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Effects of supplemental fat for high yielding dairy cows at first stage of lactation on milk yield and composition

T. Szulc[1], J. Preś[2] and A. Dobicki[1]

Agricultural University of Wrocław
[1] Department of Cattle Breeding and Milk Production
Kożuchowska 7, 51-631 Wrocław, Poland
[2] Department of Animal Nutrition and Feed Management
Norwida 25/27, 50-375 Wrocław, Poland

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ABSTRACT

The following supplements were used in the feeding of high yielding dairy cows starting 3 weeks before calving to day 100 of lactation: a fat supplement in the form of calcium-magnesium soaps, Erafet, (group I), Erafet plus rapeseed meal (group II), rapeseed cake containing 19.5% crude fat (group III). During the first three months of lactation, a increase in the daily FCM yield was noted in the experimental groups as compared with the control group with no supplements, i.e. by 4.6, 11.6 and 8.5 %, respectively in groups I-III. After withdrawing supplementation, during the subsequent four months of lactation, the cows in the experimental groups produced 1.7, 3.3 and 4.1% more milk, respectively, than the controls. The milk fat from experimental cows contained significantly more oleic (by 7.5 to 10.0%) and stearic acids (from 5.9 to 25.1%) and less C4-C16 acids.

KEY WORDS: dairy cows, fat supplementation, colostrum

INTRODUCTION

Energy deficiencies in high yielding cows are difficult to balance by using conventional feeds, and excessively increased concentrate rations lead to digestive disorders. It therefore becomes necessary to use high energy supplements, e.g. in the form of fat additives (Abel et al., 1993; Bielak et al., 1993; Stern et al., 1994; Tomlinson et al., 1994; Wu and Huber, 1994). The addition of fat does, however, cause a fall in the number of protozoa and cellulolytic

bacteria, although the overall bacterial count of the rumen rises, it also decreases the milk protein content (Klusmeyer et al., 1991; Ohajuruka et al., 1991; Brinkmann and Abel, 1992; Zawadzki, 1993; Stern et al., 1994) and a decrease in fibre digestibility (Kowalczyk et al., 1977; Oharujuka et al., 1991; Abel et al, 1993). A rise in the levels of stearic and oleic acids has been found in the milk of cows receiving fat supplements (Lebzien et al., 1992; Rohr et al., 1993; Strzetelski et al., 1993).

Most authors who introduced fat supplements into the diets for high yielding dairy cows obtained an increase in milk yield and fat content accompanied by a fall in the protein content of the milk (Bielak et al., 1993; Kraszewski et al., 1993; Sklan et al., 1994; Rahnema et al., 1994; Wu and Huber, 1994). Numerous studies have shown that added fat is most effectively utilized by ruminants when it is in the form of calcium and magnesium soaps (Burgstaller and Klein, 1989; Hermansen, 1989; Brinkmann and Abel, 1992). Their advantages are stability at storage, ease in mixing with feeds, high digestibility in the small intestine, they have no effect on volatile fatty acid composition in the rumen and improve the health and milk yield of cows.

The objective of this study was to examine changes in milk production and in colostrum and milk composition as the result of supplementing diets of high yielding dairy cows with animal or vegetable fats starting from 3 weeks before calving to 100 days after.

MATERIAL AND METHODS

The study was conducted on 73 cows with a milk yield of about 6000 kg assigned successively on the basis of analogues (from October to December) to 4 groups numbering 17-19 animals, accounting for number of lactations and milk yield during the previous 305-day lactation.

The experiment was carried out during winter feeding according to DLG standards (1986). The rations were based on maize silage (23.2% dry matter (DM), 1.34 MJ NEL, 25.9 crude protein), silage from wilted grass (44.2% DM, 2.37 MJ NEL, 59 g crude protein), distillers' grains (8.6% DM, 0.49 MJ NEL, 36 g protein), meadow hay (4.0 MJ NEL, 82 g crude protein) and barley straw (3.5 MJ NEL, 33 g crude protein). The ration of bulk feed was equivalent to 10.2 kg dry matter with a 30.0% crude fibre content. Including concentrate, the cows received an average of 16.5 kg DM with a 22.9% crude fibre content. The concentrate mixture (7.2 MJ NEL and 171 g crude protein) was offered to the cows in amount of 0.25 kg per liter of milk produced (Table 1). The bulk feed ration was provided for groups, while the concentrate mixture and fat supplement, individually.

TABLE 1

Design of experiment

Indices	GROUPS			
	I	II	III	IV
Number of cows	17	19	18	19
Concentrate for milk production, kg/day	0.35	0.35	1.5	–
Nutritive value of ration				
– energy, MJ NEL	112.5	119.5	118.1	103.8
– crude protein, g	2646	3052	3145	2592
Mean per 1 kg milk				
– energy, MJ NEL	3.07	3.15	3.18	2.89
– crude protein, g	86.7	96.5	102.8	88.5

The supplements were given twice daily starting 21 days before calving to 100 days after. Cows in groups I and II were given calcium-magnesium soaps contained in the Erafet preparation produced by INNFOSS in Plewiska near Poznań. Its composition is as follows in % DM: 92.36 protein, 10.14 ash, 80.30 crude fat; in group III, oil in rapeseed cakes (pressed at a temperature of about 80^0C) containing 19.15% crude fat. In order to bring the level of protein up to that in rapeseed cake, cows in group II were given rapeseed oilmeal. The cows received the following supplements in groups: I-350 g Erafet; II-350 g Erafet plus 1.1 kg rapeseed oilmeal; III-1.5 kg rapeseed cake; IV control group, no supplements. Fifty percent smaller supplements were given before calving.

Over a period of 7 successive months, i.e. during fat supplementation and the next 4 months, milk production was measured once per month, and the milk was analyzed for fat, protein, lactose and dry matter content using a Milco Scan ASN Foos Elektric 133 B apparatus. The specific weight of the milk was determined using a thermolactodensitometer, and casein was measured by the Wolker formaldehyde method. The urea content was determined with a BRAN LUEBBE autoanalyzer. Samples of colostrum were taken from each cow from the first milking. Fat, protein, lactose and dry matter were determined in these samples and, after precipitating casein with a solution of rennin (1:100), the content of whey protein was determined using a Milco Scan AS Foos Elektric apparatus. Within 35-60 days after calving, blood was sampled from 8 cows in each group to determine glucose, calcium, inorganic phosphorus, magnesium and urea contents with a reagent kit from POCH (Gliwice, Poland), the level of ketone bodies was assayed by the Madonia methods (1963) and asparagine transaminase activity (AspAT) was determined using Lachem reagents. Samples of milk were taken from the same cows and their fatty acid composition

was determined by gas chromatography on a Packard chromatograph on a 10.30 x 0.53 x 1 mm supelcovax column (Supelco).

The milk yield of cows was determined for the first three months of lactation, i.e. during supplementation with fat and for the next 4 months of lactation (from month 4 to 7) after withdrawing supplementation.

The results were subjected to statistical analysis by calculating means, standard deviations and the significance between groups based on single-factor variance analysis with the Duncan test.

RESULTS

The composition of colostrum from cows receiving fat and protein supplements before calving did not differ significantly from that of the control group (Table 2).

During the first three months of lactation, the average milk yield of the experimental cows was higher than of the control group (Table 3). A significant rise (by 2.78 kg) was found in cows receiving the fat supplement, Erafet, along with rapeseed oilmeal (II) and (by 2.04 kg) in cows receiving rapeseed cake (III). The FCM yield in group I was 1.44 kg greater than in the control group, and significantly higher ($P \leqslant 0.05$) in group II (by 2.74) kg and III (by 2.09 kg). The protein content in milk was lowest in the groups of cows receiving Erafet (I and II) and highest in those receiving rapeseed cake (III). A significant ($P \leqslant 0.05$) rise in the protein content in comparison with the control group was found in groups II and III. The casein content in the milk of cows from all groups was similar. The amount of lactose in the experimental cows was also uniform (about 4.80%), with only a slightly lower level in the control group (4.72%).

The urea content of the milk was highest in cows receiving rapeseed cake (24.41 mg/100 ml) and significantly lower ($P \leqslant 0.05$) in cows receiving Erafet

TABLE 2

Chemical composition of colostrum (mean and standard deviation), %

Group	Fat	Crude protein	Lactose	Dry matter	Whey protein
I. Erafet	4.18 ± 2.28	16.16 ± 4.19	1.78 ± 0.94	22.57 ± 3.89	10.01 ± 3.83
II. Erafet + rapeseed oilmeal	4.34 ± 3.20	17.71 ± 4.03	1.46 ± 0.94	23.63 ± 5.73	11.51 ± 3.29
III. Rapeseed cake	3.53 ± 2.48	15.46 ± 3.29	1.93 ± 0.89	21.74 ± 4.11	11.05 ± 4.65
IV. Control	4.35 ± 2.48	17.17 ± 4.17	1.63 ± 0.73	23.90 ± 4.72	10.36 ± 4.21

TABLE 3

Mean daily milk yield and milk composition in the first three months of lactation

Indices	GROUPS			
	I	II	III	IV
Milk yield, kg	25.03[a]	26.70[a]	25.96[a]	23.92[b]
FCM yield, kg	25.72[a]	27.02[a]	26.37[a]	24.28[b]
Dry matter, %	12.77[a]	12.55[a]	12.75[a]	12.56[b]
Fat, %	4.20	4.10	4.13	4.10
Protein, %	3.09[a]	3.06[a]	3.18[b]	3.14[a]
Lactose, %	4.82[a]	4.79[a]	4.81[a]	4.72[b]
Casein, %	2.41	2.36	2.43	2.43
Urea, mg/dl	20.69[a]	22.71[a]	24.41[b]	21.46[a]
Density, °Ld	28.6	28.36	28.9	28.6

a, b – $P \leqslant 0.05$

TABLE 4

Mean daily milk yield and milk composition in 4-7 months of lactation

Indices	GROUPS			
	I	II	III	IV
Milk yield, kg	20.49[a]	20.79[a]	20.95[a]	20.12[b]
FCM yield, kg	20.21[a]	20.26[b]	20.20[a]	19.45[b]
Dry matter, %	12.54[a]	12.25[a]	12.31[a]	12.15[b]
Fat, %	3.91	3.83	3.76	3.78
Protein, %	3.20	3.16	3.18	3.18
Lactose, %	4.80[a]	4.75[a]	4.79[a]	4.66[b]
Casein, %	2.42	2.44	2.38	2.38
Density, °Ld	29.2[a]	29.0[a]	29.5[b]	29.4[a]

a, b – $P \leqslant 0.05$

(20.69 mg/100 ml) and in control animals (21.46 mg/100 ml), but with a wide variation of standard deviation (10.4-12.0 mg/100 ml). The specific weight of the milk did not differ significantly between the groups.

During the second period of lactation (months 4 to 7), the milk yield of the cows from groups II and III was significantly higher ($P \leqslant 0.05$) than in the control group – by 0.67 kg in group II and 0.83 kg in group III, similarly, FCM yield was greater by 0.81 kg and 0.75 kg, respectively (Table 4). In all, over a seven month period of lactation, fat supplements increased the milk yield of cows: the Erafet supplement by 144 kg, Erafet plus rapeseed oilmeal, by 331 kg and rapeseed cake by 283 kg, while FCM yield rose, 211, 244 and 278 kg, respectively.

TABLE 5

Fatty acids (FA) composition of fat g/100 g FA

Indices	GROUPS				Erafet
	I	II	III	IV	
C 4 to C 13	5.84	5.55	5.59	5.93	–
C 14 to C 15	10.82	10.80	11.26	12.79	3.45
C 16	26.02[a]	26.07[a]	24.47[a]	27.97[b]	19.15
C 16 : 1	1.84[a]	1.62[a]	1.45[b]	1.76[a]	3.42
C 17	2.70[b]	2.52[a]	2.35[a]	2.37[a]	1.24
C 18	14.32[a]	15.52 [a]	16.91[a]	13.52[b]	10.14
C 18 : 1	33.40	33.02	32.65	30.70	32.48
C 18 : 2	2.82	2.65	2.80	2.80	3.95
C 18 : 3	1.09[a]	1.05[a]	1.22[b]	1.15[a]	0.55
C 20 do C 21	1.15	1.20	1.30	1.01	2.41
C 22					3.51

a, b – $P \leqslant 0.05$

No significant differences were found between groups in physiological blood parameters. All were within the normal range accepted for cattle (Kłopocki and Winnicka, 1987). Only the glucose level in the blood of cows in groups I, II (2.12; 2.11) and control (2.10 mmol/l) were slightly below the accepted limits. The urea and calcium, inorganic phosphorus and magnesium levels were in the medium range of physiological limits (Kłopocki and Winnicka, 1987).

The fat supplements changed the fatty acid composition of milk (Table 5). Significant ($P \leqslant 0.05$) changes occurred in the contents of the following acids: palmitic, palmitoleic, margarinic, stearic and linolenic. The content of oleic acid in the experimental groups rose from 7.5 to 10.0%, palmitoleic acid decreased significantly ($P \leqslant 0.05$) in all groups, although the greatest decline (12.5%) was observed in the cows receiving rapeseed cake. In this group the level of palmitoleic acid decreased significantly (by 17.6%). The addition of Erafet to the diet caused a significant ($P \leqslant 0.05$) increase in the margarinic acid content (from 6.3 to 13.9%) in comparison with the control group and group III. The level of stearic acid was significantly higher ($P \leqslant 0.05$), by about 25%, in the group receiving rapeseed cake and by 14.8% in the group receiving both Erafet and rapeseed oilmeal, in comparison with the control group.

DISCUSSION

Analysis of the composition of the colostrum of cows shows that before calving, administering the studied fat supplements not result in any significant

changes. Similarly, Olson and Bull (1986) did not find changes in colostrum composition of cows in response to feeding, while Szulc et al. (1990) observed a reduction in crude protein and whey protein in cows fed low quality silages.

The rise in milk yield in the first three months of lactation confirms the observations of other authors and points to the favourable effect of dietary fat supplements on the milk yield of cows during the high productivity period (Abel et al., 1993; Bielak et al., 1993; Kraszewski et al., 1993; Sklan et al., 1994; Tomlinson et al., 1994; Wu and Huber, 1994). Combining fat with protein supplementation (group II) increased milk yield in comparison with only fat supplementation (group I). Wu and Huber (1994) report that increased glucose absorption occurs at a higher protein level. Jilga et al. (1998) believe that by binding some fats and fatty acids in the form of very low density lipoproteins (VLDL), protein helps counteract accumulation of fat in the liver. Using fat as an energy supplement, but not as energy replacement, Abel et al. (1993) obtained a marked increase in FCM yield, while decreasing the milk protein content at the same time.

No significant differences were found between the groups in respect to fat content in the milk, although in group I that received only fat in the form of soaps, a 0.1% rise was recorded. Bielak et al. (1993), Kraszewski et al. (1993) and Strzetelski et al. (1993) obtained similar results, while Sklan et al. (1994) did not find any changes in the milk fat content. The higher amount of fat produced by the cows in the experimental groups could have been the result of passing the long-chain fatty acids of the feed to the milk directly in the mammary gland, thus saving the energy of their synthesis (Palmquist, 1990).

The somewhat lower protein content of milk from the experimental cows (except group III) is in agreement with the results of other authors (Jilg et al., 1988; Lebzien et al., 1992; Abel et al., 1993; Bielak et al., 1993; Tomlinson et al., 1994; Wu and Huber, 1994). This may be the result of lowering the amount of microbial protein in the rumen, as pointed out by Brinkman and Abel (1992) and Zawadzki (1993). Wu and Huber (1994) report that this may also be related to the worse utilization of amino acids in the mammary glands for the synthesis of milk. A significantly higher ($P \leqslant 0.05$) protein content in the milk of group III, as compared with group II, could have resulted from the slightly better utilization of rapeseed cake protein than of rapeseed oilmeal protein, as suggested by Strzetelski et al. (1993).

The lower level of lactose in the milk of the control group could be caused by a lower energy intake per litre of produced milk. The significantly greater ($P \leqslant 0.05$) DM content of milk from cows in groups I and II was the result of its greater fat, protein and lactose content.

The highest urea level in milk ($P \leqslant 0.05$) was found in cows fed rapeseed cake, which could be a consequence of the greater protein content of the ration. It may

be suggested that the higher than required level of protein in the rations fed to cows in this group (by 17.8 g per litre of produced milk) in conjunction with an increased amount of vegetable fat in the diet, could have been the reason that much of the ammonia was not utilized by bacteria (Brinkman and Abel, 1992; Zawadzki, 1993; Wu and Huber, 1994). The lowest urea content was found in the milk of cows given the fat preparation, Erafet, and indicates that the energy and protein balance in the ration was correct. The above suggests that the urea level in the milk of cows is an additional practical indicator of protein and energy balance in the ration. This conclusion supports the findings of Kirchgessner et al. (1986), Gustafsson and Palmquist (1993), Ciszuk and Gebregziabher (1994).

The biochemical blood indicators in the cows of all groups were within normal physiological limits (Kłopocki and Winnicka, 1987). Only the glucose level in groups I, II and the control was lower than given by the standards, which could have been the result of the lower than required supply of energy per litre of produced milk. The higher blood glucose level in cows from group III is the result of the greater proportion of energy and protein levels in the ration. The calcium, phosphorus and magnesium levels in the blood indicate that their supply in the diet was adequate. The higher calcium and magnesium levels than in the control group found in the blood of the experimental cows do not support the results of Rahnemy et al. (1994), according to whom the addition of fat as soaps and vegetable oils reduces the absorption of Ca and Mg from the intestines, which may lead to lowering these components in the blood. However our observations may result from the additional Ca and Mg present in the Erafet preparation.

Changes in the fatty acid composition of cow milk indicate that the addition of fats to the ration can cause significant changes in the level of fatty acids in milk, which creates the possibility of partial manipulation of milk composition through the diet. Strzetelski et al. (1992, 1993) and Kwiatkowski et al. (1993) found that after feeding rape seeds or cakes, a significant rise occurred in the proportion of C18 and C18.1 fatty acids and a fall of C4-C16 acids in milk. Lebzien et al. (1992) and Rohr et al. (1993) obtained similar results using other types of vegetable fats in the form of soaps. Jahreis et al. (1993) also found that the vitamin E level increased and the number of somatic cells in milk decreased, which could be beneficial for the health of the mammary gland.

This study has shown that the addition of fat in the form of calcium-magnesium soaps or oil in rapeseed cakes in the nutrition of high yielding cows from 3-4 weeks before and 100 days after calving, causes a highly significant rise in the milk yield and its components in the first three and 4 successive months of lactation. It was also shown that clearly better results are obtained by combining soaps and oils with protein, to which Jilg et al. (1988), Rohr et al. (1993) and Tomlinson et al. (1994) have also drawn attention. No significant decrease in the level of protein in milk was found, which in the case of using fats in

the form of soaps could be explained by their protection against hydrolysis and hydrogenation in the rumen. In effect this prevents sudden changes in the development of microorganisms, cellulose digestion or rumen fermentation (Kowalczyk et al., 1977; Jilg et al., 1988; Klusmeyer et al., 1991; Brinkman and Abel, 1992; Abel et al., 1993). Similar results obtained using rapeseed cake with a high oil content can be explained by the protective effect of rapeseed cell walls and the clearly lower level of linolenic and linoleic acids in milk fat (Khorasani et al., 1991; Strzetelski et al., 1992, 1993).

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STRESZCZENIE

Wpływ stosowania dodatków tłuszczowych w żywieniu wysokowydajnych krów w pierwszym okresie laktacji na wydajność i skład mleka

W żywieniu wysokowydajnych krów od 3 tygodni przed ocieleniem do 100 dnia laktacji stosowano następujące dodatki do dawki podstawowej: preparat tłuszczowy w formie mydeł wapniowo-magnezowych "Erafet" (grupa I), "Erafet" z poekstrakcyjną śrutą rzepakową (grupa II), wytłoki rzepakowe o zawartości 19,15 % tłuszczu (grupa III). W pierwszych trzech miesiącach laktacji stwierdzono wzrost dobowej wydajności mleka FCM krów doświadczalnych w stosunku do grupy kontrolnej, odpowiednio w grupach I-III o: 4,6; 11,6 i 8,5 %. Po zakończeniu podawania dodatków, w czterech następnych miesiącach laktacji, krowy grup doświadczalnych produkowały więcej mleka odpowiednio o: 1,7, 3,3; 4,1 %. Tłuszcz mleka krów doświadczalnych zawierał istotnie więcej kwasu oleinowego (od 7,5 do 10,0 %) i stearynowego (od 5,9 do 25,1 %), a mniej kwasów C4 – C16 niż tłuszcz mleka krów kontrolnych.