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EFFECT OF RAPESEED AND LINSEED IN SHEEP NUTRITION ON DIURNAL CHANGES IN THE CHEMICAL COMPOSITION OF MILK

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The main reasons for adding large amounts of plant fats to the diets of intensively bred female ruminants are improvements in the energy balance of rations during the critical periods of advanced pregnancy and feeding the young and improvements in rearing efficiency of progeny thanks to increased milk yield and better milk composition. Reasonable feeding of different forms of plant fats is considered one of the most efficient methods in this respect (Bencini and Pulina 1997; Brzóska 2001; Szumacher-Strabel 2005), but the complexity of digestive processes in ruminants and the multitude of factors involved warrant further investigation in this area.
The aim of the present study was to determine the effect of feeding rapeseed and linseed to lambs during high pregnancy and suckling periods on the basic chemical composition of sheep's milk determined at 6-hour intervals during day and night.

Material and methods

A total of 12 suckling Kołuda ewes of prolific and milk variety were studied during the 5th week of lactation. Sheep were kept indoors in groups and fed in accordance with the Nutrient Requirements of Cattle, Sheep and Goats (Normy Żywienia Bydła, Owiec i Kóz 2001). The components of the ewe diets used from the 3rd week of lactation and their nutritive value are given in Table 1. The level of experimental feeding to 5 months of pregnancy was consistent with physiological condition and litter size. Treatment was the composition of concentrate mixture. Animals received a standard diet in the control group (C) and a whole rapeseed and linseed diet (100 and 50 g/animal/day, respectively) in the experimental group (RL) (Table 1).
The entire daily ration was given to sheep at one feeding at 7 am. After eating the entire concentrate mixture, sheep were given the other feeds.
The basic chemical composition of milk produced by the analysed ewes was studied in 4 series at 6, 12, 18 and 24 hours postprandial. Lambs were allowed to suckle their mothers for 15 min per hour before every sampling of milk for analysis. The samples were taken from both udder halves of each ewe.
The basic composition of milk (solids, protein, fat and lactose) was analysed using a MilkoScan 133B analyser.
The results were analysed statistically using the ANOVA procedure of the Statistica 6PL packet for factorial designs: a two-factorial design (ewe feeding and series of observations) with interactions (STATISTICA - Przewodnik, 2000). Significant differences between the series were estimated using Duncan's multiple range test.

Results and discussion

Diet composition and level of intake

Table 1 gives the composition of concentrate mixtures, the daily intake and nutritive value of diets and the concentration of some chemical components. When using the rapeseed and linseed proportions formulated for the RL diet, the feeds consumed in the groups of ewes compared were highly similar in terms of nutritive value expressed as UFL, PDI and SFU. The proportion of oilseeds in the RL concentrate diet did not affect the intake of this diet (100% in both groups) or the intake of the whole feed combinations (almost 100%).

Adding oilseeds to concentrate mixtures resulted in a significant increase in the fat content of the feeds used in the experimental group. Compared to the control group (C), the feed used in the RL group had almost twice more fat (by 95.0%) and slightly more protein (by 7.1%) on a dry matter basis (Table 1).

Table 1. Composition and nutritive value of compounded diets

Item	Compounded diet/Feeding group	
	C	RL
Dry mash composition (%):		
- crushed wheat	41,7	
- wheat middlings	27,7	34,7
- rapeseed meal	27,7	41,6
- double-low rapeseed	-	14,0
- linseed	-	7,0
- MM	2,1	2,0
- fodder chalk	0,8	0,7
Daily feed consumption (kg):		
- grass and lucerne forage	3,77	3,72
- sugar beet pulp silage	2,88	2,89
- grass hay	0,70	0,70
- dry mash	0,72	0,72
Nutritive value of consumption diet:		
UFL	2,27	2,26
PDIE; g	225,6	220,0
PDIN; g	213,1	235,4
SFU	2,47	2,47
Chemical components of diets:		
- dry matter [DM]; g/100g	90,9	90,4
- protein; g/100 g DM	12,7	13,6
- fat; g/100 g DM	2,4	4,7

Compounded diets: C - control, RL - experimental

Changes in the chemical composition of the RL feed compared to the control feed (C), characterized mainly by a marked increase in fat concentration, were similar to those found in other studies in this area (Borys and Mroczkowski 2002; Barciński et al. 2003). The amount of rapeseed and linseed added to the RL diet resulted in the level of fat in the experimental feed (4.7% in DM) not exceeding the maximum reference level for ruminants (5-6% in SM), which is necessary for the normal course of forestomach digestion (Strzetelski and Zymon 2004).

Effect of feeding rapeseed and linseed diets on the concentration of milk components

Feeding rapeseed and linseed to suckling ewes resulted in significant differences in the concentration of all of the basic milk components (Table 2). The greatest changes were observed in fat content. The milk of ewes from the RL group contained 23.7% more fat than the milk of the control ewes (C). A reverse trend occurred for protein and lactose, the content of which was lower in the milk of RL ewes by 7.3 and 3.0%, respectively, compared to the C group (both differences significant at P≤0.01). The concentration of solids, however, was higher in the milk of RL ewes, with a statistically significant difference of 5.5% in relation to group C (P≤0.01).

Table 2. Essential chemical components of milk*; g/100 g

Trait	Feeding		Time after feeding [h] - Series of observation				SEM
	C	RL	6	12	18	24	
No. of observations	24	24	12	12	12	12	
In milk:							
- dry matter	16,18A	17,07A	16,57	16,60	16,43	16,92	0,132
- protein	4,53A	4,20A	4,54	4,24	4,29	4,39	0,055
- fat	5,58A	6,90A	5,97	6,30	6,08	6,62	0,143
- lactose	5,40A	5,24A	5,36	5,37	5,36	5,20	0,027
In milk dry matter:							
- protein	28,01A	24,63A	27,45	25,68	26,15	26,00	0,372
- fat	34,40A	40,31A	35,83	37,65	36,88	39,06	0,624
- lactose	34,46A	30,76A	32,43C	32,50B	32,72A	30,79ABC	0,308

C - control group, RL - experimental group [with rapeseed and linseed]
AA, BB, CC - P≤0,01; * - interactions feeding x series statistically insignificant
SEM - standard error of means

Changes in the concentration of basic chemical components of milk solids followed a similar pattern. Feeding rapeseed and linseed caused a significant increase in the concentration of fat by 17.2% and a decrease in the concentration of protein and lactose by 12.1 and 10.7%, respectively (all differences significant at P≤0.01).
The parameters in the feeding groups compared were generally similar (with variation coefficients of less than 10% except for fat content), although there was a tendency towards a favourable effect of feeding oilseeds on the level of variation (Table 2).
The effect of feeding rapeseed and linseed to sheep on the basic composition of milk is confirmed by the earlier findings (Borys and Mroczkowski 2002). In our other studies with the same oilseed supplements (Borys et al. 2005a), the only marked effect was found for fat content only (a 48.3% increase). The use of rapeseed alone at 150 g/day/animal (Borys et al. 2005b) increased the solids, protein and fat content of milk by 3.4, 4.4 and 7.7%, respectively. Marciński et al. (2003), who used linseed only (80 g/day/animal), did not obtain large differences in the basic chemical composition of milk.

Effect of time after feeding on the concentration of milk components
Time after feeding (series of observations) had no significant effect on the concentration of basic chemical components in sheep's milk. Maximum differences between the series of observations were the smallest for solids (3.0%) and lactose (3.3%) and the largest for protein (7.1%) and fat (10.9%) (Table 2).
Differences between series of observations for the concentration of basic milk components in terms of solids were of a similar nature. Maximum fluctuations in the concentration of fat in milk solids were similar to those in milk fat concentration (9.0%). Fluctuations in the concentration of protein and lactose in milk solids were twice those in milk (6.9 and 6.3%,

respectively). Differences in lactose concentration between the “24” series (for milk obtained 24 h after feeding) and the other series proved statistically significant at $P \leq 0.01$. The lack of significant differences for fat content, despite the fact that the differences for this component were the greatest between series of observations, was due to the highest variation of milk fat content (coefficients of variation v ranging from 11 to 20%).
There were some characteristic differences in the concentration of milk components in the successive series of observations according to the use of dietary rapeseed and linseed (Figures 1 and 2). Curves for changes in milk solids and fat followed a similar pattern, which was different from similar curves for protein and lactose content. The nature of differences between the curves for groups C and RL was similar for these pairs of milk components.
The concentration of solids and fat in the milk of the control ewes at 6, 12 and 18 h postprandial remained at a similar level but increased 24 h after feeding (by 4.9% for solids and by 11.5% for fat). The concentration of fat in milk solids increased linearly in the successive series of observations, with a difference of 13.4% between the milk from the extreme series of observations (6 and 24 h after feeding). In the milk of ewes from the experimental group (RL), variations in these components and fat concentration in milk solids were small during the entire 24 h after feeding.
With the differences in the protein and lactose content of ewes’ milk according to the type of feeding (a significant decrease in the RL group receiving rapeseed and linseed), the curves illustrating the amount of protein and lactose in milk in successive series of observations followed a similar pattern in both groups. The lowest protein content of milk and protein concentration in milk solids were characteristic of the milk at 6 h after feeding. During the next hours, they were similar but lower. The lactose content of milk and lactose concentration in milk solids remained more or less the same in the successive series of observations (differences up to 3-4%). One exception was a marked decrease (by 7.4%) in the concentration of lactose in milk solids in the control group between 18 and 24 h after feeding.
Some authors (Haenlein 1996) consider diurnal variation in the composition of ruminant milk as a natural phenomenon related to physiologically determined changes in the level of milk synthesis in the mammary gland. In the Churra dairy breed, Fuertes et al. (1998) found clear differences between milk from morning and afternoon milkings in the concentration of fat and solids (higher in afternoon milk by 37.9 and 11.3, respectively), with a similar protein and lactose concentration. However, other authors reported only small differences in the amount and composition of milk produced by ruminants during 24 h (Cardellino and Benson 2002; Hervieu et al. 1993; Litwińczuk et al. 2004; Niżnikowski 1998). Bencini and Pulina (1997), based on a review of several studies in this area, concluded that in sheep selected for a long time for milk there is no diurnal variation in milk amount and composition, whereas sheep not selected for milk show greater variation in this respect.
The lack of directly comparable data in the available literature prevents a more detailed discussion of the results obtained. However, comparison of the present results with those of Fuertes et al. (1998) shows some differences, especially in fat and solids, the concentration of which in the milk from evening milkings was markedly higher than that of milk from morning milkings. Meanwhile, studies by Merin et al. (1988) and Simos et al. (1991) (after Haenlein 1996) with goats revealed, similar to the present study, that compared to the milk from evening milkings, the milk from morning milkings had a higher concentration of solids, protein and fat. This corresponds to the results obtained in our study for milk composition at 24 h (morning) and 12 h (evening) postprandial (Figure 1).
Feeding sheep with rapeseed and linseed (RL group) did not change these relationships in terms of protein and lactose concentration, but altered them markedly for the concentration of fat and solids. With a higher concentration of these two components in the milk of RL than C ewes, their concentration in morning milk (“24” series) was lower than in evening milk (“12”

series) (Figures 1C and 2B). It is believed that the markedly highest fat content of milk from rapeseed- and linseed-fed ewes, produced 12 h after feeding, results from the fact that after this time, a much greater amount of fat components is digested and the transfer of absorbed fatty acids into milk reaches the diurnal maximum (Brzóska 2001).

Conclusions

Feeding rapeseed and linseed to suckling ewes had a significant effect on the concentration of basic chemical components of milk (an increase in solids and fat and a decrease in protein and lactose). Time after feeding had no significant effect on the concentration of basic chemical components in milk, with slight fluctuations in the concentration of solids and lactose (at 3%) and much greater fluctuations for protein (7%) and fat (11%). Feeding rapeseed and linseed had no effect on diurnal changes in the protein and lactose content of sheep's milk as measured at 6-hour intervals. More distinct differences were found for solids and especially for fat. Milk obtained 12 h postprandial had the highest concentration of these two components. The results obtained are considered preliminary and have to be validated in further studies using more animals.

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Figure 1. Milk's components; g/100 g

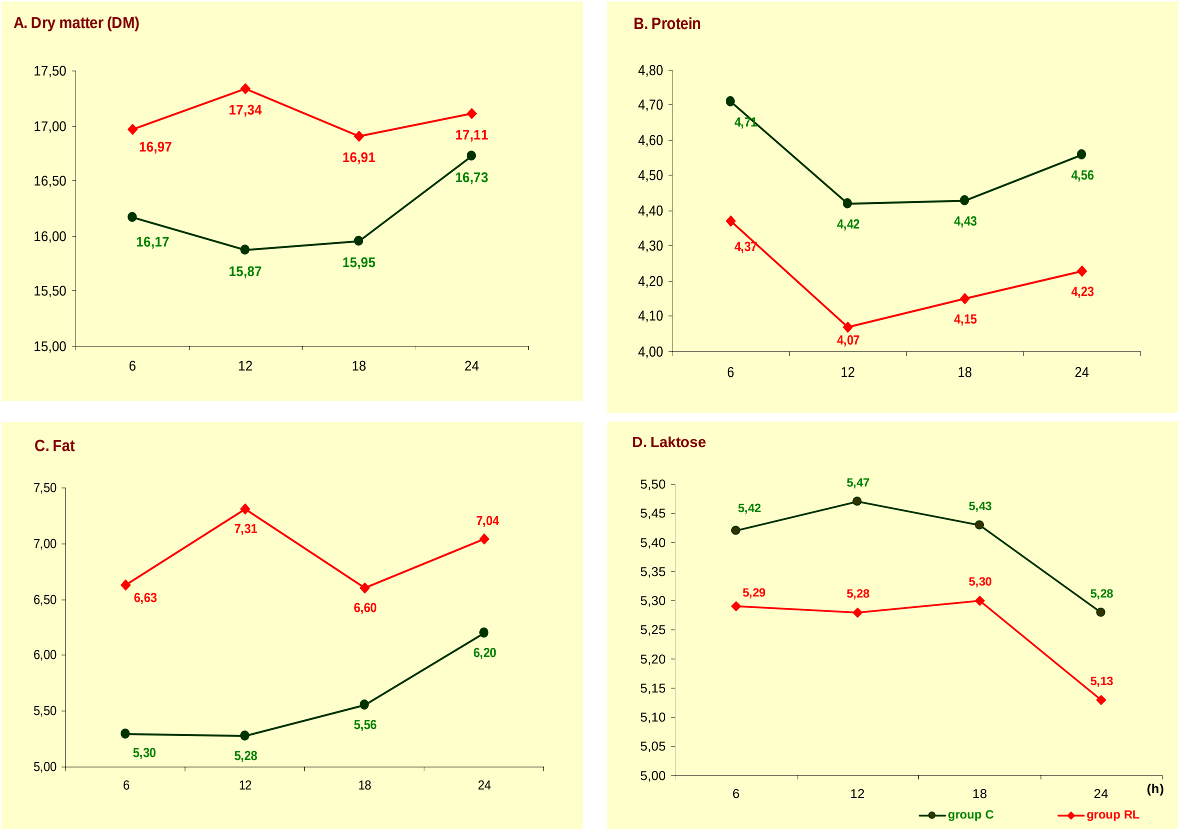

Figure 2. Components in milk DM; g/100 g