INPUT-OUTPUT RELATION OF FATTY ACIDS FROM DIETARY RAPESEED INTO MILK FAT AND CHANGES IN SERUM METABOLITES AND HORMONES IN DAIRY COWS

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ABSTRACT

Two groups of 10 cows were fed a corn silage based diet with or without 1 kg of ground rapeseed in an initial 3-month investigation period. During the following 3-week period, the proportion of rapeseed was isonitrogenically increased to 1.5 kg/animal/day.
Despite higher milk production in the rapeseed-fed cows, there were no significant differences in daily fat and protein yields between treatments.
The secreted amount of short- and middle-chain fatty-acids (C4:0 to C17:0) per animal per day decreased by 148 or 174 g, resp., whereas the production of long-chain fatty-acids increased by 138 and 183 g (1 kg or 1.5 kg rapeseed, resp.).
The butter fat of cows fed with rapeseed contained one third less C16:0 and two thirds more C18:1. These beneficial changes also significantly improve the spreadability of butter since the ratio of C18:1 to C16:0 is an index of milk-fat hardness.
The higher fatty-acid transfer from rapeseed to milk fat seems to have a glucose-saving effect. Both glucose and fatty-acids are known as stimulators of IGF-I synthesis, a process involved in milk production.
The benefits of increasing levels of dietary fat tended to be progressively decreased if too much fat was added to the diet since this caused a linear reduction in fat digestibility and lipid transfer to the udder.

INTRODUCTION

The inclusion of fat in diets for lactating cows has been increased during recent years. There are two reasons: 1. A higher energy intake of lactating cows with negative body energy balance; and 2. To improve the quality of butter fat.

MATERIAL AND METHODS

The animals used in the experiment were chosen from a herd of 300 lactating cows to obtain homogenous groups. Two groups of ten lactating Black Pied Dairy cows were formed based on milk production and state of lactation. They were fed a basic diet of corn silage ($\approx$ 31 kg) and hay (1 kg). The concentrate (5 kg, 22 % crude protein) was a mixture of cereals and soybean meal. A single kg of concentrate of the control group (I) was isonitrogenically exchanged with 1 kg of ground rapeseed in the second group (first investigation period = 3 month).
During the second investigation period, lasting 3 weeks, the proportion of rapeseed was isonitrogenically elevated to 1.5 kg/animal/day. The cows of control group (II) received the same diet as in the first period. There were significant differences in the fat content between diets (control: 490 g/animal/day = 2.9 %; rapeseed I: 880 g = 5.3 % and rapeseed II: 1060 g = 6.4 % of fat in the dry matter).

Analysis. Fatty-acids of milk fat were determined after methylation with Na-Methylate by gas-liquid chromatography. The concentration of non-esterified fatty-acids (NEFA) in serum was measured by using a commercial kit. Total serum-cholesterol concentration was determined using an automated photo-spectrometric analyzer. Insulin was determined radioimmunologically using a commercial kit from Serono (Freiburg, Germany) and the thyroid hormones using commercial kits from Henning (Berlin, Germany). Insulin-like growth factor I (IGF-I) was liberated from binding protein by acid-alcohol extraction and analysed using the method described by Kratzsch *et al.* (1992).

RESULTS

The composition of the milk fat is shown in Table 1. Diets containing supplemental rapeseed significantly altered the percentage of most fatty-acids from C12 upwards.

Total serum cholesterol and free fatty-acid concentration increased significantly with higher intake of oil-rich rapeseed (Table 2), but the treatment was without significant effect on glucose and insulin concentration. There is only a tendency towards higher glucose and lower insulin concentration in cows fed rapeseed. The plasma IGF-I concentration was significantly enhanced in the group fed 1 kg rapeseed in comparison to control I. The results of the 1.5 kg-group showed a high variation and the difference in comparison to control II was insignificant. Rapeseed glucosinolates (1.1 mmol/kg dry matter of the ration) did not influence the thyroid-hormone metabolism of the cows (Table 2).

TABLE 1.The effect of feeding rapeseed on the fatty-acid composition of milk fat (g/100 g of methylesters)

Fatty-acid	Control I	Rapeseed 1 kg	Control II	Rapeseed 1.5 kg
4 : 0	2.8 ± 0.2	2.9 ± 0.2	2.8 ± 0.2	2.8 ± 0.2
6 : 0	2.0 ± 0.1	2.0 ± 0.2	2.0 ± 0.0	1.9 ± 0.2
8 : 0	1.4 ± 0.1	1.3 ± 0.2	1.4 ± 0.1	1.3 ± 0.2
10 : 0	3.3 ± 0.2	3.1 ± 0.5	3.3 ± 0.3	2.9 ± 0.4
12 : 0	4.2^b ± 0.3	3.6^a ± 0.5	4.2^b ± 0.5	3.2^a ± 0.5
14 : 0	11.8^b ± 0.7	10.8^a ± 0.9	11.8^b ± 0.6	10.3^a ± 0.9
14 : 1	1.5^b ± 0.2	0.9^a ± 0.3	1.4^b ± 0.2	0.8^a ± 0.1
15 : 0	1.4^b ± 0.1	1.1^a ± 0.3	1.3^b ± 0.2	1.0^a ± 0.2
16 : 0	39.9^b ± 1.8	26.7^a ± 3.5	39.9^b ± 2.0	25.2^a ± 3.4
16 : 1	2.1^b ± 0.4	1.2^a ± 0.4	2.1^b ± 0.4	1.1^a ± 0.2
17 : 0	0.6 ± 0.0	0.5 ± 0.0	0.6 ± 0.1	0.5 ± 0.0
18 : 0	7.7^a ± 1.0	13.6^b ± 2.2	7.8^a ± 1.0	15.8^b ± 1.8
18 : 1	14.3^a ± 1.2	24.4^b ± 3.1	14.1^a ± 0.9	27.6^b ± 3.3
18 : 2	1.8 ± 0.1	2.0 ± 0.3	1.6^a ± 0.5	2.4^b ± 0.3
18 : 3	0.3 ± 0.0	0.4 ± 0.1	0.3^a ± 0.0	0.5^b ± 0.1
20 : 0	...	0.2 ± 0.1	...	0.3 ± 0.0
20 : 1	...	0.1 ± 0.1	...	0.1 ± 0.1

a < b (P < 0.05)

TABLE 2. Effect of feeding rapeseed on concentration of metabolites and hormones in serum or plasma

Item		Control I	Rapeseed 1 kg	Control II	Rapeseed 1.5 kg
Cholesterol	[mmol/l]	3.55^a ± 0.72	5.74^b ± 1.07	3.72^a ± 0.44	5.11^b ± 0.94
NEFA	[mmol/l]	0.30^a ± 0.08	0.51^b ± 0.11	0.31^a ± 0.11	0.59^b ± 0.15
Glucose	[mmol/l]	3.47 ± 0.37	3.62 ± 0.21	3.50 ± 0.40	3.71 ± 0.37
Insulin	[pmol/l]	196 ± 55	164 ± 48	205 ± 128	168 ± 83
IGF-I	[ng/ml]	126^a ± 17	148^b ± 16	153 ± 19	174 ± 49
T_3	[nmol/l]	3.84 ± 0.78	3.78 ± 0.32	n.d.[1]	n.d.
T_4	[nmol/l]	75.6 ± 16.5	67.5 ± 5.9	n.d.	n.d.

a < b (P<0.05) [1] not determined

DISCUSSION

There is a clear decrease of short and middle-chain fatty-acid (C4:0 to C17:0) output in milk by 148 or 174 g and an increase of long-chain (≥ C18:0) fatty-acid output by 138 or 183 g/cow/day fed 1 and 1.5 kg rapeseed, resp.
Because of the biohydrogenation of unsaturated fatty-acids, it is better to calculate the input/output relation of the whole C18 fatty-acid group (Table 3). The percentage of transfer in cows fed with 1 or 1.5 kg rapeseed amounted to 42 and 37 %, resp. The digestibility of rapeseed fat measured in bulls was about 80 % (Richter *et al.*, 1992). If this factor is corrected for, then the transfer of digested rapeseed C18 fatty-acids increased to 52 and 46 %, resp.
The efficiency of transfer decreased with increasing intake of supplemented rapeseed fat. Therefore, with regard to the decrease of fat and protein concentration in milk, 1 kg of rapeseed should be the upper limit in dairy rations.

TABLE 3. Input/Output relation of C18 fatty-acid group

Fatty-acid	Additional input by rapeseed[1] g/d	Additional output by milk[1] g/d	Transfer %
C 18 : 0	5.3	49.1	?
C 18 : 1	211.1	84.0	39.8
C 18 : 2	73.4	1.6	2.2
C 18 : 3	35.3	0.8	2.3
Σ C $18_{1\,kg}$[2]	325.1	135.5	41.7
Σ C $18_{1.5\,kg}$[3]	487.1	179.5	36.9

[1] in comparison to control group
[2] 1 kg rapeseed or [3] 1.5 kg rapeseed per animal and day

The concentration of NEFA increased with increasing proportion of dietary rapeseed oil (Table 2) and, in the same manner, cholesterol in plasma of dairy cows is usually elevated by supplemental dietary fat (Khorasani *et al.*, 1992). However, butter-cholesterol concentration was not influenced by rapeseed feeding; it amounted to 259 mg in the control (I) and 269 mg/100 g butter fat in rapeseed group (II). The mammary uptake of cholesterol seems to be independent of plasma concentration.
The higher fatty-acid transfer to the udder has a glucose-saving effect. The lower energy demand for milk fat synthesis and the glucose surplus helps to stimulate lactose production. Both fatty-acids and glucose stimulate IGF-I synthesis (Table 2). IGF-I synthesis depends on energy supply of the lactating cow and is involved in milk production (Blum, 1992).

REFERENCES

Blum, J.W. (1992). *Archiv für Tierheilkunde* **134**, 213-229.

Khorasani, G.R., De Boer, G., Robinson, P.H., and Kennelly, J.J. (1992). *Journal of Dairy Science* **75**, 492-501

Kratzsch, J., Blum, W.S., Schenker, E., Keller, E., Jahreis, G., Haustein, B., Ventz, M., and Rotzsch, W. (1992). *Experimental and Clinical Endocrinology*. **101**, 144-149

Richter, G.H., Löhnert, H.-J., and Ochrimenko, W.I. (1993). *105. VDLUFA-Kongreß*, Abstract, p. 120