et al. 2004).

Corresponding author: Ewa Wójcik, Institute of Bioengineering and Animal Breeding, Siedlce University of Natural Sciences and Humanities, Bolesława Prusa 14, 08-110 Siedlce, Poland, e-mail: ewa.wojcik@uph.edu.pl

An extremely important factor influencing the physicochemical and microbiological properties of milk is the season of the year (Pilarska 2014). According to Lipiński et al. (2012), the content of fatty acids in the total milk fat may vary depending on the season of production, the breed and individual properties of the animal, the stage of lactation, and feeding. The seasonality of changes in the composition of milk fat is mainly a question of the feeding period. The winter period is characterized by a lack of green fodder, while in summer this type of feed is the foundation of the diet. Diet is closely linked to the season of production, and is one means of adjusting the chemical composition of milk to the constantly changing demands of the market (Lipiński et al. 2012). Hence, in addition to genetic factors, nutrition is a very important element affecting milk quality, i.e. its content of fat, proteins and vitamins, taste and smell, microbial content and suitability for processing (Gawlik 2010). Intake of the appropriate amount of dry matter, total protein, fibre, minerals, micronutrients and vitamins by cows improves the quality of milk. Feedstuffs should be of good quality and high digestibility.

Another important issue is the assessment of environmental factors affecting milk yield, the content of protein, fat, casein, and urea, and somatic cell count (SCC), which determine milk quality. A study by Gnyp (2012) showed that the daily milk yield of cows and the level of fat increased with herd size. Unfortunately, the milk of animals from large herds has a higher SCC than that of cows from small herds. Variation in milk constituents is believed to be 50% determined by genetic factors and only 40% by environmental factors.

In the last decade, attention has been drawn to qualitative changes in milk and to the increase in milk production while the dairy cattle population in the country is declining. This is due to concentration of herds and continually increasing productivity of lactating cows. These changes have been accompanied by specialization of farms, both medium-sized and large. Technical changes on dairy farms have included investments in new technologies, i.e. milking parlours and milk cooling tanks. There have also been noticeable changes involving the use of rational feeding technology, owing to which specialized farms have been established that have met and continue to meet high European Union standards. It should be noted that there are also farms that have difficulty adapting to these high standards and market requirements.

Milk production requires farms of a certain size, suitably adapted equipment, and an experienced farmer. In recent years, a close correlation has been observed between production and the increase in the yield of lactating cows (Skarżyńska 2012). For many years there have been major seasonal fluctuations in milk production in Poland and around the world (Wójcik et al. 2017). This is reflected in the entire marketing chain of milk production. The main reasons for the seasonality of milk production are feeding technology and the distribution of calving during the year. In Poland, most calves are born in the autumn and winter, and the peak of lactation occurs in the first 100 days after parturition. A factor that has a very positive effect on high milk production in summer is the quantity and high quality of bulky feed. However, the pursuit of increased productivity must be combined with improvement of genetic potential (Gnyp et al. 2006).

In assessing the increase in milk yield in cows, it is also worth mentioning the negative impact of continuous improvement of milk yield on the health of cows. This is manifested in the deterioration of milk quality, metabolic diseases, and infertility, which result in increased culling and a shorter life span of high-yielding cows. This also affects the profitability of production. Higher yield should positively affect the profitability of production in Poland; however, this is a multifaceted issue that is closely linked to production (Skarżyńska 2012). According to Bortacki et al. (2017), adaptation of milking systems to the size of the herd is very important for milk production and milk quality. The authors reported better milk quality in free-stall farms and when cows were milked three times a day. This had a beneficial effect on the chemical content of protein, fat and casein, as well as on SCC.

The aim of the study was to assess the effect of the calendar month on the quantity of milk purchased by dairies and to assess the chemical quality of milk based on analysis of its content of protein, fat, casein, and urea, as well as its SCC.

MATERIAL AND METHODS

The research material consisted of data obtained from the laboratory of a dairy plant located in eastern Poland. The percentage content of protein, fat and casein, the urea level, and the somatic cell count (SCC) in the milk were determined in a MilcoScan apparatus in the laboratory. The analysis of the chemical composition of the milk was performed on bulk milk. Detailed analyses were performed in a laboratory belonging to a local dairy, which met all applicable standards. In the purchasing department, data on the purchase of milk were compiled. The milk came from small-scale farms using a free-range system. The study analysed the effect of the calendar month of the supply on the quantity of the milk purchased and evaluated the chemical quality of the milk based on its content of protein, fat, casein and urea and its SCC. Monthly milk deliveries from 35 suppliers were included in the study. A total of 421 samples were analysed, determining means and standard deviation in each month of the calendar year. To examine the influence of the delivery month on the features analysed, one-way analysis was performed by the least-squares method. The following linear model was used:

$Y_{ij} = \mu + a_i + e_{ij}$

were:

Y_{ij} – value of feature,

μ – mean,

a_i – effect of month of delivery I = 1,..., 12,

e_{ij} – sampling error.

Duncan’s test ($P < 0.05$) was used to determine the significance of differences between means.

RESULTS AND DISCUSSION

A total of 421 milk deliveries were analysed. The average annual volume of milk purchased in the analysed delivery months was 92.77 litres. Differences were observed in the amount of milk bought in individual months and seasons (Fig. 1). The most milk was purchased in June and the least in December. The greatest volume of milk was purchased in the spring. The differences observed in the amount of milk purchased were statistically significant ($P < 0.05$). Salamończyk et al. (2013) made similar observations to ours, reporting the largest procurement of milk in the spring and summer, accounting for as much as 28% of the purchase of raw milk for the entire year. Śmigielska (2014) also observed differences in the amount of milk purchased by dairies in individual seasons of the calendar year. The author compared the results with the results from previous years and found that over several years the quantities of milk procured in a given production season may vary between months by as much as 7.7%. Wójcik et al. (2017) also found that an 18% greater volume of milk was produced in the summer than in the winter. The volume of the purchase is significantly affected by the temperature of the environment in which cows produce milk. According to Daniel (2008), the optimal temperature for lactating cows is 4–6ºC, while at temperatures above 22ºC feed utilization gradually decreases. At temperatures of 30ºC and above, the cow's productivity decreases by about 20%, and the milk is often of inferior quality.

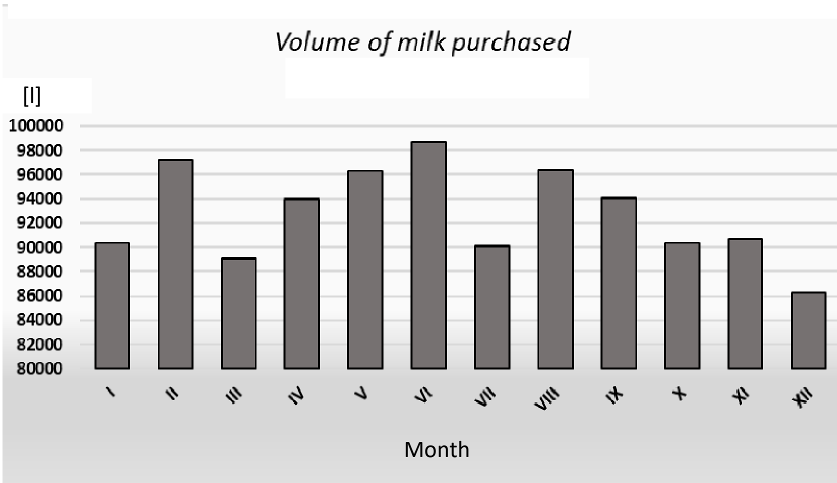

Fig. 1. Mean volume of annual milk purchased by dairies

Evaluation of the chemical quality of milk in the study was based on analysis of its content of protein, fat and other components. The average content of fat was 4.18 ± 0.14%, protein 3.23 ± 0.10%, casein 2.61 ± 0.10%, urea 222.92 ± 27.44 mg/l, and SCC (in thousands) 246.67 ± 30.94. Differences were observed in the content of fat, protein, casein and urea and in SCC between months of the year (Table 1). The highest percentage of fat was recorded in January, and the lowest in August. The highest protein content was also observed in January, and the lowest in July. The most casein was observed in January and the least in August; the most urea in January and the least in April; and the highest SCC in September and the lowest in February.

There were statistically significant differences in fat content between different months, in protein content between January and August and other months, in urea between May and June and other months, and in SCC between the winter and spring months and the summer and autumn months (Table 1). According to Bogucki et al. (2006), such factors as time of year and the volume of the monthly supply have a significant impact on the quality characteristics of milk: percentage of protein and fat, somatic cell count and microbial count. In the present study, the effect of the season of the year on the fat and protein content in the milk may also be due to changes in the feeding system and environmental temperature. The lowest share of fat, protein and casein in the milk was recorded in the summer months. Similar results were obtained by Wasilewicz (2011) and Pilarska (2014), who reported relationships between the time of year, feeding, and milk protein and fat content. The lowest content of protein and fat was observed in the summer season during pasture grazing. Wielgosz-Groth (2008) also claims that the seasonality of feeding is a factor causing changes in the chemical composition of milk.

Table 1. Effect of month of purchase on percentage content of fat, protein, casein, urea and SCC in raw milk

Delivery month	Fat [%]	Protein [%]	Casein [%]	Urea [mg/l]	SCC [1000/ml]
			$\overline{X}$ ± SD		
I	4.30 ± 0.12^{ab}	3.43 ± 0.06^{a}	2.71 ± 0.09	199.50 ± 17.38^{b}	176.00 ± 16.67^{a}
II	4.36 ± 0.18^{a}	3.34 ± 0.10^{ab}	2.63 ± 0.07	206.50 ± 16.06^{b}	177.00 ± 20.41^{a}
III	4.34 ± 0.15^{ab}	3.31 ± 0.08^{ab}	2.58 ± 0.08	209.50 ± 19.09^{b}	195.50 ± 19.39^{a}
IV	4.31 ± 0.10^{ab}	3.30 ± 0.15^{ab}	2.63 ± 0.17	213.50 ± 16.06^{b}	180.00 ± 23.34^{a}
V	4.21 ± 0.13^{abc}	3.35 ± 0.16^{ab}	2.67 ± 0.15	279.50 ± 18.59^{a}	205.00 ± 28.99^{a}
VI	4.05 ± 0.10^{bc}	3.20 ± 0.8^{ab}	2.55 ± 0.07	284.50 ± 13.23^{a}	255.00 ± 24.35^{b}
VII	3.91 ± 0.11^{c}	3.19 ± 0.10^{ab}	2.53 ± 0.05	226.50 ± 10.20^{b}	320.50 ± 13.44^{b}
VIII	3.87 ± 0.10^{c}	3.18 ± 0.08^{b}	2.52 ± 0.07	214.50 ± 19.90^{b}	325.50 ± 17.42^{b}
IX	3.98 ± 0.07^{c}	3.21 ± 0.09^{ab}	2.54 ± 0.08	217.00 ± 18.28^{b}	329.50 ± 16.07^{b}
X	4.02 ± 0.19^{bc}	3.32 ± 0.07^{ab}	2.63 ± 0.06	219.00 ± 11.91^{b}	295.50 ± 12.09^{b}
XI	4.16 ± 0.08^{abc}	3.37 ± 0.08^{ab}	2.66 ± 0.07	206.00 ± 12.53^{b}	280.50 ± 18.99^{b}
XII	4.26 ± 0.07^{ab}	3.36 ± 0.11^{ab}	2.66 ± 0.11	199.00 ± 16.77^{b}	220.00 ± 17.69^{a}

[abc] Mean values marked with different letters are statistically different ($P < 0.05$).

The season thus has a significant effect on variation in the chemical composition of cow milk (Litwińczuk et al. 2006; Lipiński 2012). Similar observations have been made by Stenzel et al. (2001), Kwaśnicki et al. (2003) and Salamończyk et al. (2016) who also noted that milk had a higher fat and protein content in winter than in summer, which they suggest was due to the lower energy content in the summer feed ration. According to Kruczyńska (2005), feedstuffs with increased crude fibre content provide energy to the ruminal microflora, thereby influencing the level of milk fat by breaking down the fibre into simple organic compounds. According to Czerniawska-Piątkowska et al. (2004), differences observed in protein and casein levels are also influenced by the breed, and even by the percentage composition of genes in a given breed within their genotypes. Milk quality and nutrient concentrations are also affected by the stage of lactation (Guariglia et al. 2015) and by the environment in which the animals live (Czerniawska-Piątkowka and Szewczuk 2008).

The average urea level obtained in our study was 214 mg/l. Similar values for this parameter (220 mg/l) have been reported by Salamończyk (2013). These researchers found the lowest urea level in the winter and the highest level in the summer. According to the authors, cows fed green forage often have a higher urea level in a litre of milk. We obtained similar results in our research. Another important parameter is the somatic cell count in milk, which reflects the health status of the mammary gland (Malinowski 2001). In our research, we observed an increase in the somatic cell count in the summer/autumn season. According to Pilarska (2014) also Czerwińska and Piotrowski (2011), this parameter may vary depending on the season, the health condition of the cows, and the milking system. In the summer, there is an increase in the number of microorganisms and the number of somatic cells, while the bacterial count is lowest in winter, which is linked to the lower survivability of pathogens and with overcooling of milk.

Unfortunately, a high SCC negatively affects the physical and chemical properties of casein, destabilizing it and reducing its quality and technological properties (Albezio et al. 2005). Casein is a very important protein that influences the profitability of the dairy industry (Ramos et al. 2015). As SCC increases, the level of fat increases as well (Rangel et al. 2009; Guariglia et al. 2015), as observed in our study. According to Salamończyk et al. (2013), milk quality is influenced by many other factors, such as daily hygiene in cattle housing, milking devices, the cleanliness of cows, monitoring of udder health, and pre-and post--milking procedures.

CONCLUSION

1. The analyses carried out in the study revealed differences in the amount of milk purchased by dairies between months and seasons. The quality of milk from small-scale farms was indicated by its very good microbial parameters and chemical composition. This is the result of a significant improvement in the acquisition of milk on farms, with stringent requirements regarding its chemical and hygienic quality, as well as in its transport to dairy plants.
2. The assessment of the chemical composition of the raw milk, i.e. the levels of fat, protein, casein and urea, as well as the SCC, showed significant differences between months of the calendar year. In summer, the content of fat, protein and casein in the raw milk was lower, and the urea level and SCC were higher.

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WPŁYW PORY ROKU NA JAKOŚĆ SKUPOWANEGO MLEKA

Streszczenie. Celem podjętej pracy była ocena wpływu niektórych czynników na skład chemiczny surowego mleka: tłuszczu, białka, kazeiny, mocznika i liczby komórek somatycznych. W pracy analizowano wpływ wielkości dostawy na jakość skupowanego mleka. Analiza skupu mleka w poszczególnych miesiącach wykazała, że najwięcej mleka dostarczono do skupu w czerwcu, zaś najmniej – w grudniu. Ze składu chemicznego mleka surowego wynika, że zawierało ono średnio 4,18% tłuszczu, 3,23% białka, 2,61% kazeiny, 222,92 mg/l mocznika i 246,67 tys./ml LKS. Zaobserwowane różnice w średnich wartościach w poszczególnych miesiącach były statystycznie istotne.

Słowa kluczowe: mleko krowie, pora roku, skład i jakość.