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CHANGES IN BASIC MILK COMPONENTS, PROPERTIES OF MILK AND RENNET CURDLING DUALITY DURING LACTATION OF EAST FRIESIAN EWES

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Abstract

The evaluation of the changes in basic milk components, properties of milk and rennet curdling quality during lactation was carried out over the period of three succesive years using milk samples obtained from a total of 27 ewes of the East Friesian breed, reared on a small sheep farm in the Wallachian region**.** The contents of all basic milk components (total solids (TS), fat (F), protein (P) and lactose (L)) were significantly affected by the stage of lactation, whilst the contents of TS, F and P increased gradually with the advancement of lactation. The lactose content in the course of lactation was relatively the most constant of all milk components, confirming its role as an osmotic regulator and a compensator for variations in all other components. On the other hand the daily milk yield gradually decreased depending on the stage of the lactation. The stage of lactation had also a highly significant effect both on all milk properties (pH, titrable acidity (TA) and rennet clotting time (RCT)) under study and on rennet curdling quality (RCQ). The pH of milk gradually decreased between the 33rd and 129th day of lactation. However thereafter the pH rose gradually until the end of lactation. In comparison with pH values, the values of TA had an opposite tendency. The RCT ranged from 78 to 123 s and the longest RCTs were found on the 33rd and 67th day of the lactation. On the other hand the shortest RCTs were found in the middle of lactation.

The RCQ was relatively good and uniform in the course of lactation. However the worst RCQ was found in the first sampling. On the other hand, the best RCQ was found in the middle of lactation. To conclude the above mentioned, it should be added that the change of feeding ration between the first and second sampling did not have a significant effect on the contents of F, L and on DMY. This change also did not have a significant effect either on all milk properties under study or the RCQ.

Keywords: milk composition, milk properties, quality of rennet curdling, ewe, East Friesian

Introduction

The composition of sheep milk and its production during lactation is influenced by a lot of different factors, whilst the most important factors are the breed, nutrition, health state, the environment and the number and stage of lactation. The effect of the stage of lactation on milk composition in different sheep breeds have been observed by Maria and *Gabina* (1993), *Èapistrák et al.* (1995), *Fuertes et al.* (1998) and *Antunoviè et al.* (2001).

Unlike cows milk, sheep milk is used, due to its specific composition, almost exclusively for the production of cheese so that its quality is based not only on its nutrient content but also on its renneting ability. The rennet clotting properties (RCP) in sheep milk are important in cheese manufacture and in the sensorial characteristics of the product obtained (Calvo, 2001). The RCPs in sheep milk are influenced by a large number of factors, while the most important factors are the composition of milk, pH, titrable acidity, somatic cell count, quality of rennet and the environment. The evolution of the pH and renneting properties of the milk in Massese ewes during lactation has been observed by *Pugliese et al.* (2000).

Generally it is possible to state that Czech production of sheep cheese is very low and is ranked among lowest in EU. On the other hand, especially due to the relatively good economics of this production and the growth of consumer demand for sheep cheese, the domestic production of sheep cheese is expected to rise slightly in future. The most important dairy sheep breed in the Czech Republic is the East Friesian breed (EF). Nevertheless, its proportion in the total number of sheep is only ca. 2.6 % (*Holá*, 2005). A significant part of EF sheep in the Czech Republic is reared as purebred. However, rams of this breed are very often used in improvement crossing with ewes of Improved Wallachian breed.

The objective of this study was to evaluate the changes in basic milk components, properties of milk and rennet curdling quality during lactation of East Friesian ewes. Attention was also paid to assess the effect of the lactation stage on daily milk yield (DMY).

Materials and Methods

The evaluation of the changes in basic milk components, properties of milk and rennet curdling quality in the course of lactation was carried out over the period of three succesive years using milk samples obtained from a total of 27 ewes of the EF breed, reared on a small sheep farm in the Wallachian region. The age of ewes varied from 2 to 7 years. In all years under study, lambing occurred indoors during March. After lambing, the ewes with lambs were reared indoors until the end of April. In all years under study, the weaning of lambs was carried out during the last ten days of April. In the period from the lambing until the end of April, the daily feeding ration of ewes consisted of 1 kg fodder beet, 0.5 kg of concentrate mixture (50% barley and 50% wheat), meadow hay (*ad libitum*) and mineral lick (*ad libitum*). From the beginning of May until the end of lactation, the main part of the daily feed ration of ewes was ad libitum grazing on the permanent pasture, supplemented with 1kg of meadow hay, mineral lick (*ad libitum*) and 0.25 kg of the aforementioned concentrate mixture. During the whole period under study, all ewes were reared in one group under identical conditions and without any principal differences in nutrition and management. All ewes were in well body condition and clinically healthy (including udders).

Milk records and samplings were carried out six times each year under study whereas the first milk record and sampling was carried out on the average 33rd day of lactation. The following milk records and samplings were carried out on the average 67th, 95th, 129th, 158th and 191st day of lactation. Ewes were milked by hand twice a day and their milking was finished on the average 216th day of lactation. Milk records and sampling were carried out during the morning (7 a.m.) milking. Milk yield was also recorded during the evening (7 p.m.) milking. In the period up to the weaning of lambs, before each milk record and sampling, the lambs were separated from their mothers 12 hours prior to the morning milking. After the evening milk recording, the lambs were allowed to back their mothers.

Milk samples were not conserved, but after milking, all samples were cooled to 5 to 8^0C and transported in a thermo-box to a specialised milk laboratory at the Mendel University of Agriculture and Forestry in Brno. Analyses always started within 4 hours of sampling. As part of the laboratory analysis, the following milk components were determined: total solids (TS), fat (F), protein (P) and lactose (L). The following milk properties were determined: pH, titrable acidity (TA) and rennet clotting time (RCT). The evaluation of the rennet curdling quality (RCQ) and daily milk yield (DMY) in the course of lactation was also an integral part of this study. The laboratory analysis concerning TS, F, P, L, pH and TA were carried out by standard laboratory methods.

The rennet clotting time (RCT) was the time period (in seconds) between the application of 2ml of the rennet solution to 100ml of the milk which was tempered at 35 ^{0}C and the aggregation of milk. The rennet solution was obtained by diluting 5ml of Fromase®750 TL (DSM Food Specialties, Netherlands) to 95ml of distilled water. Fromase®750 TL is a liquid microbial coagulant preparation derived from a selected strain of Rhizomucor miehe. The renneted milk was placed for 1 hour in a thermostat at 35^{o}C. Next, the curd was tipped out into Petri dish and the RCQ was evaluated by a score description according to the appearance and firmness of the curd and the appearance of the whey (*Table 1*). The DMY was determined by weighing. Weighing were carried out to the nearest 0.1 kg.

***Table 1*. Evaluation of RCQ**

Category	Appearance and firmness of curd and appearance of whey.
1	Curd very good and hard, keeping its shape after its removal from the container. Whey is clear, of yellow-greenish colour.
2	Curd good but a little softer, not keeping its shape quite perfectly. Excretion of whey not perfect. Whey is greenish.
3	Curd not good, soft, partly not keeping its shape. Whey milky white.
4	Curd very bad, not keeping its shape. Whey milky white.
5	Flocculation of casein very weak or not visible.

Data were subjected to a four-way analysis of variance (ANOVA) using the SAS for Windows v. 9.1 (SAS Institute, 2005) statistical package. The mathematical model used was $Y_{ijkl} = \mu + R_i + L_j + S_k + T_l + e_{ijkl}$ where μ was the overall mean, R_i the fixef effect of year of the study (i = 1, 2 and 3), L_j the fixed effect of order of lactation (j = 1 … 6), S_k the fixed effect of litter size (k = 1 and 2), T_l the fixed effect of sampling time (l = 1 … 6) and e_{ijkl} the random residual error. Statistical significant effects were further analyzed and means were compared using Sheffe's multiple range test. The null hypothesis was tested that means for each dependent variable did not differ between the six sampling times.

Results and Discussion

The contents of all basic milk components were significantly affected by the stage of lactation (*Table 2*), whilst the contents of TS, F and P increased gradually with the advancement of lactation.

***Table 2*. The changes of basic milk components and daily milk yield during lactation**

Characteristic		Day of lactation						F - test
		33	67	95	129	158	191	
Total solids (%)	Mean	15.59 ^{A}	16.41 ^{B}	17.42 ^{C}	18.10 ^{C}	19.04 ^{D}	20.68 ^{E}	162.13 **
	S.E.	0.22	0.13	0.23	0.12	0.11	0.15	
Fat (%)	Mean	4.96 ^{A}	5.19 ^{A}	6.07 ^{B}	6.71^{C}	6.97 ^{C}	7.80 ^{D}	125.30 **
	S.E.	0.14	0.11	0.15	0.08	0.09	0.09	
Protein (%)	Mean	4.69 ^{A}	5.23 ^{aB}	5.55 ^{bBC}	5.90 ^{C}	6.28 ^{D}	6.66 ^{E}	121.44 **
	S.E.	0.08	0.07	0.09	0.06	0.05	0.10	
Lactose (%)	Mean	4.87 ^{AC}	4.98 ^{AC}	4.79 ^{AC}	4.43 ^{aB}	4.68 ^{bBC}	5.00 ^{A}	15.80 **
	S.E.	0.06	0.03	0.05	0.05	0.05	0.08	
Daily milk yield (kg)	Mean	1.19 ^{A}	1.16 ^{aA}	1.01 ^{bA}	0.82 ^{cB}	0.64 ^{dB}	0.42 ^{C}	91.48 **
	S.E.	0.04	0.04	0.04	0.03	0.03	0.02	

The values in the same line marked with different letters (a – d) and (A – E) differ significantly (P ? 0.05) and highly significantly (P ? 0.01), respectively; **=P<0.01

The above-mentioned tendency is in line with the results published by *Casoli et al.* (1989), *Gonzalo et al.* (1994), *Fuertes et al.* (1998) and *Ploumi et al.* (1998). However Hassan (1995) reported that during the first 2–5 weeks of lactation the contents of TS, F and P decreased as a results of the increased DMY in this period. The contents of TS, F and P increased depending on the day of lactation from 15.59% to 20.68%, from 4.96% to 7.80%, and from 4.69% to 6.66% respectively, while data is comparable to that published by *Jandal* (1996) and *Sahan et al.* (2005). On the other hand, *Hassan* (1995) reported markedly higher contents of TS and F at the end of the lactation. DMY gradually decreased depending on the stage of the lactation, which is in line with the results published by *Hassan* (1995) and *Ochoa-Cordero et al.* (2002). The lactose content in the course of lactation was relatively the most constant of all milk components, confirming its role as an osmotic regulator and a compensator for variations in all other components. The highest contents of lactose were found on the 33rd and the 67th day of lactation and at the end of the lactation. On the contrary, its lowest content was found on the 129th day of lactation. This tendency is in line with the results published by *Ochoa-Cordero et al.* (2002). On the other hand, *Pavič et al.* (2002) reported a highest L content at the begining of lactation and the lowest at the end of lactation.

The lactation stage had a highly significant (P ? 0.01) effect both on all milk properties under study and on RCQ (*Table 3*).

***Table 3*. The changes of basic milk properties and rennet curdling quality during lactation**

Characteristic		Day of lactation						F – test
		33	67	95	129	158	191	
pH	Mean	6.65 ^{AB}	6.61 ^{AB}	6.51 ^{B}	6.26 ^{C}	6.62 ^{AB}	6.76 ^{A}	24.63 **
	S.E.	0.02	0.02	0.02	0.06	0.03	0.04	
Titr. acidity (^{0} SH)	Mean	7.24 ^{A}	8.33 ^{AD}	9.80 ^{B}	11.88 ^{C}	9.44 ^{BD}	8.93 ^{BD}	38.82 **
	S.E.	0.21	0.13	0.25	0.12	0.11	0.15	
Rennet clotting time (s)	Mean	113 ^{AB}	123 ^{A}	78 ^{B}	78 ^{B}	112 ^{AB}	107 ^{AB}	6.12 **
	S.E.	8.55	5.54	6.99	7.31	8.98	9.46	
Rennet curdlig quality	Mean	1.93 ^{a}	1.70 ^{ab}	1.41 ^{ab}	1.26 ^{b}	1.82 ^{ab}	1.63 ^{ab}	3.89 **
	S.E.	0.16	0.13	0.11	0.10	0.13	0.12	

The values in the same line marked with different letters (a, b) and (A – D) differ significantly (P ? 0.05) and highly significantly (P ? 0.01), respectively; **=P<0.01

The pH of milk is influenced by hygienic and climatic conditions and for sheeps milk there is typically a slightly higher acidity in comparison with cows milk (*Pavièt et al.,* 2002). *Martini and Caroli* (2003) reported that the pH of milk is significantly influenced by the breed of sheep. In our study, the pH of milk gradually decreased between the 33rd and 129th day of lactation. However thereafter the pH rose gradually until the end of lactation. A similar tendency and values of pH were reported by *Pugliese et al.* (2000). In comparison with pH values, the values of TA had an opposite tendency. This means that its value gradually increased until the 129th day of lactation and thereafter the TA fell gradually until the end of lactation. On the other hand, *Boroš et al.* (1985) and *Jelínek et al.* (1990) reported that TA values of ewes milk gradually increased during lactation, whereas *Sahan et al.* (2005) reported that the TA of milk in Awassi ewes decreased during lactation, and reached its lowest values in the final week of lactation.

Sheeps milk contains more F, SNF, P, CN, whey proteins and total ash compared to goats and cows milk and these differences make the rennet clotting time (RCT) for sheep milk shorter (*Jandal,* 1996). *Martini and Caroli* (2003) reported that the RCT of sheeps milk is affected by the breed of sheep due to the differences in pH values of milk among breeds. The rennet clotting time (RCT) ranged from 78 to 123 s and the longest RCTs were found on the 33rd and 67th day of the lactation. On the other hand the shortest RCTs were found in the middle of lactation. The RCTs were relatively stable at the end of lactation and ranged from 112 to 107 s. A similar tendency was reported by *Pugliese et al.* (2000). On the other hand, *Jelínek et al.* (1990) reported that from the 90th day of lactation the RCT of milk in Cigaia ewes gradually decreased till the end of lactation. The rennet curdling quality (RCQ) was relatively good and uniform in the course of lactation. However the worst RCQ was found in the first sampling. On the other hand, the best RCQ was found in the middle of lactation (95th and 129th day).

To conclude the above mentioned, it should be added that the change of feeding ration between the first and second sampling did not have a significant effect on the contents of F, L and on DMY. This change also did not have a significant effect either on all milk properties under study or the RCQ.

Conclusions

The contents of all basic milk components were significantly affected by the lactation stage, whilst the contents of TS, F and P increased gradually with the advancement of lactation. The stage of lactation also had a higly significant effect both on all milk properties under study and on the RCQ. The worst RCQ was found in the first sampling. On the other hand, the best RCQ was found in the middle of lactation.

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