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Further studies on the effect of fat supplementation of concentrates fed to lactating dairy cows. 1. Effect on feed intake, feed intake pattern and milk production and composition

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Summary

A feeding trial was carried out as a 3 × 3 Latin square with 9 cows which were fed long hay and concentrates without supplemented fat (treatment C0), with 12 % supplemented fat (treatment C12) or with 12 % supplemented fat adsorbed on a carrier of vermiculite (treatment C12C).

Supplementing the concentrates with fat resulted in a higher milk yield. With both fat-supplemented concentrates the milk fat content was initially increased, but this was rapidly followed by a rather sharp decrease. The final result was a lower milk fat content with treatment C12 and a slightly higher milk fat content with treatment C12C. Protein content of the milk was decreased with both treatments C12 and C12C.

With feeding fat-supplemented concentrates feed intake pattern changed in that the rate of intake decreased and the concentrates were eaten in several small quantities.

Introduction

In the past few years the opinion of feeding large quantities of fat of different sources to dairy cows has changed. Results of feeding trials by Palmquist (1978) and Rijpkema & de Visser (1982), in which large quantities of fat (7-10 % of total dry matter) were fed, did not show any negative effect on feed intake and milk production.

By adding large amounts of fat to concentrates fed to dairy cows the energy value of the concentrates can easily be increased. Especially in early lactation, rations used for high-yielding dairy cows can use such an increase in energy value to meet energy requirements.

However, concentrates high in fat cause problems in feed manufacturing. Mixtures with high fat levels usually do not give pellets with sufficient hardness required for automatic feeding systems. Absorbing the fat on a carrier might solve this problem and also may prevent interference with rumen fermentation by fat. In a trial with dairy cows concentrates without or with added fat, either as such or on a carrier, were examined with regard to feed intake and milk production.

Materials and methods

The trial was carried out as a 3 × 3 Latin square design with 3 dairy cows per treatment per period. Each period lasted 3 weeks. The first week of a period was used for adaptation to the new ration. During the second and third week of each period the intake of roughage and concentrates as well as the milk production and composition were measured.

The animals used in this trial were in the second part of their lactation. The animals were kept in a tie-stall, where they could be fed individually.

The ration was fed twice daily and consisted of 7 kg of long hay and 12 kg of one of the three mixtures of concentrates. One mixture (treatment C0) served as a control, containing no added fat. The two other mixtures contained 12 % added fat (11 % tallow + 1 % palm kernel oil). The fat was mixed with the other ingredients, either as such (treatment C12) or after adsorbing it on a carrier of Palabora vermiculite in a premix (treatment C12C). The mixtures were subsequently pelleted. Details on the composition of the concentrates are given in a subsequent paper (van der Honing et al., 1982). The chemical composition of the hay and the concentrates are shown in Table 1.

The data were tested for significant differences by means of analysis of variance.

Table 1. Chemical composition of hay and concentrates (%).

	Hay	Concentrates		
		CO	C12	C12C
Dry matter	86.6	88.2	88.1	88.7
Inorganic matter	8.3	9.7	7.8	12.6
Crude protein	19.0	23.9	22.2	22.3
Crude fibre	27.8	8.6	8.3	8.4
Crude fat (hexane)[1]	2.8	1.7	14.5	13.8
Crude fat (Berntrop)[2]	–	2.3	14.8	14.1
Neutral detergent fibre	58.7	22.6	21.3	19.9

[1] Analysis based on hexane extraction.
[2] Analysis based on hexane extraction preceded by hydrolysis with HCl.

Table 2. Milk production and composition in the 2nd and 3rd week of the experimental periods.

treatment →	CO		C12		C12C	
week →	2	3	2	3	2	3
Milk (kg/day)	22.9	21.4	22.6	23.5	23.4	22.6
Fat-corrected milk (kg/day)	21.6	20.0	21.7	20.6	25.3	22.3
Fat (%)	3.63	3.55	3.72	3.18	4.54	3.91
Fat (g/day)	835	762	846	749	993	885
Protein (%)	3.11	3.19	3.06	3.07	3.07	3.09
Protein (g/day)	712	681	689	720	715	690
Roughage intake (kg/day)	6.60	6.75	6.41	6.45	6.61	6.58

Results and discussion

The concentrates offered to the animals were always completely eaten. The pellets of both mixtures with added fat (C12 and C12C) were of poor quality, some 25 % being meal. The intake pattern of the concentrate mixtures differed. The mixtures with added fat (C12 and C12C) were eaten in several small quantities. Four hours after feeding, some 20 % was still left. Part of this difference in feed intake pattern can be due to the fact that some 25 % of the concentrates was offered as meal. The animals were not used to eating meal. Nevertheless, also in other trials with concentrates containing added fat the same difference in feed intake pattern was noticed (Sharma et al., 1978; Rijpkema & de Visser, 1982). There was no difference between the C12 and C12C concentrates in this respect.

Using such types of concentrates with added fat may cause problems when they are to be used in automatic feeding systems or when large amounts of concentrates are fed in the milking parlour. In the latter case the time of eating will be too short because of the feed intake pattern. The roughage intake was not influenced by the type of concentrates fed. Only a small tendency was noticed for smaller feed refusals for the CO concentrate (Table 4).

Table 2 shows the main results obtained in the second and third weeks of each period, respectively. To determine if the adaptation to the diets was complete af-

Table 3. Difference between the third and the second weeks.

	D (third – second week)			F	Probable significance
	CO	C12	C12C		
Milk (kg/day)	−1.5	0.9	0.8	16.3	P <0.05
Fat-corrected milk (kg/day)	−1.7	−1.1	−3.0	23.3	P <0.05
Fat (%)	−0.08	−0.54	−0.64	14.5	P <0.05
Fat (g/day)	−73	−98	−108	0.4	n.s.
Protein (%)	0.07	0.02	−0.02	2.1	n.s.
Protein (g/day)	−31.4	31.2	25.3	5.9	P <0.05
Roughage intake (kg/day)	0.15	0.04	−0.03	1.2	n.s.

Table 4. Analysis of variance of week 3.

	CO	C12	C12C	F	Probability
Milk (kg/day)	21.4	23.5	22.7	6.9	<0.05
Fat-corrected milk (kg/day)	20.0	20.6	22.3	7.5	<0.05
Fat (%)	3.55	3.18	3.91	30.1	<0.01
Fat (g/day)	762	749	886	12.1	<0.05
Protein (%)	3.19	3.07	3.08	5.2	<0.05
Protein (g/day)	681	720	698	2.5	n.s.
Roughage intake (kg/day)	6.75	6.45	6.58	3.1	n.s.

ter the second week, the results of the second and third week were compared. Table 3 gives their differences.

Analysis of variance showed significant differences for milk production, fat-corrected milk, milk fat percentage and milk protein production between the results of the second and third week. From this it was concluded that during the second week adaptation to the ration was not yet complete. Therefore only the results of the third week were analysed further. The results of the analysis of variance are shown in Table 4.

Milk production increased by adding fat to the ration (C12 and C12C). This is probably due to the much higher energy intake of the animals fed concentrates containing 12 % added fat.

The fat content of the milk was rather low for all concentrates (C0, C12 and C12C). In two measurements taken before the experiments started the average fat content of the milk was 4.39 %. The low milk fat content in the control period (C0) may be the result of the high concentrates: roughage ratio and to a lesser extent due to the low fat content (1.67 %) of the diet during that period.

Several reviews deal with the effect of fat supplementation of the diet of dairy cows on milk production and composition (Palmquist, 1978, 1981; Hagemeister & Kaufmann, 1979; Palmquist & Jenkins, 1980; Storry, 1981). From these a number of conclusions may be drawn. The effect of fat supplementation is often twofold. First, it may interfere with rumen fermentation, but not always in the same direction. When feeding diets with sufficient roughage to prevent the production of extreme amounts of propionate in the rumen, fat supplementation tends to shift the fermentation from acetate towards propionate (Kowalczyk et al., 1977; Rohr et al., 1978). This may cause a decreased de novo synthesis of fatty acids in the mammary gland, resulting in a lower milk fat content. A decreased milk fat content after feeding unprotected fat has been observed in a number of experiments (Wrenn et al., 1976; Rohr et al., 1978; Kaufmann & Hagemeister, 1979; Rijpkema & de Visser, 1982). If, on the other hand, diets low in roughage are fed which normally cause excessive amounts of propionate being produced in the rumen, fat supplementation may shift rumen fermentation from propionate towards acetate (Storry et al., 1974) resulting in an increase of the milk fat content.

Coating the supplemented fat will largely prevent interference with rumen fermentation (Bines et al., 1978) and this has often been observed to result in a rather consistent higher milk fat content (Wrenn et al., 1976; McLeod & Schaefer, 1977; Bines et al., 1978; Sharma et al., 1978; Smith et al., 1978; Kronfeld et al., 1980).

Apart from an effect on rumen fermentation high levels of dietary fat will increase lipid and triglyceride content in blood plasma (Storry, 1981) which also reduces the intramammary synthesis of fatty acids which may result in a decrease of the milk fat content (Bines et al., 1978).

In our experiments the comparatively high fat intake (up to 2.0 kg/day) of the animals after feeding the fat-supplemented concentrates tends to increase the milk fat content in the second week, but to decrease again the milk fat content in the third week. Feeding the concentrate C12 resulted in a decreased fat content in week 3 compared with feeding concentrate C0, but feeding the 'protected' concentrate C12C caused a sharp increase in week 2 followed by a decrease to approximately the same level as after feeding the control diet (C0). So, the immediate response of the cows to an increased fat supply seems initially to result in an elevated output of milk fat. This was however very soon followed by a rather sharp decrease. In earlier experiments (Rijpkema & de Visser, 1982) it was also found that feeding concentrates supplemented with fat (7 %) initially resulted in an increased milk fat content as compared with the control treatment. This gradually changed to a decrease in the course of the experiment, which lasted 20 weeks. The time when the difference in fat content between the control diet and the fat-supplemented diet changed from positive to negative, coincided with the point where the cows changed from losing to gaining body weight. In our experiments the animals were in positive energy balance during all treatments. An initial increase of the milk fat content followed by a sharp decrease after feeding unprotected tallow was also observed by Wrenn et al. (1976).

The difference in milk fat output between feeding C12 and C12C may result from a different effect on rumen fermentation. In more detailed experiments in which the same concentrates were fed to rumen-fistulated animals (Tamminga, unpublished results) differences in rumen fermentation appeared to be rather small. It seems therefore not unreasonable to assume that the postruminal utilization of protected and unprotected fat also differs possibly with respect to the lipid fractions (high density lipoproteins: HDL; low density lipoproteins: LDL and very low density lipoproteins: VLDL) in which they are transported in the blood plasma. Such differences might result in a different uptake by the mammary gland because there is a preference for the uptake of VLDL and LDL (Storry, 1981). Unfortunately no information is available on the distribution over the various fractions of absorbed fatty acids from unprotected fat as compared to protected fats. The increased fat supply may also have affected the endocrine balance resulting in a different distribution of nutrients between mammary gland and other tissues.

Due to the higher milk production with C12 the total yield of milk fat (g/day) was equal with treatment C0 and C12. The increased yield of milk fat with treatment C12C resulted from both a higher milk production and a slightly higher milk fat content.

The protein content of the milk was decreased for both fat-supplemented concentrates (C12 and C12C), which confirms other findings (McLeod et al., 1977; Rohr et al., 1978; Rijpkema & de Visser, 1982). Almost the total difference in milk protein content between treatment C0 and the other treatments can however be explained by a dilution effect due to the higher milk yields, because there was no difference in total milk protein production (g/day) between the different treatments.

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