

# The effect of rolled rape seeds on milk composition and lactational responses

**W. Nowak and A. Potkański**

*Institute of Animal Nutrition and Feed Management,  
August Cieszkowski Agricultural University  
Wółyńska 33 , 60-637 Poznań, Poland*

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## ABSTRACT

Forty-five multiparous cows (74-146 d after calving) were blocked into 3 groups of 15 animals on the basis of calving date and milk yield. Within each group the cows were allotted at random to treatment sequences in a 3x3 Latin square design. Cows were fed a ration composed of pasture, maize silage and meadow hay. Treatments were: control (CK), 6 kg concentrate without rolled rape seeds (WRS), MR – 5 kg concentrate and 0.7 kg WRS and HR – 4 kg concentrate and 1.4 kg WRS. The administration of 1.4 kg (HR) rolled rape seeds per cow insignificantly increased the daily milk yield by 1.2 kg and milk fat content. Supplemental fat tended to nonsignificantly decrease the percentage protein content in milk (CK, 3.10, MR, 3.03, HR, 3.04), but the total daily protein production was not affected by treatment. Rolled rape seeds affected the fatty acid composition of milk fat. There was a significant ( $P < 0.05$ ) increase of C 18:1 and C 18:3 content as a result of adding WRS, but no effect on C 18:2 concentration.

**KEY WORDS:** cows, rolled rape seeds, milk composition, fatty acids

## INTRODUCTION

Consumers today are more health-conscious and demand dairy products lower in milk fat, especially saturated fatty acids. Dietary manipulation is one of the methods used to alter the fatty acid composition of milk. The ideal milk fat, based on current recommendations, would contain >10% polyunsaturated fatty acids, >82% monounsaturated fatty acids and <8% saturated fatty acids (Baer, 1991). Recent studies confirmed the possibility of increasing the concentration of unsaturated fatty acids in milk by providing cows unsaturated fats fed with plant seeds,

soyabean, sunflower, and cotton seeds. Full fat oilseeds have mainly been used for dairy cows: whole sunflower seeds (Rafalowski and Park, 1982), whole cottonseeds (Coppock et al., 1987), evening primrose seeds (*Oenothera paradoxa*) (Strzetelski et al., 1999), rape seeds (Murphy et al., 1987; Strzetelski et al., 1992, 1998).

Fat supplements are often added to dairy rations during lactation when milk energy exceeds energy consumed. Fat addition increases the efficiency of fat utilisation, enhances the lipogenic:glucogenic ratio, and increases the concentration of energy in the diet without decreasing its fibre content (Palmquist and Jenkins, 1980). However, results from feeding trials that were designed to assess supplemental fat are so far inconsistent. Fats have been reported to inhibit fermentation, particularly crude fibre (Kowalczyk et al., 1977; Nowak, 1997), reduce roughage intake (Steele, 1985), and change the acetate:propionate ratio leading to a decrease in milk fat content. Development of ruminally inert fats (Ca-salts, prilled fat) has partially overcome some negative effects of normal fats (oils, tallow) on ruminal fermentation. However, inert fats usually are more expensive than normal fats. Utilisation of whole rape seed by ruminants without chemical treatment with NaOH or H<sub>2</sub>O<sub>2</sub> (Hussein et al., 1996) is limited by the thick seed coat. Rolling rape seeds could be an inexpensive method of preparing these seeds. Because of the slow liberation of oil from rape seeds, this treatment could only slightly interfere in rumen fermentation while permitting enzymatic digestion in the small intestine and modification of milk fat fatty acid composition.

The objective of the study was to examine the effect of replacing concentrate by rolled rape seeds (WRS) from the Polish double improved variety Jantar, on milk production, milk fat and protein contents and on the fatty acid composition of milk fat.

## MATERIAL AND METHODS

Forty-five multiparous cows (74-46 d after calving) were blocked into three groups of fifteen animals on the basis of calving date and milk yield. Within each group the cows were allotted at random to treatment sequences in a Latin square design. Rolled whole rape seeds (WRS) 0.0, 0.7 kg and 1.4 kg were offered in 3x3 Latin square design with 21 day periods. Treatments were: control (CK) – 6 kg concentrate without WRS, MR – 5 kg concentrate and 0.7 kg WRS, and HR – 4 kg concentrate and 1.4 kg WRS. One kg of concentrate was replaced by 0.7 kg of WRS because of the higher concentration of energy and protein in rape seeds than in concentrate. The nutritive values of feeds (energy value UFL, protein digestible in the intestine PDIE, and PDIN) were calculated according IZ-INRA (1997) using INWAR ver. 1.0.

The forage portion of each diet consisted of pasture, maize silage and meadow hay. Grass pasture intake was measured once a week for all experimental cows according to Gawęcki (1994), and intake of hay and maize silage individually every day. Maize silage, concentrate and meadow hay were sampled weekly throughout the experiment and frozen at  $-20^{\circ}\text{C}$ . Samples were combined into period composites and dried at  $50^{\circ}\text{C}$ . Dry matter, crude protein, ether extract and ash in the feed sample were analyzed according to AOAC (1990). Cows were milked twice daily and milk yield was measured daily. Once a week the milk samples from morning and afternoon milking were analyzed for the content of fat and protein. Once on day 18 of the experimental periods, milk samples were also analyzed for fatty acid composition. Protein and fat in milk were analyzed using a Foss Milko-Scan. Fatty acids in milk were determined by gas chromatography (Chrom 5) on a fused silica capillary column coated with a Supelco -SP- 216PS film as described by Man (1966).

On day 21 of each period jugular blood samples were collected from all cows 2 h after the morning feeding. Serum samples were prepared by centrifugation and stored at  $-20^{\circ}\text{C}$  before being analyzed for glucose, urea and cholesterol using Sigma kits.

Data were analyzed using StatGraph ver. 7.0 procedures.

## RESULTS AND DISCUSSION

Chemical composition and nutritive value of feeds are given in Table 1. Rape seeds contained 404 g of ether extract in one kg of DM and as a result the average ether extract concentrations increased by 221 g for diet MR, and by 439 g for diet HR because of the inclusion, respectively, of 0.7 or 1.4 kg WRS. Replacing con-

TABLE I

Chemical composition and nutritive value of feeds, %

Items	Concentrate	Rape seed	Maize silage	Hay
DM % as fed	89.3	90.5	27.4	92.4
Crude protein	15.62	18.46	2.59	10.4
Ash	3.12	3.52	1.26	4.52
Crude fibre	5.00	8.95	6.41	26.3
Ether extract	3.21	36.56	0.87	2.49
PDIE	10.62	3.07	1.64	6.74
PDIN	9.38	11.76	1.42	5.91
UFL	0.94	1.14	0.24	0.63

IZ-INRA (1993): UFL-unit for milk production; PDI-protein truly digestible in the small intestine; PDIN -PDI dependent on  $\text{NH}_3\text{-N}$  amount; PDIE-PDI dependent on energy amount

concentrate with WRS in the diet provided approximately 1.15% and 2.31% percentage units of additional fat in dry matter of the diet. Thus, the amount of fat in the HR diet did not exceed the 5-6% unprotected fat recommended by Palmquist (1991). The average intake of pasture grass was approximately 44 kg (6.92 kg DM), maize silage 14 kg (3.87 kg DM) and meadow hay 2.5 kg (2.31 kg DM). Rape seeds had no significant effect on the intake of maize silage and hay, similarly to the results of Hussein et al. (1996). Other researchers also indicated that dry matter intake was not affected by supplementing diets with ground or extruded rape seed as 3% added fat (Wiesen et al., 1989) or Jet-Sploded rape seeds (Khorasani et al., 1992). Gagliostro and Chilliard (1991) found that although fat supplementation lowered dry matter intake, energy intake was not decreased. Smith et al. (1978) concluded that gut fill, palatability or concentration of blood metabolites were not major factors limiting energy intake in diets containing protected tallow. The negative effect of fat on dry matter intake tends to increase as fat saturation decreases and as the amount of fat supplementation increases (Pantoja et al., 1996). The effect of added fat on voluntary feed intake seems to depend on the type of fat used, the way in which it is added, and the amount used (Clapperton and Steele, 1983). Steele (1985) suggested that oil and fats exert an influence on DM consumption by physically preventing ruminal micro-organisms from gaining access to other dietary constituents or alternatively, free fatty acids released by hydrolysis may have toxic effects on some microbes, leading to altered populations within the rumen.

The administration of 1.4 kg rolled rape seeds (HR) (Table 2) per cow nonsignificantly increased the yield of milk, milk fat content ( $P < 0.05$ ) and significantly increased daily fat production by 89 g per day similarly to the results obtained by Clapperton and Steele (1983). Strzetelski et al. (1992) found a higher FCM yield among cows fed control diets without rape seeds and formaldehyde- or heat-treated rape seeds.

TABLE 2

Mean daily milk yield, fat and protein content in milk

Item	Diets			SEM
	CK <sup>1</sup>	MR <sup>2</sup>	HR <sup>3</sup>	
Daily milk yield, kg	18.4	18.9	19.6	3.67
Fat, %	3.98	4.12	4.20	0.32
Protein, %	3.10	3.03	3.04	0.28
Fat, g/day	733 <sup>a</sup>	779 <sup>b</sup>	822 <sup>b</sup>	91
Protein, g/day	571	573	595	45
Fat+protein, g/day	1304 <sup>a</sup>	1352 <sup>ab</sup>	1417 <sup>b</sup>	151

<sup>a,b</sup>  $P < 0.05$ <sup>1</sup> CK – control<sup>2</sup> MR – with 0.7 kg rolled whole rape seeds<sup>3</sup> HR – with 1.4 kg rolled whole rape seeds

Murphy et al. (1990) reported no significant effect of including 15% unrolled whole rape seeds in the concentrate and a significant increase of cow performance as result of including the same amount of ground rape seeds. Shingoethe et al. (1996) recorded an increase of milk production as an effect of supplementing fat by using sunflower seeds and extruded soyabeans, and no significant effect on milk composition. On the other hand, Syrjällä-Qvist and Aspilla (1984) found no significant effect of added crushed canola seeds on fat content, milk yield and protein level. Holter et al. (1992) suggested that the substitution of fat for some of the concentrate, even if it did not reduce total dry matter intake or digestion rate under *ad libitum* intake, would enhance energy intake and even prevent milk fat depression. In a previous experiment milk fat percentage was depressed in cows fed high-linoleic and high-oleic sunflower oil (Kalschuer et al., 1997), soyabean oil (Banks et al., 1980), whole sunflower seeds (Casper et al., 1988), and extruded soyabeans (Kim et al., 1991). Palmquist and Jenkins (1980) pointed out that polyunsaturated fatty acids in particular inhibit the growth of ruminal microbes, which can reduce microbial digestion of fibre, protein synthesis and volatile fatty acid (VFA) production as the fatty acid content in the ration increases, unless these fatty acids are made insoluble by saponification with Ca.

In the present study, dairy cows received supplemental fat that tended to decrease the percentage of protein in milk, but total daily protein production was not affected by the treatment. In the experiment of Strzetelski et al. (1992), ground formaldehyde- or heat-treated rape seeds lowered the milk protein content, but these differences were not statistically significant. Holter et al. (1992) found a negative effect of whole cottonseed on milk protein content, similarly to results obtained by Palmquist and Jenkins (1980), Coppock et al. (1987), and Khorasani et al. (1991). Casper and Shingoethe (1989) suggested that supplemental fat inhibits the release of somatotropin, thereby reducing mammary uptake of amino acids. In contrast, Smith et al. (1978) stated that reduced VFA production can influence the synthesis of milk constituents, and milk protein synthesis usually does not decline during fat supplementation, but the depression in milk protein concentration, associated with dietary addition of fat is also related to reduced availability of glucose. Lower propionate production may increase the utilisation of amino acids available for milk synthesis. Khorasani et al. (1991) supposed that lower milk protein content may be related to lower acetate production in the rumen, which could increase the utilisation of amino acids as an energy substrate.

Dietary manipulation is one of the factors altering the fatty acid composition of milk fat. Clinical research has indicated that C 18:1 present in rapeseed oil has a hypocholesterolemic effect equivalent to that of C 18:2, and has the ability to lower the risk of coronary heart disease (Noakes et al., 1996). Milk products that contain less saturated fatty acids and more unsaturated C:18 may be desirable to health-conscious consumers. In general, short-chain fatty acids are synthesized in

the mammary gland, while long-chain fatty acids arise from mobilization of body reserves or from dietary sources. Rape seed has a unique fatty acid profile, 40% fat (unsaturated fatty acids) that consists primarily of oleic, 55%, linolenic, 25%, and linoleic acids, 14%. The fatty acid composition of milk fat in our experiment was affected by including rolled whole rape seeds (Table 3). There was a significant ( $P < 0.05$ ) increase of C 18:1 and C 18:3 content as a result of adding WRS, but no effect on the concentration of C 18:2. When Strzetelski et al. (1992) fed formaldehyde- or heat-treated ground rape seeds, they obtained a significant increase of C 18:1, C 18:2 and C 18:3 fatty acids in milk fat. Banks (1987) suggested that elevated levels of oleic acid in milk fat are due to either increased dietary C 18:1, as a result of partial rumen hydrogenation, or increased desaturation of C 18:0 in the gut wall and the mammary gland. These changes in milk unsaturated fatty acid composition and the lower content of C 18:0 were probably influenced by a relatively low rate of biohydrogenation of oleic and linoleic acids in the rumen, which is rather typical of inert rumen fermentation sources of unsaturated fats. Changes in unsaturated fatty acids were not as great as those that occurred with abomasal infusion of oils (Christensen et al., 1994), demonstrating the biohydrogenation that occurred when WRS were fed in the present experiment. A linear decrease in C 16:0, and linear increases in C 18:1, C 18:2

TABLE 3

Fatty acids composition of milk fat, g per 100 g of total fatty acids

Fatty acids	Diets <sup>1</sup>			SEM
	CK	MR	HR	
C 4:0	2.8	3.1	3.2	0.12
C 6:0	2.5	2.1	2.2	0.18
C 8:0	0.9	0.8	0.7	0.11
C 10:0	2.1	1.9	2.0	0.43
C 12:0	3.1	3.1	2.9	0.37
C 14:0	11.9	10.9	11.4	3.33
C 14:1	0.2	0.2	0.2	0.09
C 15:0	1.4	1.0	1.1	0.13
C 15:1	1.1	-	1.4	0.18
C 16:0	29.4	27.6	28.0	9.38
C 16:1	1.6	0.9	2.1	0.27
C 17:0	0.1	0.1	0.1	0.02
C 18:0	13.8 <sup>a</sup>	10.9 <sup>b</sup>	11.4 <sup>b</sup>	3.30
C 18:1	24.7 <sup>a</sup>	29.7 <sup>b</sup>	28.3 <sup>b</sup>	11.24
C 18:2	1.7	1.7	1.5	0.41
C 18:3	0.5 <sup>a</sup>	0.6 <sup>a</sup>	0.8 <sup>b</sup>	0.20
C 20:0	0.7 <sup>a</sup>	1.6 <sup>b</sup>	1.2 <sup>c</sup>	0.10

<sup>a,b,c</sup>  $P < 0.05$

<sup>1</sup> as in Table 1

and C 18:3 were observed (St John et al., 1987) after abomasal infusion of dairy cows with graded concentrations of rape seed oil. Kalscheur et al. (1997) reported that addition of sunflower oil decreased percentages of C 14:0, C 15:0, C 16:0, C 17:0 and C 18:3, increased the concentration of *cis* C 18:1, and no change of C 18:2. Shingothe et al. (1996) found significant changes of fatty acid composition by reducing saturated fatty acids from 71 to 60%, and increasing polyunsaturated fatty acids from 2.3 to 4% as a result of including whole cottonseed and extruded soyabbeans. Milk from cows fed whole cottonseed and Ca-tallowate in the experiment of Lubis et al. (1990) contained unsaturated fatty acids (mostly C 18:1) and lesser quantities of short-chain fatty acids. Chouinard et al. (1997) found that increasing the amount of dietary fat linearly decreases the proportion of C 12:0, C 14:0 and C 16:0 in milk. Inclusion of rape seeds in the diet improved the softness of milk fat by raising the iodine number and decreasing the melting points of milk fat (Murphy et al., 1990).

Most previous studies (Bines et al., 1978) indicated that the plasma glucose concentration does not change when fat is fed to dairy cows. Our results (Table 4) confirm those of Khorasani et al. (1992) who found higher concentration of glucose in plasma as an effect of including canola fat, as in our experiment. In the present study, total serum cholesterol increased as the level of WRS inclusion increased. Khorasani et al. (1992) observed a positive relationship between serum cholesterol and dietary fat, however, Schneider et al. (1988) reported no change in plasma cholesterol when inert fat was fed to lactating cows. These results suggest that the impact of dietary fat on plasma cholesterol concentration will vary, depending on the dietary level of fat and type of diet.

TABLE 4

The effect of dietary addition of rolled rape seeds on plasma metabolites, mmol/l

Item	Diets <sup>1</sup>			SEM
	CK	MR	HR	
Glucose	2.86 <sup>a</sup>	3.07 <sup>a</sup>	3.41 <sup>b</sup>	0.24
Urea	2.31	2.34	2.12	0.17
Cholesterol	2.30 <sup>a</sup>	3.60 <sup>b</sup>	3.48 <sup>b</sup>	0.67

<sup>a,b</sup> P<0.05

<sup>1</sup> as in Table 1

The results of our experiments suggest that feeding lipid in the form of rolled rape seeds improves its chances of escaping biohydrogenation in the rumen and more rumen by-passed lipids would be digested in the intestine. The results of the present study indicate that use of WRS would result in positive changes in the fatty acid composition without negative effects on milk production.

## CONCLUSIONS

Rolled whole rape seeds used at a level of 0.7 -1.4 kg/day per cow can substitute for a part of concentrate in feeding high yielding cows in the first part of lactation. The feeding of rolled rape seeds rich in unsaturated fatty acids can have a beneficial effect on fatty acid composition of milk fat. The inclusion of rolled rape seeds also increased serum glucose and total cholesterol concentrations.

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## STRESZCZENIE

### **Wpływ gniecionych nasion rzepaku na wydajność i skład chemiczny mleka**

Przeprowadzono doświadczenie na czterdziestu pięciu krowach mlecznych w układzie 15 łączonych kwadratów łacińskich 3x3. Dawka kontrolna CK zawierała 6 kg mieszanki treściwej bez dodatku nasion rzepaku, dawki doświadczalne zawierały: MR – 5 kg mieszanki treściwej + 0,7 kg gniecionych nasion rzepaku (WRS), HR – 4 kg mieszanki treściwej + 1,4 kg gniecionych nasion rzepaku. Dodatek 1,4 kg nasion rzepaku do dawki złożonej z zielonki pastwiskowej, kisonki z kukurydzy i siana spowodował zwiększenie wydajności mleka o 1,2 kg oraz dobowej produkcji tłuszczu o 89 g. Stwierdzono przy tym tendencję do zmniejszenia procentowej zawartości białka w mleku (CK-3,10%, MR-3,03%, HR-3,04%), jednak dobowa produkcja białka nie różniła się istotnie pomiędzy dawkami. Dodatek tłuszczu spowodował istotne ( $P < 0,05$ ) zwiększenie udziału kwasów nienasyconych C 18:1 i C 18:3 w tłuszczu mleka.