

# The effect of feeding ground formaldehyde- or heat-treated rape seeds on cow performance and milk composition

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## ABSTRACT

Thirty-two lactating dairy cows, divided into four groups of eight cows each, were fed from day 10 to 110 of lactation rations composed of maize silage, meadow hay and concentrate mixture (control group K), with an addition of ground rape seeds var. Jantar OO: unprotected (group RN), treated with formaldehyde (group RF) or heat-treated (group RO). The daily ration of ground seeds was 1.5 kg per cow. In addition, all of the cows in each group received extra concentrate mixture in amounts depending on their milk yield. Cows from group K had a lower FCM (approximately 21 kg per day ( $p \leq 0.05$ ) than those in groups RF and RO (about 23 kg each). Milk yield in group RN (21.5 kg) did not significantly differ from the others. The difference in the percentage fat content in the milk was statistically significant ( $p \leq 0.05$ ) only between group K (3.88) and RF (4.29). The milk from cows in groups RF and RO contained less protein than the others, but these differences were not statistically significant. The unsaturated fat content in the milk fat of cows receiving rape seeds was higher, especially in group RF, than in the control.

**KEY WORDS:** dairy cows, rape seeds treatment, milk, fatty acids

## INTRODUCTION

Earlier studies carried out in the Institute of Animal Production showed that addition of crushed rape seeds or soya bean treated with formaldehyde to the diets of dairy cows improved the productivity and milk fat content, decreased hydrogenation of fats in the rumen and altered the composition of milk (Stankiewicz, 1987; Stasiniewicz, 1982; Strzetelski et al., 1987a; Strzetelski et al., 1987b). When Kraszewski et al. (1989) fed roasted meal from whole rape seeds, they obtained an increase in productivity and milk fat content. Ruegsegger and Schultz (1985) fed cows heated soya bean seeds and found a higher milk yield and changes in rumen fermentation and nitrogen metabolism. However, Driver et al. (1990) did not find any significant differences in daily milk production and

composition when providing a diet containing heated soya bean seeds or heated soya bean oilmeal.

The objective of this study was to compare the effects of feeding, ground rape seeds from the Polish double improved variety, Jantar, treated with formaldehyde with that made from heated seeds on milk production, milk fat and protein contents and on the fatty acid composition of milk fat.

#### MATERIAL AND METHODS

Thirty-two Black and White Lowland cows were divided by the analogue method into four groups of eight cows each, taking into account the consecutive (1-3) and stage of lactation and daily milk yield, and were given from day 10 to 110 of lactation a basic diet composed of (in kg): maize silage 30, meadow hay 5, lucerne meal 1 and concentrate mixture 3 without rape seeds (control group K) or with rape seeds (1.5 kg) in the form of: untreated ground rape seeds (group RN), formaldehyde-treated (group RF) or heat-treated (group RO). The basic diet was supplemented with 100 g of a mineral mixture. According to Polish standards (oat feed units and crude protein) the basic ration covered the maintenance requirement plus that for production of 14 litres of milk. For every additional litre, the cows received 0.4 kg of concentrate mixture (Table 2).

Rape seeds were ground in a universal grinder using 4 mm sieves. The ground seeds were treated with formaldehyde at a ratio of 4 g/100 g of crude protein (Strzetelski et al., 1987a) or heated to 70-80°C for 3 hours in a horizontal drier, then ground.

Milk yield was recorded daily during the experiment while milk fat and protein contents, weekly. Samples were taken once on day 90 to determine the fatty acid composition.

The chemical composition of the feeds was determined by the conventional methods, the protein and fat contents of milk were determined using a Milko Scan 104 apparatus. Fatty acids in rape seeds and milk fat were assayed as fatty acid methyl esters by gas chromatography (Pye Unicam 104) on a 10 EGSS-X Gas Chrom P column, while the glucosinolate content of rape seeds was assayed by the Wetter method (1955, 1957).

The energy value of the rations was calculated using the INRA nutritional value tables, expressing it as metabolizable energy in MJ and net energy for lactation in feed units for milk production (UFL) and as the nutritive value of ration protein dependent on the protein digested in the rumen (PDIN) and on the digestible organic matter content fermented in the rumen (PDIE).

Statistical analysis was carried out by single variable variance analysis and multiple range test using the Statgraphics program, ver. 2.6 (1985/87).

## RESULTS

The composition of the feeds is given in Table 1.

TABLE 1

Chemical composition of feeds, %

| Feed                      | Dry matter | Crude protein | Ether extract | Crude fiber | N-free extractives | Ash  |
|---------------------------|------------|---------------|---------------|-------------|--------------------|------|
| Barley, ground            | 86.40      | 11.26         | 1.83          | 5.60        | 65.14              | 2.57 |
| Wheat bran                | 87.23      | 15.27         | 4.18          | 11.23       | 52.09              | 4.46 |
| Soya bean oilmeal         | 89.00      | 46.11         | 0.65          | 4.89        | 29.54              | 7.81 |
| Rape seed var. Jantar 00* | 93.04      | 22.57         | 42.31         | 9.14        | 14.02              | 5.00 |
| Meadow hay                | 84.63      | 9.11          | 1.84          | 28.01       | 36.48              | 9.19 |
| Maize silage              | 20.85      | 1.98          | 0.74          | 5.31        | 11.52              | 1.30 |
| Lucerne meal              | 89.78      | 16.30         | 3.41          | 21.31       | 39.62              | 9.14 |

\* Glucosinolates (uM/g) and erucic acid content (%): 7.84 ITC, 10.07 VOT, 0.20 C 22:1

The feeds containing rape seed had almost 9 times more crude fat and about 10% more crude protein than the control feed (Table 2).

TABLE 2

Composition of concentrate mixtures, %

| Specification                   | Feed mixtures for groups |       |       |       | Mixture for lactation |
|---------------------------------|--------------------------|-------|-------|-------|-----------------------|
|                                 | K                        | RN    | RF    | RO    |                       |
| Ingredients, %                  |                          |       |       |       |                       |
| Barley, ground                  | 40                       | 10    | 10    | 10    | 30                    |
| Wheat, ground                   | —                        | —     | —     | —     | 21                    |
| Wheat bran                      | 40                       | 30    | 30    | 30    | 15                    |
| Field bean, ground              | —                        | —     | —     | —     | 15                    |
| Soya bean oilmeal               | 20                       | 10    | 10    | 10    | 15                    |
| Mineral mixture <sup>1</sup>    | —                        | —     | —     | —     | 3                     |
| Rape seeds, ground <sup>2</sup> | —                        | 50    | 50    | 50    | —                     |
| Chemical composition            |                          |       |       |       |                       |
| Dry matter, %                   | 87.25                    | 90.24 | 89.66 | 91.42 | 84.71                 |
| In dry matter, %                |                          |       |       |       |                       |
| crude protein                   | 22.72                    | 23.97 | 24.55 | 23.97 | 22.37                 |
| ether extract                   | 2.90                     | 25.50 | 25.58 | 24.11 | 2.19                  |
| crude fibre                     | 8.84                     | 8.02  | 7.80  | 7.70  | 6.95                  |
| N-free extractives              | 60.53                    | 37.60 | 36.81 | 39.13 | 64.40                 |
| ash                             | 5.01                     | 4.91  | 5.26  | 5.09  | 4.09                  |

<sup>1</sup> Commercial mineral mixture Mikrofos % 50, CaCO<sub>3</sub> 25, fodder salt 25%

1 kg of Mikrofos contents, g: 124 P, 255 Ca, 80 Na, 93 Cl, 4 Mg, 0.164 Mn, 0.6 Fe, 0.21 Cu, 0.04 Co, 1.0 Zn, 0.02 J

<sup>2</sup> K—control group; RN—untreated; RF—formaldehyde treated; RO—heat treated

The intake of silage (25-27 kg), hay (about 4-5) and concentrate (about 3-4) was similar, and therefore the dry matter, energy (metabolizable and net) as well as crude protein and PDIN and PDIE, did not differ significantly among groups. The rations containing rape seeds were deficient in PDIE in respect to PDIN; this difference on UFL, was in group K, 1.4g, in groups RN, RF and RO from 8.5 to 9g.

The daily milk yield (kg) was similar in all of the groups. Statistically significant differences were found only between the FCM of cows in group RF and RO with K ( $p \leq 0.05$ ; Table 3, Fig. 1). The milk fat content from the control group was lower ( $p \leq 0.05$ ) than in the other groups, however no significant differences were found in the milk protein contents depending on the type of diet (Table 3).

TABLE 3

Milk yield and composition and feed conversion per 1 kg of FCM

| Item                         | Groups |        |        |         | SE    |
|------------------------------|--------|--------|--------|---------|-------|
|                              | K      | RN     | RF     | RO      |       |
| Milk yield, kg/day:          |        |        |        |         |       |
| initial                      | 19.6   | 19.3   | 20.5   | 21.0    | 2.63  |
| final                        | 18.2   | 19.6   | 19.8   | 19.7    | 2.22  |
| average                      | 21.2   | 21.5   | 22.2   | 23.2    | 2.11  |
| average FCM                  | 20.8 a | 21.5 b | 23.3 b | 23.2 b  | 2.06  |
| Milk fat, %                  | 3.9 a  | 4.0 ab | 4.3 b  | 4.0 ab  | 0.23  |
| Milk protein, %              | 3.0    | 3.0    | 2.9    | 2.8     | 0.12  |
| Feed conversion per 1 kg FCM |        |        |        |         |       |
| concentrate mixture, kg      | 0.30   | 0.30   | 0.29   | 0.29    | 0.03  |
| dry matter, kg               | 0.75 a | 0.75 a | 0.68 b | 0.69 b  | 0.07  |
| crude protein, g             | 111    | 113    | 104    | 107     | 5.36  |
| ME, MJ <sup>1</sup>          | 7.72 a | 7.84 a | 7.16 b | 7.29 ab | 0.56  |
| NE, UFL <sup>1</sup>         | 0.64   | 0.65   | 0.59   | 0.60    | 0.046 |

Values in the same line followed by different letters are significantly different ( $P \leq 0.05$ )

<sup>1</sup> ME -- metabolic energy, NE (UFL) -- net energy in feed units for milk production; calculated on basis of INRA feed tables (1988)

Cows from groups RF and RO used less concentrate mixture, nutrients and energy per 1 kg FCM produced than the cows from the other groups, although these differences were not statistically significant in all cases (Table 3).

The proportions of the individual fatty acids in the milk fat from cows receiving rape seeds differed significantly in comparison with the control (Table 4). An increase in the contents of C18:2, C18:3 as well as C18:0, C18:1 and C20:0 acids was found with fatty acids from C8:0 to C16:1 decreasing. The greatest changes in the fatty acid composition occurred when treated rape seeds were given, especially in group RF, which is indicated by the higher total percentage of fatty acids C18: (C8-C16) than in the other groups.

TABLE 4

Proportion of fatty acids (FA) in milk fat and in rape seeds, g/100 g FA

| FA  | Groups  |           |          |           | SE    | Rape seeds |
|---|---------|-----------|----------|-----------|-------|------------|
|   | K       | RN        | RF       | RO        |       |            |
| C <sub>8.0</sub>  | 0.53 a  | 0.41 ab   | 0.36 b   | 0.35 b    | 0.13  | 0.16       |
| C <sub>10.0</sub>                                       | 1.45 a  | 1.23 ab   | 1.18 b   | 1.16 b    | 0.21  | 0.06       |
| C <sub>12.0</sub>                                       | 2.68 a  | 1.84 b    | 1.80 b   | 1.75 b    | 0.66  | 0.05       |
| C <sub>14.0</sub>                                       | 13.78 a | 8.97 b    | 7.88 b   | 8.01 b    | 2.70  | 0.12       |
| C <sub>16.0</sub>                                       | 41.07 a | 23.82 b   | 22.50 b  | 25.22 b   | 11.25 | 4.54       |
| C <sub>16.1</sub>                                       | 2.32 a  | 1.76 b    | 1.57 b   | 1.63 b    | 0.42  | 0.42       |
| C <sub>18.0</sub>                                       | 9.23 A  | 18.00 B   | 16.65 B  | 17.36 B   | 4.46  | 1.68       |
| C <sub>18.1</sub>                                       | 21.80 a | 35.05 b   | 37.63 b  | 35.15 b   | 10.63 | 58.66      |
| C <sub>18.2</sub>                                       | 1.80 Cc | 2.15 BbCc | 3.35 AaB | 2.83 BbCc | 0.98  | 18.20      |
| C <sub>18.3</sub>                                       | 0.58 Cc | 1.03 BbCc | 1.69 AaB | 1.36 AaBb | 0.46  | 10.45      |
| C <sub>20.0</sub>                                       | 0.21 b  | 0.25 b    | 0.44 a   | 0.42 a    | 0.16  | 0.92       |
| sum C <sub>18</sub>                                     | 33.41 a | 56.23 b   | 59.32 b  | 56.70 b   | 17.55 |            |
| sum C <sub>8-C<sub>16</sub></sub>                       | 61.83 a | 38.03 b   | 35.29 b  | 38.12 b   | 15.37 |            |
| ratio C <sub>18</sub> :(C <sub>8-C<sub>16</sub></sub> ) | 0.54 a  | 1.48 b    | 1.68 b   | 1.49 b    | 0.78  |            |

Values in the same line followed by different letters are significantly different: capitals -  $P \leq 0.01$ , small letters -  $P \leq 0.05$ .

## DISCUSSION

The lack of significant differences in milk yield (kg/day) among the cows fed untreated rape seeds (group RN) and the control group can be explained by the similar energy intake in both groups with the slight increase in the energy concentration of the ration in group RN having no significant effect on milk production. The addition of fats to the concentrate mixture increases the energy content in the ration and thus allows highly productive cows to reach their potential productivity, especially in the first period of lactation when their ability to consume feed is limited (Driver et al., 1990; Murphy et al., 1990; Rueggsegger and Schultz, 1985; Schneider et al., 1988). In spite of the PDIE deficiency in relation to PDIN in the rape seed diet in comparison with the control, the fat content in group RN was somewhat higher than in K. The addition of fat to concentrate mixtures may also influence better utilization of energy since the mammary glands are able to incorporate fatty acids; especially unsaturated ones, directly, into milk fat (Brumby et al., 1978; Palmquist, 1990). The inclusion of greater amounts of fats, especially oils containing long chain unsaturated fatty acids, may significantly change fermentation in the rumen and decrease the digestibility of fibre, and therefore exert an unfavourable effect on milk production (Jenkins and Palmquist, 1984; Jenkins, 1987; Jenkins and Jenny, 1989; Kowalczyk et al., 1977; Palmquist and Jenkins, 1980). In the experiment presented here, with the amount of rape seed oil in the ration for cows receiving

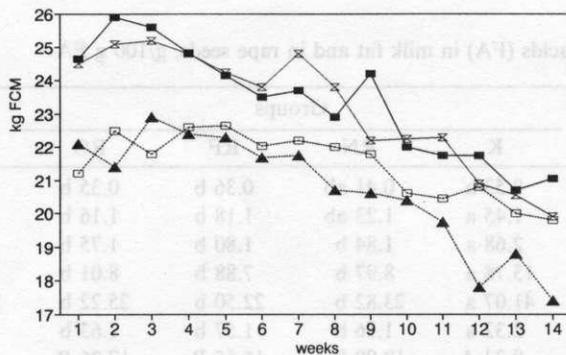


Fig. 1. Changes in the daily milk yield during experimental period

—■— RF —×— RO —▲— K —□— RN

unprotected rape seeds having been increased, the percentage of fat in the milk was also found to have increased. It may be assumed that in spite of the increased amount of fat in the diet, only slight changes occurred in the digestive processes in the rumen and in nutrient digestibility (Murphy et al., 1987), probably due to the slow liberation of oil from the rape seeds (Jigl et al., 1988; Steele et al., 1971). This may retard the biohydrogenation processes in the rumen which, when free oil is added, proceed very rapidly (Banks et al., 1990). The trans-forms of acids which arise during the process of biohydrogenation in the rumen are particularly active inhibitors of de novo synthesis of fatty acids in the mammary gland. Feeding cows with oil may therefore lead to changes in the amount of trans C18:1 acids reaching the mammary gland, thus affecting the amount of fat in the milk (Banks et al., 1984; Banks et al., 1990; Jenkins and Palmquist, 1982). The positive effect of feeding rape seed oil on milk production as well as on the milk fat content has been presented in many papers (Murphy et al., 1987; Murphy et al., 1990; Nałecz, 1986; Strzetelski et al., 1987a).

The greater productivity of cows receiving formaldehyde or heat-treated rape seeds than those receiving unprotected rape seeds indicates that both treatments which protect protein from degradation in the rumen had a favourable influence on the utilization of dietary nutrients. A consequence of this is, in spite of the similar deficiency of PDIE to PDIN, that the cows fed protected rape seeds produced more milk than the animals receiving unprotected seeds. The somewhat higher productivity of cows from group RO over RF could have been caused by the better utilization of heated rape protein than of formaldehyde-treated protein. The higher fat content in the milk of cows from group RF over RO may indicate that formaldehyde treatment was more effective than heating. It can be assumed that formaldehyde treatment limited changes in rumen fermentation more than did heating and was more effective in preventing changes in nutrient digestibility and inhibition of biohydrogenation in the rumen

(Banks et al., 1990; Driver et al., 1990; Ruegsegger and Schultz, 1985; Storry et al., 1980). The digestion of fat could have been more intensive in the small intestine where, after the protein coat had been digested, the long chain and unsaturated fatty acids were directly absorbed and incorporated into milk fat. Many studies have shown that treatments restricting fat metabolism in the rumen may also restrict the antibacterial effects of polyunsaturated fatty acids and limit to a much smaller degree the *de novo* synthesis of fat in the mammary gland, thus allowing better energy utilization, (Banks et al., 1990; Jenkins and Palmquist, 1982; Jenkins and Palmquist, 1984; Ruegsegger and Schultz, 1985; Schneider et al., 1988; Storry et al., 1980). In our earlier studies we have also shown an increase the daily milk yield and fat content when feeding formaldehyde-treated ground rape seeds, in comparison with untreated ground rape seeds (Stankiewicz, 1987; Strzetelski et al., 1987a). Similar results were also obtained by Kraszewski et al. (1989) by feeding heated ground rape seeds. In the experiment by Ruegsegger and Schultz (1985) cows fed rations containing heated soya beans produced during the first 15 weeks of lactation an average of 2 kg/day more milk with a slightly higher fat content than animals receiving soya bean oilmeal.

A somewhat lower protein content in milk from cows fed protected and unprotected rape seeds is in agreement with results reported in other papers. In those experiments, various oilseeds were fed (Driver et al., 1990; Mielke and Schingoethe, 1981; Mohamed et al., 1988; Murphy et al., 1987; Murphy et al., 1990; Nałęcz, 1986; Ruegsegger and Schultz, 1985; Strzetelski et al., 1987a). It may be assumed that the lower protein content in the milk of cows fed rations with a high fat content may be caused by lowering the activity of insulin, which mobilizes the utilization of amino acids for synthesis of milk protein (Palmquist and Moser, 1981). It was found that decreased glucose uptake by the mammary gland when cows were given rations with high fat contents may decrease the protein content in milk (Cummins and Russel, 1985).

More C18:2 and C18:3 acids in the milk fat of cows in group RF than RO suggests that when formaldehyde is used to protect the protein of rape seeds, the process of biohydrogenation in the rumen progressed more slowly than when heated rape seeds were given. This is also indicated by the presence of stearic acid (C18:0) in the milk fat. This fatty acid is produced in the rumen by hydrogenation of C18:1 acid (Murphy et al., 1990). Banks (1987) reports that the increase of C18:1 in milk fat may be the result of both its increased amount in the ration, the partial inhibition of hydrogenation in the rumen as well as of intensified dehydrogenation of C18:0 in the small intestine walls or mammary glands. According to Kinsella (1972) there are highly active enzymes in the mammary gland which catalyse the dehydrogenation of stearic acid and have a significant effect on increasing the amount of C18:1 acid in the milk fat. The higher supply of C:18 acids to the mammary gland (when feeding rape seeds) could have inhibited

the synthesis of acids from C8:0 to C16:1. The ratio of total C18:(C8-C16) indicates that this process could have occurred to a higher degree when formaldehyde treated rape seeds were fed. Many studies (Mattos and Palmquist, 1974; Murphy et al., 1990; Nałęcz and Kasperowicz, 1986; Rafalowski and Park, 1982; Stankiewicz, 1987; Stasiniewicz, 1982) have found a rise in the total eighteen carbon acids and a decrease in the amount of C4 to C16 acids when various oilseeds were fed.

In summarising the above results it can be said that protection of rape seed protein from degradation in the rumen, both by formaldehyde treatment (4 g/100 g protein) or by heating to 70-80°C improved productivity and changes in the composition of milk when compared with the effects of feeding normal seeds. Heating seeds was less effective than formaldehyde treatment of ground rape seeds.

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## STRESZCZENIE

**Wpływ skarmiania śrutowanych nasion rzepaku, traktowanych formaldehydem lub ogrzewanych, na produktywność krów i skład mleka**

Trzydzieści dwie krowy mleczne, podzielone na cztery grupy po 8, żywiono od 10 do 110 dnia laktacji dawkami pokarmowymi złożonymi z kiszonki z kukurydzy, siana łąkowego i mieszanki treściwej (grupa kontrolna K), dodatkiem śruty z nasion rzepaku OO, odm. Jantar: nietraktowanej (grupa RN) lub traktowanej formaldehydem (grupa RF) bądź ogrzewanych (grupa RO). Dzienna dawka nasion rzepaku wynosiła 1,5 kg na sztukę. Poza tym krowy otrzymywały specjalną mieszankę treściwą, w zależności od wydajności mleka. Produkcja FCM była mniejsza ( $P \leq 0.05$ ; ok. 21 kg) w grupie K niż w grupach RF i RO (ok. 23 kg), w grupie RN (ok. 21,5 kg) nie różniła się od pozostałych. W procentowej zawartości tłuszczu w mleku stwierdzono istotne różnice ( $P \leq 0.05$ ) tylko między grupą K (3,88) a RF (4,29). Mleko krów z grup RF i RO zawierało mniej białka niż w pozostałych, lecz różnice okazały się nieistotne. Zawartość nienasyconych kwasów tłuszczowych w tłuszczu mleka krów otrzymujących nasiona rzepaku była większa, szczególnie w grupie RF, niż krów kontrolnych.