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Effects on milk fat composition and cow performance of feeding concentrates containing full fat rapeseed and maize distillers grains on grass-silage based diets

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Abstract

Two experiments were carried out to determine the effect on milk fat composition and cow performance of including ground full fat rapeseed (FFR) and maize distillers grains (MDG) in the concentrate supplement. Unwilted grass-silage was the basal forage in both experiments. In Expt. 1, 8 kg/day of concentrate containing 0 (control), 80 (low), 140 (medium) or 200 g/kg (high) FFR was fed to four groups of 16 cows each for 7 weeks. Milk yield, milk constituent yield and milk composition which was compared using 13 cows per treatment were not significantly affected by FFR inclusion. The milk fat (using all 64 animals) from cows on the high FFR concentrate contained significantly lower proportions of C6:0, C8:0, C14:0, C14:1 ($P<0.05$) compared to those produced by cows on the other three concentrates. It also contained lower proportions of C10:0 and C12:0 ($P<0.05$) compared to that from cows on the control or medium FFR concentrate. Cows on the high and medium FFR concentrate had significantly lower proportions of C16:0 ($P<0.01$) and significantly higher proportions of C18:1 ($P<0.05$) in their milk fat compared to the other two treatments. Solid fat content in the milk fat at 10°C was also significantly lower on the former two treatments ($P<0.05$). In the second experiment 6 kg/day of concentrate containing O (control), 700 (MDG1) and 920 g/kg (MDG2) MDG was fed to three groups of 12 cows each for 6 weeks. Silage intake, milk yield or the concentration or yield of milk fat and lactose were not significantly different between treatments. Milk protein concentration and yield were depressed ($P<0.05$) by the inclusion of both levels of MDG. Including both levels of MDG significantly reduced the proportions of C10:0, C12:0, C14:0, C14:1, C16:0, C16:1 and C18:3 ($P<0.05$) and significantly increased the proportions of C4:0, C18:0, C18:1 and C18:2 ($P<0.05$). The changed fatty acid composition resulted in a softer fat as indicated by the solid fat content at 10°C which was 480, 355 and 314 g/kg on the control, MDG1 and MDG2 concentrates, 8 days after feeding commenced. The results of these experiments show that, on a grass-silage based diet, the fatty acid profile of milk fat can be significantly altered, resulting in a softer fat, by feeding 1.12 or 1.60 kg of FFR or 4.20 or 5.52 kg of MDG in the concentrate supplement daily. FFR may be the supplement of choice because the levels of MDG required to give similar changes in milk fat composition and softness had negative effects on milk protein concentration.

Keywords: Milk fat composition; Full fat rapeseed; Maize distillers grain

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1. Introduction

A previous study at these Research Centres has shown that it is possible to alter the fatty acid composition of milk fat by including ground full fat soyabeans or ground full fat rapeseeds (FFR) in the concentrate mixture fed to lactating cows (Murphy et al., 1990). The unsaturated 18-carbon fatty acids in these oilseeds are hydrogenated in the rumen to stearic acid (C18:0). This is then absorbed from the intestine and it is converted to oleic acid (C18:1) in the mammary gland by an intramammary stearic acid desaturase, the presence of which has been demonstrated by Kinsella (1972). Thus, increasing the supply of stearic acid to the gland results in an increased level of oleic acid in the milk fat with a concommitant reduction in palmitic acid (C16:0) thereby resulting in a softer fat. In the study of Murphy et al. (1990), only one level of full fat rapeseed was given and it was not possible to determine if this was the optimum in terms of changing the fatty acid composition of the milk fat.

However, both full fat soyabeans and full fat rapeseed are expensive ingredients which can increase the cost of the concentrate supplement significantly. Therefore, an alternative less expensive ingredient which would achieve the same effect is worthy of evaluation. Maize distillers grain (MDG) is a by-product of the distilling industry. It is a relatively inexpensive ingredient which contains about 100 g/kg of oil and up to 90% of the fatty acids present are 18-carbon fatty acids. Such an ingredient could give the same changes in milk fat composition if fed in adequate quantities.

Therefore, the purpose of the two experiments reported here was (a) to determine the optimum level of FFR to give to cows in terms of changing milk fat fatty acid composition and cow performance, and (b) to study the effect of feeding two levels of MDG in the concentrate on milk fat composition and cow performance, on grass-silage based diets.

2. Materials and methods

2.1. Experiment 1

Four concentrate mixtures based on barley, soyabean meal and FFR were formulated as shown in Table 1. The control concentrate contained no FFR but 80, 140 and 200g per kg FFR was included in the three other concentrate mixtures in place of a proportion of the

Table 1
The ingredient (kg/1000 kg) and chemical composition (g/kg DM) of the control and full fat rapeseed (FFR) concentrate mixtures

	Concentrate mixtures			
	control	low FFR	medium FFR	high FFR
Barley	690	640	600	560
Soyabean meal	230	200	180	160
FFR	–	80	140	200
Molasses	50	50	50	50
Dicalcium phosphate	10	10	10	10
Ground limestone	10	10	10	10
Salt	7.5	7.5	7.5	7.5
Calcined magnesite	2.5	2.5	2.5	2.5
Composition				
Dry matter	861	864	863	870
Crude protein	221	209	211	209
Oil	18	42	65	85
Ash	71	73	74	74
Crude fibre	61	64	65	65
Estimated ME (MJ/kg DM)	12.5	13.0	13.5	14.0

The following trace mineral/vitamin supplement was added per tonne of concentrate mixture: manganese sulphate 150 g; zinc oxide 25 g; ferrous sulphate 240 g; copper sulphate 40 g; calcium iodate 3 g; vitamin A 8 m.i.u.; vitamin D_3 2 m.i.u.; vitamin E 5000 i.u.

barley and soyabean meal so as to maintain the mixtures iso-nitrogenous.

In the pre-experimental period cows were on a diet of 7 kg/day of a commercial concentrate plus the same grass-silage that was fed during the experiment, ad lib. The feeding experiment was a randomised block design with a total of 64 animals. Animals were blocked into groups of four on the basis of calving date and milk yield in the pre-experimental week and then assigned at random to one of the following concentrate treatments: 1. control concentrate (0% FFR); 2. low FFR (80 g/kg) concentrate; 3. medium FFR (140 g/kg) concentrate; and 4. high FFR (200 g/kg) concentrate. Three blocks of animals were grouped on the basis of calving date only as they were put on treatments within 7 days of calving and therefore no pre-experimental milk yield was available. These were subsequently excluded from the statistical analysis for milk yield and composition as no pre-experimental values were available to use as a covariate but were included in the bulk and individual cow samplings for fatty acid and solid fat analysis. First-lactation animals ($n=24$) were blocked separately from those in their second or higher lactation. Cows had calved on average 16 days (range 1–40 days) at the start of the experiment. The experimental period was 7 weeks.

Concentrates were group-fed at a rate of 8 kg fresh weight per cow per day, in two feeds, after the morning and evening milkings. Moderate quality silage (dry matter, 174 g/kg; pH, 4.96; crude protein 168 g/kg DM; ash, 120 g/kg DM; modified acid detergent fibre (MADF), 375 g/kg DM; in vitro dry matter digestibility (DMD), 647 g/kg DM) was self-fed ad lib from behind an electrified barrier.

2.2. Experiment 2

Three concentrates based on barley, soyabean meal and MDG were formulated as shown in Table 2. The control concentrate consisted of barley and soyabean meal principally; the second concentrate consisted of barley and MDG so as to be iso-nitrogenous with the control, and the third mixture was principally MDG without any barley.

Before going on to treatments all cows were on a flat rate of 7 kg of concentrates (208 g/kg crude protein, 112 g/kg crude fibre, 46 g/kg oil) per day plus grass silage ad lib. The feeding experiment was a randomised block design with a total of 36 lactating cows calved between 27 and 126 days at the start of the experiment. Cows were blocked into groups of three on the basis of calving date and milk yield in the pre-experimental

Table 2
The ingredients (kg/1000 kg) and chemical composition (g/kg DM) of the control and maize distillers concentrate mixtures (MDG1 and MDG2)

	Control	MDG1	MDG2
Barley	620	220	–
Soyabean meal	300	–	–
Maize distillers grains	–	700	920
Molasses	50	50	50
Limestone flour	10	10	15
Dicalcium phosphate	10	10	5
Salt	7.5	7.5	7.5
Calcined magnesite	2.5	2.5	2.5
Composition			
Dry matter	879	893	896
Crude protein	236	235	274
Crude fibre	42	57	73
Oil	22	97	120
Ash	75	79	85
Estimated starch	330	130	20
Estimated ME (MJ/kg DM)	12.5	12.7	12.8

The following trace mineral/vitamin supplement was added per tonne of concentrate mixture: manganese sulphate 150 g; zinc oxide 25 g; ferrous sulphate 240 g; copper sulphate 40 g; calcium iodate 3 g; vitamin A 8 m.i.u.; vitamin D_3 2 m.i.u.; vitamin E 5000 i.u.

week and then assigned at random to one of the following concentrate treatments: 1. control concentrate (0 MDG); 2. concentrate containing 700 g/kg MDG (MDG1); 3. concentrate containing 920 g/kg MDG (MDG2). The experimental period was 6 weeks.

Concentrates were individually fed at a rate of 6 kg per cow per day, in two feeds, after the morning and evening milkings. Grass-silage was individually fed from behind Calan electronic doors, each cow receiving 100 g/kg in excess of what she had consumed on the previous day. The silage was unwilted and had the following analysis: dry matter 221 g/kg, pH 4.42, crude protein 212 g/kg DM, ash 91 g/kg DM, MAD fibre 310 g/kg DM and in vitro DMD 747 g/kg DM.

2.3. Measurements and analysis

In both experiments, milk yield was measured on 5 days per week and milk composition, fat, protein and lactose was determined on successive PM and AM samples once weekly. These milk samples were composited in proportion to yield according to treatment and the fat was analysed for total fatty acid profiles and solid fat content to give a weekly value corresponding to days 2, 9, 16, 23, 30 and 37 after treatment commenced, in Expt. 1 and to days 5 and 12 before and 2, 9, 16 and 23 days after treatment commenced in Expt. 2. In the final week of the trial 500 ml samples of milk were taken from each cow at a successive morning and evening milking. These samples were composited by cow (morning and evening samples mixed in proportion to yield) and the fat was analysed for fatty acid profiles and solid fat content in Expt. 1 and fatty acid profiles in Expt. 2. Concentrates were sampled on six occasions in Expt. 1 and three occasions in Expt. 2. Silage was sampled twice from the face of the clamp in Expt. 1 and twice weekly from the feed boxes in Expt. 2.

All feedstuffs were analysed by standard procedures. Milk composition was determined by automated infrared analysis using a Milkoscan 203 (Foss Electric, Denmark). For detailed fat analysis, cream was obtained by centrifugation and held at −18°C overnight. The cream was warmed to 60°C for 10 min and centrifuged to obtain the milk fat. Fatty acids were analysed as their methyl esters, prepared by transesterification with 2 M methanolic potassium hydroxide (ISO 5009, 1978), by gas-liquid chromatography (GLC) using a Pye Unicam 204 gas chromatograph fitted with dual flame ionization detectors. Separation was carried out on a 2.13 m long × 2 mm i.d. glass column packed with 10% EGA (ethylene glycol adipate) on gas chrom Q 100/120 mesh (Analabs, North Haven, CT, USA). The N_2 carrier gas and H_2 flow rates were 20 ml/min and the air flow rate was 300 ml/min. The injector temperature was 200°C and the detector temperature was 250°C. The chromatograph was programmed from 80°C (with an initial delay of 2 min) at a rate of 16°C/min during each analysis and held at a final temperature of 200°C until all FA were eluted. The fatty acids were identified based on the retention times determined with a fatty acid standard mixture. Peak areas were computed using a Trilab 2000 microcomputer (Trivector Scientific Ltd., UK).

2.4. Statistical analysis

In Expt. 1, data was analysed using the GENSTAT V package (Reference Manual, 1988). Milk yield, constituent yield and composition were analysed using pre-experimental milk yield as a covariate taking out block effects as well as treatments. Total fatty acids and solid fat content in the milk fat was analysed by analysis of variance again taking out block effects as well as treatments. The fatty acid and solid fat data were analysed for linear and quadratic effects of the inclusion level of rapeseed. Statistically significant differences between treatment means were determined using Student's *t*-test.

In Expt. 2, data was analysed using the GLM procedure of SAS (6.04). Milk yield, constituent yield and composition were analysed using data from the immediate pre-experimental week, days in milk and lactation number as covariates and taking out block and treatment effects. Silage intake was analysed using pre-experimental liveweight and lactation number as covariates and taking out block as well as treatment effects. The fatty acids in the milk fat from individual cows were analysed without a covariate but taking out block as well as treatment effects. Statistically significant differences between treatment means were determined using Student's *t*-test.

3. Results

3.1. Experiment 1

The four concentrate mixtures were similar in composition except for oil content which increased with increasing FFR inclusion (Table 1).

Neither milk yield, milk constituent yield or milk composition was significantly different between concentrate treatments (Table 3).

The fatty acid profile of the milk produced on the different concentrate treatments based on the individual cow samples is shown in Table 4. There was a significant linear reduction in the concentrations of C6:0

Table 3
Cow[1] performance on the control and FFR concentrates in Expt. 1

	Concentrate mixtures				SE of diff.[2]
	control	low FFR	medium FFR	high FFR	
Milk yield (kg/day)	21.2	20.7	19.8	20.7	0.96
Fat					
g/kg	31.6	29.6	31.8	30.4	1.27
g/day	660	604	626	623	31.8
Protein					
g/kg	29.4	29.9	30.4	29.5	0.91
g/day	624	617	603	609	33.5
Lactose					
g/kg	48.5	48.8	48.5	49.1	0.63
g/day	1026	1005	958	1011	47.8

[1]Data analysed from 52 cows (13 blocks).
[2]SE of diff. = standard error of difference.

Table 4
Effect of feeding three levels of FFR in the concentrate supplement on the fatty acid composition (g/kg fatty acids) of milk fat in Expt. 1[1]

	Concentrate mixtures				SE of diff.[2]	Significance of effect	
	control	low FFR	medium FFR	high FFR		linear	Quadratic
C4:0	31^{a+}	34^{b}	32^{ab}	31^{a}	1.3	NS	*
C6:0	22^{a}	22^{a}	22^{a}	19^{b}	0.7	**	**
C8:0	13^{a}	13^{a}	13^{a}	11^{b}	0.8	*	NS
C10:0	31^{a}	28^{ab}	29^{a}	23^{b}	2.5	*	NS
C12:0	34^{a}	31^{ab}	33^{a}	26^{b}	2.9	*	NS
C14:0	116^{a}	111^{a}	109^{a}	95^{b}	5.6	***	NS
C14:1	12^{a}	12^{a}	11^{a}	9^{b}	0.9	**	NS
C16:0	307^{a}	295^{a}	261^{b}	243^{b}	12.0	***	NS
C16:1	25^{a}	22^{b}	23^{b}	23^{b}	0.9	*	NS
C18:0	95^{a}	109^{a}	119^{ab}	136^{b}	11.2	***	NS
C18:1	239^{a}	253^{a}	286^{b}	316^{c}	13.7	***	NS
C18:2	21^{ab}	19^{b}	23^{a}	22^{a}	1.1	NS	NS
C18:3	6^{a}	5^{b}	5^{b}	5^{b}	0.3	NS	NS

[1]Data analysed from all cows ($n=64$).
[2]SE of diff. = standard error of difference.
[+]Within rows means not sharing a common superscript differ significantly ($P<0.05$).

Table 5
Effect of feeding three levels of FFR in the concentrate supplement on the solid fat content in the milk fat (g/kg) at different temperatures[1]

Temperature (°C)	Concentrate mixtures				SE of diff.[2]	Significance of effect	
	control	low FFR	medium FFR	high FFR		linear	quadratic
0	574[a+]	571[a]	523[b]	483[b]	21.4	***	NS
5	536[a]	525[a]	473[b]	424[c]	23.2	***	NS
10	448[a]	429[a]	374[b]	322[c]	24.2	***	NS
15	307[a]	300[a]	247[b]	213[b]	22.4	***	NS
20	160[a]	163[a]	130[b]	124[b]	12.8	**	NS
25	80[a]	89[a]	73[ab]	65[b]	7.8	*	NS
30	32[ab]	39[a]	29[ab]	25[b]	5.3	NS	NS

[1]Data from all cows analysed ($n=64$).
[2]SE of diff. = standard error of difference.
[+]Within rows means not sharing a common superscript differ significantly ($P<0.05$).

($P<0.01$), C8:0 ($P<0.05$), C10:0 ($P<0.05$), C12:0 ($P<0.05$), C14:0 ($P<0.001$), C14:1 ($P<0.01$), C16:0 ($P<0.001$) and C16:1 ($P<0.05$) and a significant linear increase in the concentrations of C18:0 ($P<0.001$) and C18:1 ($P<0.001$) with the level of FFR inclusion. No significant linear effects were observed for C18:2 or C18:3. Significant quadratic effects were observed for C4:0 ($P<0.05$) and C6:0 ($P<0.01$) only.

The solid fat content in the milk fat (individual cow samples) between 0 and 30°C from cows on the different concentrate treatments is shown in Table 5. It was significantly lower on the medium FFR and high FFR treatments compared to the other two treatments between 0 and 20°C. At 5 and 10°C the high FFR treatment had a significantly lower solid fat content than the other three treatments. There were significant linear reductions in solid fat content at 0°C, 5°C, 10°C, 15°C ($P<0.001$), 20°C ($P<0.01$) and 25°C ($P<0.05$) as the level of FFR in the diet increased.

The proportions of C16:0 and C18:1 in total fatty acids and the solid fat content in the milk samples composited weekly by treatment over the first 6 weeks of the feeding trial are shown in Fig. 1. The C16:0 proportion tended to increase on the control and low FFR treatments from about 270 g/kg total fatty acids up to 300 g/kg g total fatty acids. Both the medium and high FFR treatments consistently had lower proportions of C16:0 between days 9 and 37 with the high FFR treatment having concentrations under 250 g/kg total fatty acids between days 16 and 37. The C18:1 content of the milk fat was consistently higher on the high FFR treatment between days 9 and 37 reaching a concentration of almost 340 g/kg total fatty acids on day 23. The proportion of C18:1 in the control and low FFR treatments was similar and tended to decrease with time, being at 230 g/kg total fatty acids on day 37. Milk on the medium FFR treatment had C18:1 concentrations which were intermediate (270–290 g/kg total fatty acids) between the control/low FFR and the high FFR treatments between days 23 and 37.

The changes in solid fat content at 10°C during the course of the experiment tended to reflect the changes in fatty acid composition. The high FFR treatment had the lowest solid fat content between days 9 and 37 with concentrations under 330 g/kg on days 16 and 23. The solid fat content tended to increase with time on the control, and low FFR treatments and was at levels of 470–490 g/kg DM on day 37. It also increased on the medium FFR and high FFR treatments between days 23 and 37 and reached levels of 400 and 370 g/kg, respectively.

3.2. Experiment 2

The chemical composition of the three concentrate mixtures is shown in Table 2. The control and MDG1 concentrates were similar in proximate composition except for oil content. As would be expected, including 700 g MDG/kg of concentrate increased the oil content from 22 g/kg DM in the control to 97 g/kg DM in the MDG1 concentrate. Again as would be expected, the MDG2 concentrate was higher in oil at 120 g/kg DM. This concentrate was also higher in crude protein con-

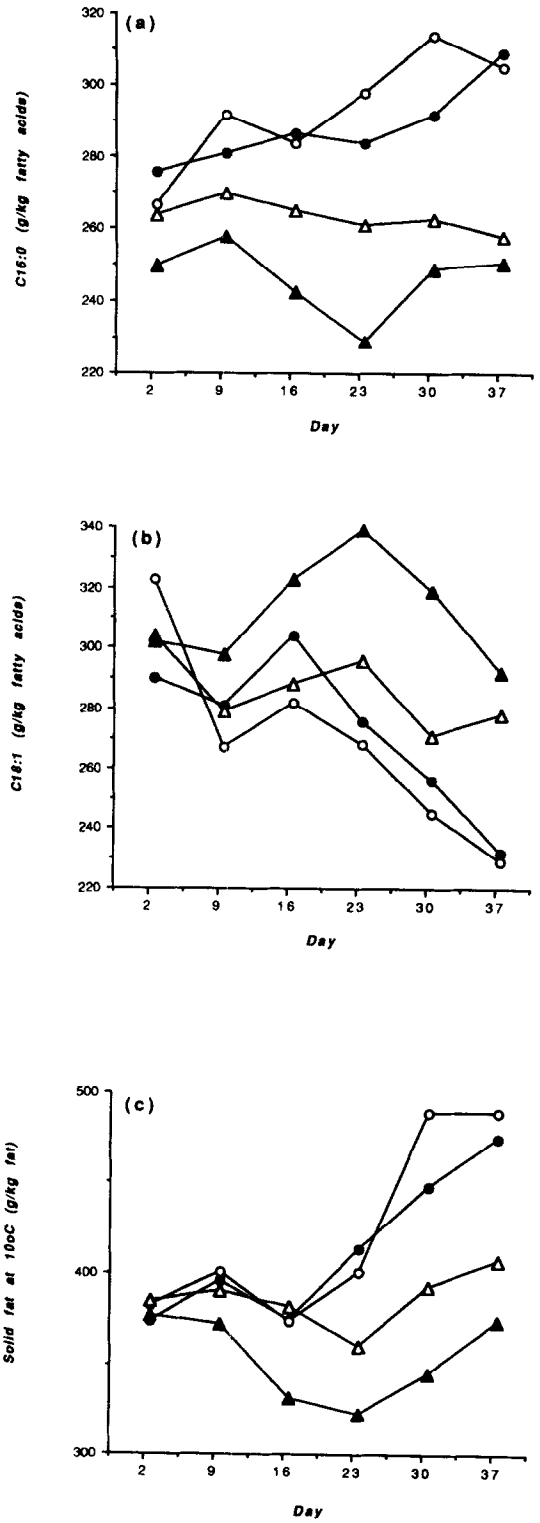

Fig. 1. The (a) C16:0 (g/kg fatty acids), (b) C18:1 (g/kg fatty acids) and (c) solid fat content (g/kg fat) at 10°C in the milk fat from cows fed the control concentrate (○) and the low (●), medium (△) and high (▲) full fat rapeseed concentrates from day 2 to 37 of the feeding period in Expt. 1.

tent and there was an increase in crude fibre content with MDG inclusion. The estimated starch content of the concentrate mixtures decreased from 330 g/kg DM in the control to 130 and 20 g/kg DM in the MDG1 and MDG2 concentrates, respectively.

Cow performance on the three concentrate mixtures is shown in Table 6. Silage intake, milk yield or the concentration or yield of milk fat and lactose were not significantly different between treatments. However, milk protein concentration and yield were significantly depressed ($P<0.05$) by the inclusion of MDG in the concentrate. The depression was numerically greater on MDG2 than MDG1 concentrate although not significantly different.

Table 7 gives the fatty acid profiles of the milk fat produced on the concentrate treatments. The inclusion of both levels of MDG in the concentrate significantly reduced the proportions of C10:0, C12:0, C14:0, C14:1, C16:0, C16:1 and C18:3 ($P<0.05$). It significantly increased the proportions of C4:0, C18:0, C18:1 and C18:2 ($P<0.05$). The proportion of C6:0 was unaffected by the type of concentrate in the diet and in the case of C8:0 only the high level of MDG (920 g/kg) reduced it significantly ($P<0.01$). In the case of C10:0 and C12:0 the MDG2 concentrate resulted in a lower proportion than the MDG1 concentrate ($P<0.05$).

In Fig. 2 the proportions of C16:0, C18:1, and the solid fat content at 10°C in the bulk treatment milks are shown. The concentrate treatments were imposed from day 1. The proportion of C18:1 before the experimental treatments were imposed was similar for all three groups of cows (225–260 g/kg fatty acids). There was little change on day 2 but by day 9 the C18:1 on the MDG1 and MDG2 concentrates was 279 and 310 g/kg of fatty acids compared to 228 on the control. These relative differences were maintained on days 16 and 23. In contrast, the proportion of C16:0 followed the reverse pattern. It ranged from 260–280 g/kg of fatty acids in the three groups of cows before and on day 2 immediately following the feeding of the experimental concentrates but on day 9 and subsequently the pro-

Table 6
The effect of including maize distillers grains in the concentrate mixture at 700 g/kg (MDG1) and 920 g/kg (MDG2) on silage dry matter intake and milk production and composition

	Control	MDG1	MDG2	SE of diff.[1]
Silage DM intake (kg/day)	9.3	8.9	8.9	0.33
Milk yield (kg/day)	22.4	22.7	22.0	0.64
Milk fat				
g/kg	33.0	35.2	35.0	1.13
g/day	748	799	762	36.7
Milk protein				
g/kg	29.5[a+]	27.6[b]	26.7[b]	0.62
g/day	681[a]	624[b]	577[b]	22.9
Lactose				
g/kg	47.6	47.0	46.7	0.67
g/day	1096	1077	1014	49.4

[1]SE of diff. = standard error of difference.
[+]Within rows, means not sharing a common superscript differ significantly ($P < 0.05$).

Table 7
The effect of including maize distillers grains at 700 g/kg (MDG1) and 920 g/kg (MDG2) in the concentrate supplement on milk fat fatty acid composition in Expt. 2

	Control	MDG1	MDG2	SE of diff.[1]
C4:0	36[a]	41[b]	43[b]	1.3
C6:0	24	25	23	0.9
C8:0	15[a]	15[a]	13[b]	0.7
C10:0	33[a]	29[b]	23[c]	1.9
C12:0	37[a]	31[b]	26[c]	2.2
C14:0	113[a]	90[b]	84[b]	6.4
C14:1	11[a]	9[b]	9[b]	0.5
C16:0	288[a]	244[b]	244[b]	7.4
C16:1	23[a]	19[b]	19[b]	1.0
C18:0	118[a]	141[b]	136[b]	5.5
C18:1	226[a]	270[b]	293[b]	11.9
C18:2	17[a]	28[b]	31[c]	1.7
C18:3	5[a]	4[b]	4[b]	0.5

[1]SE of diff. = standard error of difference.
[+]Within rows, means not sharing a common superscript differ significantly ($P < 0.05$).

portion of C16:0 on the control concentrate remained close to 300 g/kg of fatty acids, while the proportion on the MDG1 and MDG2 concentrates stabilised at about 250 g/kg of fatty acids. The solid fat content at 10°C was between 420 and 460 g/kg before and immediately after introducing the experimental concentrates. Subsequently, the content on the control concentrate was between 450 and 500 g/kg, whereas on the MDG1 and MDG2 concentrates it was about 350 and 310 g/kg, respectively.

4. Discussion

4.1. Cow performance

The inclusion of either FFR or MDG in the concentrate did not affect milk, fat or lactose concentrations

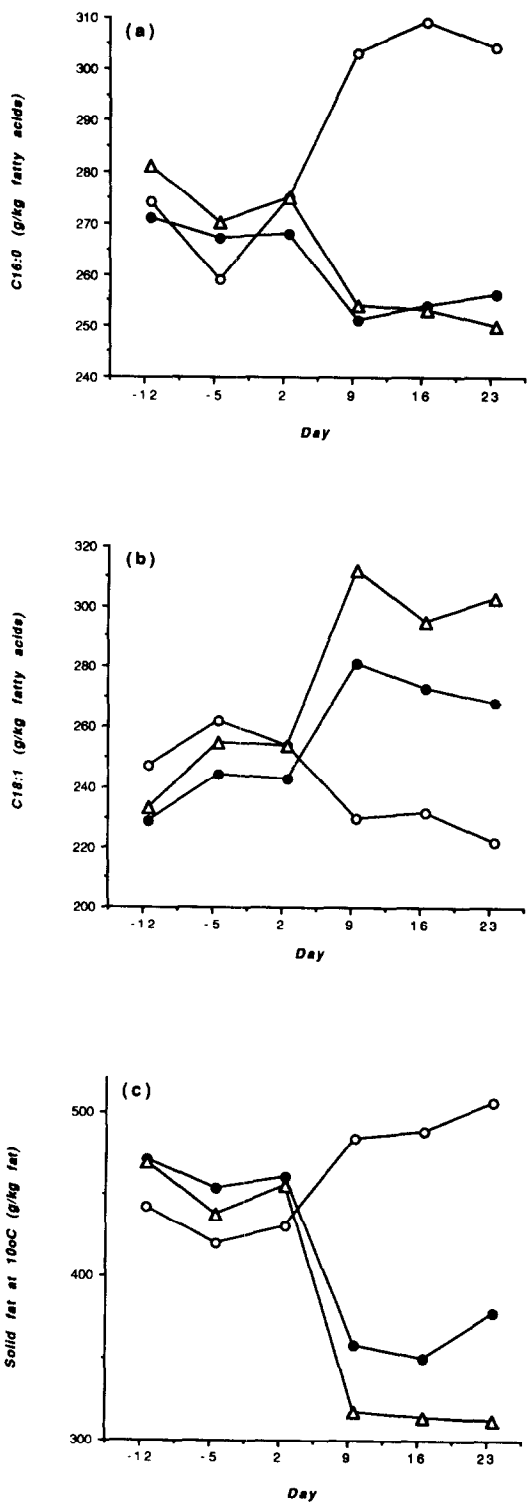

Fig. 2. The (a) C16:0 (g/kg fatty acids), (b) C18:1 (g/kg fatty acids) and (c) solid fat content (g/kg fat) at 10°C in the milk fat from cows fed the control concentrate (○), MDG1 (●), MDG2 (▵) concentrates, before and after supplementation was commenced on day 1 in Expt. 2.

or yield. However, MDG inclusion significantly reduced protein concentration and yield, whereas FFR had no effect. These results are in broad agreement with recently published reports on feeding FFR (Emanuelson, 1989) and MDG (Palmquist and Conrad, 1982; van Horn et al., 1985; Voss et al., 1988; and Foster and Larson, 1991). These authors observed significant decreases in milk protein with diets containing distillers grains compared to soyabean meal, whereas Emanuelson (1989) found no such effect with FFR. The decreased starch content of the MDG concentrates should not have been a factor as the estimated total starch intake on the control concentrate only accounted for 12 per cent of total DM intake. The medium FFR, high FFR, the MDG1 and MDG2 concentrates supplied 520 g, 680 g, 582 g and 720 g of oil, respectively, per day. Therefore, the difference in the effect on milk protein is unlikely to be due to differences in the level of oil intake. The fatty acid composition of the oil supplied from FFR and MDG would be quite different in terms of the supply of C18:1, C18:2 and C18:3, but this is also unlikely to be the reason for the different effect. In a recent review, Wu and Huber (1994) found that the depression in milk protein concentration occurred regardless of the type of fat fed. The different effect on milk protein due to MDG and FFR feeding observed in this experiment may be due to the slow release of oil in the rumen from the FFR, minimising its negative effect on rumen metabolism, as suggested by Emanuelson (1989). The oil in the MDG concentrates would be much more available in the rumen. Also with the MDG concentrate there may have been a limitation in lysine supply to the mammary gland. It has been demonstrated that lysine supply to the duodenum is lower in diets containing corn or corn by-products (Oldham, 1981).

4.2. Milk fat composition

Feed and animal factors influencing milk fat composition have been recently reviewed by Palmquist et

al. (1993). It is accepted that because of the mammary stearyl CoA desaturase, increasing the supply of C18:0 to the gland increases the C18:1 in milk fat and decreases the C16:0 due to a decrease in de-novo synthesis. These are the changes in milk fatty acid composition observed in the two experiments reported here as well as a decline in the medium chain-length (C10 to C14) fatty acids. These changes are similar to those observed previously with feeding of full fat rapeseed (Handy and Kennelly, 1983; Emanuelson, 1989; Murphy et al., 1990), full fat soyabeans (Perry and McLeod, 1968; Murphy et al., 1990), soya oil (Banks et al., 1980), sunflower seeds (Rafalowski and Park, 1982) or whole cottonseed (De Peters et al., 1985). With FFR feeding the change in proportions of C16:0 and C18:1, the fatty acids having most impact on softness, only reached significance on the medium FFR and high FFR treatments where 1.12 and 1.60 kg of FFR was fed daily per cow. The low FFR treatment (0.64 kg FFR/cow/day) had very little effect on the fatty acid profiles of the milk fat. The proportion of C18:1 on the medium FFR treatment in the present experiment is similar to that measured by Murphy et al. (1990) where 1.05 kg of FFR was fed. Feeding the higher level of 1.60 kg per cow per day of FFR (high FFR) significantly increased the C18:1 further to 316 g/kg fatty acids.

Both oil sources used have approx. 900 g/kg of their fatty acids as 18-carbon fatty acids. The relative proportions of C18:0, C18:1, C18:2 and C18:3 in them would be quite different but as hydrogenation is extensive in the rumen most would be converted to C18:0. The changes in milk fatty acid composition were similar with both oil sources which would be compatible with the assumed mechanism of rumen hydrogenation and subsequent desaturation in the mammary gland.

While the treatment composite samples analysed during the course of the experiment showed variations in the proportions of C16:0 and C18:1 particularly in the FFR experiment the differences between treatments were similar to those observed in the individual cow analyses. The full effect on the milk fatty acid composition was not evident immediately but the differences between treatments were apparent on day 9 after treatment commenced in both experiments.

4.3. Milk fat softness

The solid fat content at 10°C is a good indicator of the degree of softness of the milk fat. This decreased to less than 350 g/kg with both the high FFR and MDG2 concentrates and at this concentration butter manufactured from this milk fat should be spreadable at refrigeration temperatures. In the FFR experiment the solid fat content at 10°C tended to increase on all treatments between day 23 and 37 which was a reflection of the fatty acid composition.

5. Conclusions

The results of these experiments show that, on a grass-silage based diet, feeding 1.12 or 1.60 kg of FFR or 4.20 or 5.52 kg of MDG in the concentrate supplement daily significantly alters the fatty acid profile of milk fat. The result is an increased level of C18:1, a decreased level of C16:0 and a softer milk fat. The greatest change in fatty acid composition and milk fat melting profile was achieved with 1.6 kg of FFR daily without any negative effects on cow performance. The high levels of MDG given here did have the desired effect on the fatty acid profile and physical characteristics of the milk fat but their use at these levels may be undesirable because of the negative effects on milk protein.

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Kurzfassung

Murphy, J.J., Connolly, J.F. und McNeill, G.P., 1995. Einfluß der / fütterung von Konzentraten mit Rapsschrot und Mais-Schlempefeststoffen zu einer Grassilageration auf die Milchfettzusammensetzung und die Milchleistung von Kühen. *Livest. Prod. Sci.*, 44: 1–11.

Es wurden zwei Experimente durchgeführt, um den Einfluß von Rapsschrot (FFR) und Mais-Schlempefeststoffen (MDG) als Zusätze zum Fraftfutter auf die Leistung und die Milchfettzusammensetzung von Kühen zu untersuchen. Grasanwelksilage bildete die Raufuttergrundlage in beiden Experimenten. Im ersten Experiment wurden 1,8 kg Konzentrat/Tag verabreicht, das 0 g (Kontrolle), 80 g (niedrig), 140 g (mittel) oder 200 g/kg (hoch) Rapsschrot enthielt und an vier Gruppen von je 16 Tieren über 7 Wochen gefüttert wurde. Die Milchmengenleistung, die Leistungen an Milchinhaltsstoffen und die Milchzusammensetzung, die durch die Verwendung von 13 Kühen je Behandllung verglichen wurden, waren durch die Anwendung von Rapsschrot nicht signifikant beeinflußt. Das Milchfett (bei Verwendung aller 64 Tiere) von Kühen der hohen Rapsschrotkonzentration enthielt signifikant weniger Anteile an C6:0, C8:0, C14:0, C14:1 ($P<0,05$) im Vergleich zu jenen,, die von den Kühen der anderen drei Konzentratstufen produziert wurde. Es enthielt auch weniger Anteile an C10:0 und C12:0 ($P<0,05$) im Vergleich zu jenem Milchfett, das von den Kühen der Kontrolle und der mittleren Rapsschrotkonzentration stammte. Die Kühe mit der hohen und mittleren Rapsschrotkonzentration hatten signifikant geringere Anteile an C16:0 ($P<0,01$) und signifikant höhere Anteile C18:' ($P<0,05$) in ihrem Milchfett im Vergleich zu den anderen beiden Behandlungen. Der Anteil von festen Fetten in der Milch bei 10°C war auch signifikant niedriger als die vorhergehenden beiden Behandlungen ($P<0,05$). In dem zweiten Experiment wurden 6 kg Kraftfutter je Tier und Tag verabreicht, das 0 g (Kontrolle), 700 g (MDG1) und 920 g/kg (MDG2) enthielt. MDG wurde an drei Gruppen zu je 12 Kühen 6 Wochen gefüttert. Die Silageaufnahme, die Milchleistung sowie die Konzentration und die Leistung an Milchfett und Laktose waren zwichen den Behandlungen nicht signifikant verschieden. Die Millchproteinkonzentration und die Milchproteinmenge waren durch die Hinzunahme von MDG in die Ration auf beiden Stufen niedriger. Weiterhin reduzierte die Einbeziehung von MDG die Anteile von C10:0, C12:0, C14:0, C14:1, C16:0, C16:1, und C18:3 ($P<0,05$) und erhöhte gleichzeitig die Anteile von C4:0, C18:0, C18:1, und C18:2 ($P<0,05$) signifikant. Die veränderte Fettsäurenzusammensetzung verursachte ein weicheres Fett, wie der Fest fettanteil bei 10°C zeigte, der mit 480, 355 und 314 g/kg bei der Kontrolle sowie den MDG1- und MDG2-Konzentraten, 8 Trage nach Beginn der Fütterung festgestellt wurde. Die Ergebnisse dieser Experimente zeigen, daß bei einer Grundration von Grassilage das Fettsäureprofil des Milchfetts in Richtung eines weicheren Fettes durch die Fütterung von 1,12 oder 1,60 kg FFr bzw. 4,20 oder 5,52 kg MDG als Konzentratsupplement verändert werden kann. FFR mag das Supplement der Wahl sein, weil das erforderliche Niveau von MDG für eine ähnliche Veränderung in der Milchfettzusammensetzung und im Weichheitsgrad negative Effekte auf den Milcheiweißgehalt hat.