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Hygienic quality, milk yield and basic composition of sheep milk depending on the stage of lactation

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The aim of the study was to determine the influence of the stage of lactation on the yield and quality of sheep milk. The material for the investigation was milk from morning milking of 30 East Friesian sheep in their third to fifth lactation. Milking began after the lambs were weaned and continued for about 120 days. Milk samples were collected individually from the sheep in three stages of lactation: at its peak, during the stabilized stage and at the end (late) lactation. Daily milk yield, total bacterial count, somatic cell count and the basic composition of the milk were determined. The microbiological quality of the milk was very high and the somatic cell count was favourable. As lactation progressed the somatic cell count increased while microbiological quality remained stable. At the end of lactation a significant increase was noted in the concentration of dry matter, protein and fat, accompanied by a decrease in lactose concentration, in comparison with the peak of lactation. Yield was shown to be negatively correlated with fat (–0.63; p≤0.01) and dry matter (–0.53; p≤0.01) and positively correlated with lactose (0.61; p≤0.01).

KEY WORDS: sheep milk / phase of lactation / hygienic quality / basic composition

Sheep milk is characterized by high nutritional value, as indicated by its high concentrations of basic components. As lactation progresses the content of individual components fluctuates, which unquestionably has significance for processing. Due to its rich chemical composition it is an excellent raw material for the production of soft and hard ripened cheeses, as well as fermented drinks [8]. Its basic composition and quality depend on numerous genetic and environmental factors and on the interactions between them [5, 6, 7, 8, 17]. Previous research on dairy sheep has mainly dealt with changes in milk yield over the course of lactation (the lactation curve) and their genetic determinants. However, there has been insufficient research on the effect of the stage of lactation on the quality of the milk obtained [15, 16], including its somatic cell count [4, 6]. Furthermore, information on this subject is often inconclusive.

The aim of the study was to determine the effect of the stage of lactation on the yield and quality of sheep milk.

Material and methods

The study was conducted at the Swadzim Agricultural Experimental Station (farm in Złotniki) of the Poznań University of Life Sciences. The material for the study consisted of milk collected from 30 East Friesian ewes in their third to fifth lactation. The sheep were housed indoors and fed in groups. The complete feed ration consisted of wheat meal, wheat bran, rapeseed extraction meal, and haylage. Commercial milking was begun after the lambs were weaned (about day 80 of lactation) and continued for about 120 days. The sheep were milked twice a day in a 14-stall side-by-side milking parlour with a mechanical milking machine (Polanes). Milk yield was monitored by the A4 method, applying basic principles of milking hygiene. Milking of each sheep was preceded by fore-stripping and washing of the udder and teats. Samples for microbiological cultures were collected into sterile test tubes following disinfection of the teats with 70% ethyl alcohol.

Milk samples were collected individually from each sheep during morning milking in three stages of lactation:

– peak lactation (from weaning to day 120 of lactation)
– stabilized lactation (between days 120 and 160 of lactation)
– final period of lactation (after day 160)

The refrigerated milk was transported to the laboratory for analysis. The total bacterial count, somatic cell count, and proximate composition of the milk (content of dry matter, fat, protein and lactose) were determined. The hygienic quality of the milk, i.e. the total bacterial count (TBC) and somatic cell count (SCC), was determined by flow cytometry in an IBCm apparatus (Bentley, Minnesota, USA). The proximate chemical composition of the milk was determined in a Milkoscan FT+ analyser (Foss).

Statistical analysis was performed in Statistica software v.12.5. The effect of the stage of lactation on daily milk yield and milk quality indicators was estimated by one-way analysis of variance; significance of differences was estimated by Tukey's test. Data pertaining to the total bacterial count and somatic cell count in the milk were log-transformed according to Ali and Shook [3] before statistical verification. In addition, Pearson's correlation coefficients were calculated for daily milk yield and milk components.

Results and discussion

Analysis of the quality of the milk revealed a significant ($p \leq 0.05$) increase in somatic cell count between peak yield and the end of lactation (Tab. 1). An earlier study by Bielińska [5], conducted on sheep of the 05 line, also found that the somatic cell count in milk increased as lactation progressed and the udder lengthened. The highest SCC and TBC were observed at the start of lactation and during the drying-off period. During these two periods the probability of mastitis increased. During the drying-off period sheep are milked once a day or every other day, and the risk of mastitis is highest at this time [5]. Bielińska-Nowak et al. [6] report that during the drying-off period in sheep the hygienic quality of the milk declines, as the somatic cell count (SCC) and total bacterial

count (TBC) increase. Different results were obtained by Antunac et al. [4], who demonstrated a downward trend for SCC during lactation. The authors noted the highest SCC at the start of lactation and the lowest at the end. A study by Malinowski [12] on cow milk showed that the stage of lactation did not affect the somatic cell count in the milk in the case of udders that were not infected with pathogenic bacteria, which indicates a high standard of hygiene during milking and sample collection as well as good udder health.

Table 1
The hygienic quality of sheep's milk depending on the lactation stage

Parameter	Stage of lactation					
	peak of lactation		stabilized lactation		end of lactation	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Log_{10} SCC	1.31[a]	0.53	1.55[ab]	0.64	1.72[b]	0.53
Log_{10} TBC	0.92	0.90	1.08	0.88	1.19	0.88

SCC – somatic cell count
TBC – total bacterial count
a, b – means with different superscript letters differ significantly at $p \leq 0.05$

Analysis of the microbiological quality of the milk (Tab. 1) showed no significant differences between individual stages of lactation. This may indicate that milking hygiene principles were followed on the farm and that udder health was very good [2]. The TBC in the milk was only observed to increase slightly at the end of lactation. It should be noted that no cases of mastitis were observed during control milking. The mean TBC in the milk was 55,000/cm^3 and the SCC was 123,000/cm^3, which confirms that the milk was of high hygienic quality. According to Commission Regulation (EC) no. 1662/2006, raw sheep milk containing over 500,000 bacterial per ml can be used for 'the manufacture of products made with raw milk by a process that does not involve any heat treatment'.

The milk yield of sheep depends on factors such as breed, diet, age, health condition, body weight, stage of lactation, number of lambs suckled, and how the milk is acquired [5, 7]. The present study showed a significant ($p \leq 0.01$) decrease in daily milk yield as lactation progressed (Tab. 2). Results obtained by other authors [4, 13] indicate that dairy sheep in the early period of lactation have higher daily milk yield than in the later stages.

The chemical composition of sheep milk depends in part on the age of the animal, the stage of lactation, the health condition of the udder, and the structure of the udder [5]. In the

Table 2
Milk yield and basic composition of sheep's milk depending on the lactation stage

Parameter	Stage of lactation					
	peak of lactation		stabilized lactation		end of lactation	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Daily milk yield (kg)	0.70^{A}	0.20	0.33^{B}	0.13	0.25^{B}	0.12
Dry matter (%)	15.67^{A}	0.7	16.60^{A}	1.13	21.08^{B}	2.30
Fat (%)	4.81^{A}	0.78	6.14^{B}	0.73	8.82^{C}	1.28
Protein (%)	5.49^{A}	0.34	5.11^{A}	0.52	6.96^{B}	1.14
Lactose (%)	4.66^{A}	0.02	4.65^{A}	0.02	4.59^{B}	0.03

A, B – means with different superscript letters differ significantly at $p \leq 0.01$

milk analysed the mean content of dry matter was 17.33%, protein 5.68%, fat 6.30% and lactose 4.64%. The content of dry matter, fat and protein increased significantly ($p \leq 0.01$) with the course of lactation. These results are confirmed in an earlier study by Bielińska [5], which showed the lowest percentage of basic components of sheep milk at peak lactation, while daily milk yield was highest. The results of other studies [1, 11, 18] confirm that milk yield in sheep decreases while the concentration of basic components increases during commercial milking. Similarly, Konieczny [10] observed significant differences in the content of dry matter in milk between the start and finish of lactation. Niżnikowski et al. [14] report that dry matter in milk decreased as milk yield increased in East Friesian sheep. Bielińska-Nowak et al. [7] observed the highest content of dry matter in the last month of commercial milking.

It should be noted that among the milk components analysed the greatest increase—nearly two-fold—was noted for fat content (Tab. 2). These results are consistent with those obtained by other authors [5, 9, 11, 18, 22]. A study by Mikolayunas et al. [13] found no significant effect of the stage of lactation on the fat content of milk, but in the final period of lactation the concentration of this component was somewhat higher than in the initial period. The authors state that that this was probably due to different numbers of sheep in the groups.

The present study showed a significant ($p \leq 0.01$) increase in protein content in the milk at the end of lactation. An increase in the concentration of this component in sheep milk as lactation progressed has also been noted by Pavic et al. [18], Sahan and Say [20], Bielińska [5] and Mikolayunas et al. [13].

The reverse tendency was noted in the case of lactose content in the milk, with a significant ($p \leq 0.01$) decrease observed in the third stage of lactation. Pugliese et al. [19] also

Table 3
Phenotypic correlation between milk yield and composition of sheep's milk

Parameter	Daily milk yield (kg)	Fat (%)	Protein (%)	Dry matter (%)
Protein (%)	–0.27	0.72**	–	–
Dry matter (%)	–0.53**	0.96**	0.88**	–
Lactose (%)	0.61**	–0.74**	–0.69**	–0.77**
Fat (%)	–0.63**	–	–	–

**Correlations at $p \leq 0.01$

observed a reduction in lactose content in the milk of Suffolk sheep over the course of lactation. Yilmaz et al. [22], however, found no significant effect of the stage of lactation on lactose content in the milk of sheep raised in extensive conditions.

The link between the yield and chemical composition of sheep milk is well known [19, 21]. In the present study (Tab. 3), yield was found to be negatively correlated with the concentration of fat (–0.63; $p \leq 0.01$) and dry matter (–0.53; $p \leq 0.01$) and positively correlated with lactose content (0.61; $p \leq 0.01$). Previous research [5] showed that milk yield in sheep may be positively correlated with udder and teat size. Furthermore (Tab. 3), positive correlation coefficients were found between content of dry matter and fat (0.96; $p \leq 0.01$), dry matter and protein (0.88; $p \leq 0.01$), and protein and fat (0.72; $p \leq 0.01$), and negative correlation coefficients between the content of lactose and dry matter (–0.77; $p \leq 0.01$) and lactose and fat (–0.74; $p \leq 0.01$). The values obtained are somewhat higher than in a study by Yilmaz et al. [22] conducted on the milk of Red Karaman sheep in Turkey.

To sum up, the milk of East Friesian sheep was found to be of high quality in terms of bacterial count and somatic cell count. The somatic cell count of the milk increased with the course of lactation, while the total bacterial count did not undergo significant changes. At the end of lactation a significant increase was noted in the concentration of dry matter, protein, and fat, and a decrease in lactose, in comparison with peak lactation. Daily milk yield and the concentration of individual milk components were closely correlated.

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