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THE INFLUENCE OF HYGIENIC QUALITY PARAMETERS ON COMPOSITION AND PHYSICAL PROPERTIES OF OLKUSKA SHEEP MILK*

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Key words: sheep's milk, milk composition, physical properties, hygienic quality, correlations.

Abstract

The aim of this study was to determine the influence of sheep's milk hygienic quality parameters on its composition and physical characteristics. During the three-year study 140 samples of Olkuska sheep milk were collected for analyzes. The samples were taken during the morning milking, and then were tested to determine the composition, physical properties, the presence of inhibitory substances, somatic cell count (SCC) and the total number of microorganisms. The increase in SCC and the total number of microorganisms caused an increase in dry matter content, total protein, casein, fat, total and soluble ash, pH, viscosity, conductivity and freezing point, and a decrease in lactose content, acidity and density. Statistically significant correlations were obtained for the relationship between SCC and the content of casein, fat, acidity, pH, density, and conductivity. As regards the total number of microorganisms most of the correlations were statistically significant, and the calculated correlation coefficients were higher than in case of SCC.

WPŁYW PARAMETRÓW JAKOŚCI HIGIENICZNEJ NA SKŁAD I WŁAŚCIWOŚCI FIZYCZNE MLEKA OWIEC OLKUSKICH

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Słowa kluczowe: mleko owcze, skład, właściwości fizyczne, jakość higieniczna, współzależności.

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Abstrakt

Celem badań było określenie wpływu parametrów jakości higienicznej mleka owczego na jego skład i cechy fizyczne. W trakcie trzyletnich badań pobrano do analiz 140 próbek mleka owiec olkuskich. Próbki pobierano z porannego udoju, następnie poddawano badaniom w celu określenia składu, właściwości fizycznych, obecności substancji hamujących, liczby komórek somatycznych (SCC) oraz ogólnej liczby drobnoustrojów. Wzrost SCC i ogólnej liczby drobnoustrojów powodował wzrost zawartości suchej masy, białka ogółem, kazeiny, tłuszczu, popiołu ogólnego i rozpuszczalnego, pH, lepkości przewodności i temperatury zamarzania oraz spadek zawartości laktozy, kwasowości i gęstości. Statystycznie istotne współczynniki korelacji uzyskano dla zależności między SCC i zawartością kazeiny, tłuszczu, kwasowością, pH, gęstością i przewodnością. W odniesieniu do ogólnej liczby drobnoustrojów większość obliczonych zależności była istotna statystycznie, a uzyskane współczynniki korelacji były wyższe niż dla SCC.

Introduction

The hygienic quality of milk is determined on the basis of the presence of inhibitory substances, the total number of microorganisms and the cytological quality, that is somatic cell count (SCC). However, the most frequently used and found in research and literature hygienic quality indicators are the total number of microorganisms and somatic cell count. Their widespread application results from good accuracy of the assessment. At the same time both indicators are closely related and in most cases high total number of microorganisms is accompanied by high number of somatic cells.

Increased total number of microorganisms informs about milk bacterial contamination and as demonstrated SEVI et al. (1999) it is closely related to the occurrence of udder inflammation (mastitis), which is caused by pathogenic organisms, particularly Staphylococcus and Streptococcus. Inflammatory conditions also cause an increase in the number of somatic cells. The milk originating from a healthy udder contains a small number of these cells. The occurrence of disease states, in particular caused by novobiocin-sensitive coagulase negative staphylococci (Streptococcus spp. and Enterococcus spp.), leads to a significant increase in milk leukocytes (produced as a defense reaction of the organism), thus an increase in SCC. Therefore, somatic cell count is widely used as an indirect method of detecting udder inflammatory conditions (ARIZNABARRETA et al. 2002, RAYNAL-LJUTOVAC et al. 2007, SEVI et al. 1999a, TIETZE and MAJEWSKI 1995).

Increased somatic cell count and the total number of microorganisms adversely affect the yield, composition, and physical characteristics of collected milk, as well as the subsequent fermentation processes and the quality of obtained final products. Studies conducted on sheep milk unquestionably confirm the impact of mastitis on milk yield, which is significantly lower

comparing to the quantities of milk obtained from healthy sheep. According to numerous publications losses may range from 3% to 14% of the average milk yield, and depend on the nature of the infection. Losses associated with the production of cheese from milk with a high somatic cell count may be as high as 15.5% (EL-SAIED et al. 1998, GONZALO et al. 1994, 2002, LEITNER et al. 2008, OSIKOWSKI et al. 1999, PELLEGRINI et al. 1997). Furthermore, such cheese is characterized by up to 4% lower content of protein as compared to cheese manufactured from low somatic cell count milk (RAYNAL-LJUTOVAC et al. 2007). Changes in the chemical composition of the milk relate primarily to the components synthesized in mammary gland such as fat, protein and lactose. Chronic mastitis causes a decrease in the fat content, increase in the protein content and at the same time a decline in the casein. This leads to reduction in the casein number – a very important milk quality indicator from the technological point of view. In case of mastitis lactose content is reduced significantly. It is associated with a decrease in the ability to synthesize milk constituents in the infected udder. This is also of great technological importance, since adequate lactose content is necessary for the proper fermentation processes during the production of fermented milk drinks as well as in cheese production. Lower content of calcium and phosphorus, and increased content of chlorine, sodium, and potassium were also found in the milk of sheep with clinical mastitis. The decline in calcium content is particularly worrying, because it affects rennet coagulation process and determines the quality of the clot. The milk clotting time is prolonged and obtained clot is looser. Moreover, in the case of mastitis the pH rises and can even reach 7 as a slightly acidic reaction of milk results from the presence of acidic phosphates and casein (ALBENZIO et al. 2005, BONCZAR 1994, BONCZAR and PACIOREK 1999, CAROPRESE et al. 2006, JURCZAK 2005, KĘDZIOR 2005, PIECZONKA 1999, RAYNAL--LJUTOVAC et al. 2007, SEVI et al. 1999).

As it was demonstrated numerous studies have shown that mastitis causes a decrease in milk yield and affects milk composition. Especially the influence of SCC is well documented. However scientific publications on the statistical relationships of sheep's milk hygienic quality parameters to its physicochemical characteristics are rare. For this reason the aim of this research was to determine the correlations between sheep milk somatic cell count and the total number of microorganisms and its components and physical characteristics.

Materials and Methods

The study was conducted using a flock of Olkuska sheep. The age of sheep ranged from 2 to 8 years. Animals were under two different feeding systems: stable-diet for the first three month of lactation and grazing at the grass

pasture for the rest of the experiment. A single sample of experimental material consisted of milk obtained from individual lacting sheep. Milk was collected at monthly intervals for the first 5 months of lactation to guarantee the sufficient amount of milk for analyzis. All analyzed samples were taken during the morning milking. Until lamb weaning milking was carried out after earlier (about 8 hours) separation of sheep from their lambs. Milking was carried out manually. The milk samples in the glass bottles were placed in cooler boxes and immediately transported to the laboratory where the analyzes were conducted. The study was conducted for three years, a total of 140 samples was analyzed.

Analyzed milk samples were studied to determine the basic composition, physical and hygienic quality. In particular following parameters were determined (*Mleko surowe...* PN-A-86036:1998, *Mleko...* PN-A-86122:1968, *Mleko...* PN-EN ISO 8968-1:2004):

– dry matter content according to the oven-drying method,
– fat content according to Gerber method,
– proteins content according to Kjeldahl method,
– total ash content by dry mineralization in temperature + 525°C,
– soluble ash content callculated as a difference between total ash and ash insoluble in 10% hydrochloric acid,
– lactose content,
– casein content according to Wolker method,
– casein number (the ratio of casein to total protein),
– total (titratable) acidity and pH,
– density by thermolactodensimeter,
– viscosity on Rheotest RN 3.1 apparatus,
– freezing point (temperature) using Funke Gerber cryoscope,
– electrical conductivity,
– presence of inhibitors with STD-Abiotest,
– somatic cell count (SCC) on Fosomatic 360 apparatus,
– the total number of microorganisms on BactoScan 8000 apparatus.

The results were statistically analyzed aiming to determine correlations between the parameters of hygienic quality and other parameters of the overall quality of sheep's milk. Statistical analyzes were performed using The Statistica 8.0 PL software.

Results and Discussion

Inhibitors in this experiment were detected in a few samples for which at the same time both somatic cell count and the total number of microorganisms obteined the highest values. The results confirmed the facts, ie. these sheep

were given antibiotics because of existing strong inflammation of the udder. The milk from these animals was not used for consumption or further processing. Due to the small number of such samples this indicator is not taken into account in further analyzes.

The influence of somatic cell count and the total number of microorganisms was considered in the first place, in relation to the basic components of milk, and then to the physical parameters.

The increase in somatic cell count in the milk of Olkuska sheep was accompanied by an increase in the content of dry matter, total protein, casein, fat, total and soluble ash, the number of casein and a decrease in lactose content. However, statistically significant correlation coefficients related only to the relationship between somatic cell count and the content of casein and fat.

The results concerning the relationship between the total number of microorganisms and basic chemical components of milk were very similar to those calculated for somatic cell count (Table 1). This is due to the fact that bacterial infections are the most common cause of increase in the number of somatic cells. The correlations were also positive (with the exception of relationship with the number of casein), but their strength was distinct. Statistically significant coefficients were calculated for the corelations with dry matter, total protein, casein, fat, total and soluble ash. The highest coefficients, close to 0.5, were obtained for the correlation between the total number of microorganisms and total and soluble ash.

Table 1

Correlations between the basic chemical components of Olkuska sheep's milk and somatic cell count and the total number of microorganisms

Parameter	Somatic cell count	The total number of microorganisms
Dry mass	0,022	**0,357***
Lactose	-0,193	-0,048
Total protein	0,257	**0,319***
Casein	**0,284***	**0,287***
Casein number	0,015	-0,044
Fat	**0,357***	**0,415***
Total ash	0,197	**0,464***
Soluble ash	0,208	**0,483***

* statistically significant correlation coefficient ($\alpha = 0.05$)

The results obtained in the present study regarding the content of dry matter, protein, fat and lactose are consistent with findings by BONCZAR on Poland Longwool variety rząskowska sheep milk (BONCZAR 1994). Also OLECH-

NOWICZ and STEPPA (2000) conducting research on milk of dairy sheep 05 (13/16 Friesian sheep, 3/16 Polish merino) found that milk obtained from animals with healthy glands (somatic cell count below 250000/ml) contained significantly lower amount of protein than milk of animals with inflammation. At the same time the content of lactose was higher. A statistically significant increase in protein and fat and a decrease in lactose content in the milk of infected sheep also found WÓJTOWSKI et al. (1998) and GUT et al. (1999) who examined sheep milk of three synthetic lines among others with varying degrees of participation of East friesian and Polish merino sheep. Calculated correlation coefficients between the log SCC and the percentage content of protein, fat and lactose were 0.354, 0.192 and -0.575 respectively. The increase in protein content due to the increasing number of somatic cells was also observed in milk of churra sheep (EL-SAIED et al. 1998, 1999), for which the correlation coefficient between log SCC and the percentage of protein content was 0.12 and 0.16. Results for correlation with protein content and fat are also consistent with the results of research conducted by RIGGIO et al. (2007) and ALBENZIO et al. (2002) and relating protein with findings by ALBENZIO et al. (2004) LEITNER et al. (2004) and RODRIGUEZ-NOGALES et al. (2007). A statistically significant decrease in lactose content with an increase in SCC confirmed studies by VIVAR-QUINTANA et al. (2006) carried out on milk of Assaf sheep hybrids with churra and castellana sheep. The decrease in lactose content with the increase in the number of somatic cells also corresponds to the findings by other authors, among others by SEVI et al. (1999) for Comisana sheep milk, SINAPISI et al. (2007) or LEITNER et al. (2004) and is associated with a decrease in the ability to synthesis this component in the infected udder. Sinapis et al. analyzing milk of Boutsiko ewes obtained correlation coefficient -0.19.

Similarly to cows milk, the percentage increase in protein content caused by the increasing somatic cell count may be explained by the parallel increase in blood proteins in milk of sheep with bacterial infections (EL-SAIED et al. 1998, 1999, RAYNAL-LJUTOVAC et al. 2007). Such a finding is also reported by other authors who indicate that the increase or no change in protein content in milk despite the decreasing casein content can be explained by an increase in the content of blood serum proteins which are excreted in milk through the loosened epithelial cells of infected animals (ALBENZIO et al. 2005, 2002, SEVI et al. 2001). The increase in the percentage of fat in milk with an increased SCC, whether caused by the occurrence of bacterial inflammation or secretion disorders may be explained by the effect of "dilution", as the amount of fat does not change while the amount of milk from sick animals is greatly reduced (ALBENZIO et al. 2002). Whereas the increase in ash content can be explained by increasing sodium and chloride content in milk of sheep with udder inflammation. This is due to changes in the permeability of cell membranes and the

interstitial spaces that cause the passage of these minerals from the animal's blood to the milk in order to maintain the osmotic equilibrium (BONCZAR 1994, BONCZAR et al. 1994, RAYNAL-LJUTOVAC et al. 2007).

A slight increase in casein content with deteriorating hygienic quality of milk obtained in this experiment has no confirmation in the literature. The presence of mastitis in fact leads to the reduction in the amount of components synthesized in sheep mammary gland and therefore to the decrease in the amount of secreted casein (SEVI et al. 1999, 1999a). Hence, it is likely that the relationship obtained in the experiment is accidental, especially that the correlation coefficients are low.

The influence of somatic cell count in milk on its physical characteristics was analyzed earlier by BONCZAR et al. (1994). She stated an increase in the pH of milk, its viscosity and electrical conductivity and a slight decrease in density in case of sheep udder disease states. The correlation factors, except for the density of milk (0.1), were statistically significant and were approximately 0.3. In addition, a relatively high correlation coefficient (-0.46) was observed for correlation with titratable acidity. In the present experiment the results were similar (Table 2). Statistically significant correlations were found between somatic cell count and pH (0.48), titratable acidity (-0.36), electrical conductivity (0.33) and density (-0.31). Only for viscosity the correlation coefficient was not statistically significant, although the results confirmed an increase in viscosity with increasing number of somatic cells.

Table 2

Correlations between the physical characteristics of Olkuska sheep's milk and somatic cell count and the total number of microorganisms

Parameter	Somatic cell count	The total number of microorganisms
Titratable acidity	**-0,355***	**-0,300***
pH	**0,481***	**0,640***
Density	**-0,309***	**-0,315***
Viscosity	0,127	0,139
Electrical conductivity	**0,333***	**0,431***
Freezing point	-0,083	-0,198

* statistically significant correlation coefficient (α = 0.05)

As in the case of somatic cell count increased total number of microorganisms was accompanied by an increase in pH, electrical conductivity, freezing point and viscosity and a decrease in density and titratable acidity. Statistically significant correlations were found for pH, electrical conductivity, titratable acidity and density.

The increase in pH value when somatic cell count increases was reported by RAYNAL-LJUTOVAC et al.(2007) and VIVAR-QUINTAN et al. (2006). VIVAR-QUINTAN et al. also noted lower titratable acidity of milk with somatic cell count above 3000000/ml. Also ALBENZIO et al. (2005) and SEVI et al. (1999) observed a statistically significant increase in pH value with an increase in SCC. This increase was particularly noticeable in milk containing over 1000000 of somatic cells in 1 ml compared to milk from healthy sheep (SCC < 500000/ml). Whereas WÓJTOWSKI et al. (1998) reported no significant differences in pH values of milk from healthy sheep and from those with infected udders. They found, however, impact of SCC on the freezing point. Milk from infected halves of udders was characterized by freezing point at the level of -0.5866, while from healthy at -0.5787. The correlation coefficient between log SCC and the freezing point was 0.132.

Conclusions

The study confirmed the impact of hygienic quality parameters, in particular of somatic cell count and the total number of microorganisms, on the composition and physical properties of sheep's milk. Especially in the case of the total number of microorganisms the majority of the calculated correlation coefficients was statistically significant and had higher values than the one callculated for the correlation with SCC. The deterioration of hygienic quality of Olkuska sheep milk caused an increase in the content of dry matter, total protein, casein, fat, ash, pH, viscosity, conductivity and freezing point and a decrease in lactose content, acidity and density.

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