Technical

Review of Rapeseed Meal in Animal Nutrition: Ruminant Animals[1]

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ABSTRACT

During recent years, world literature in this area has increasingly dealt with the assessment of low glucosinolate RSM-type (LGRSM). Generally, the LGRSM-types show clear advantages over the high glucosinolate RSM-types (HGRSM). Acceptibility of concentrates to dairy cattle may be influenced negatively by increasing RSM of commercial Canadian HG-type beyond 15%. LGRSM seems to be acceptable up to at least 20% of the concentrate mixture. LGRSM-type meal of cv. Candle may possibly still be accepted at higher levels. There are indications of a higher nutritive value of the LG vs the HGRSM types. Candle has been found to be as good as, if not better than, Tower RSM. HGRSM of European origin at a level of 15-20% of the concentrate seems to decrease milk production and to influence milk composition negatively. Canadian-type LGRSM feeding at a level of 25% of the concentrate does not seem to be harmful to dairy cattle. Inclusion of 34% LGRSM lowered feed intake and milk yield. Higher milk yields are indicated when Candle is included, in comparison to Tower. Only a limited influence on milk composition (protein, fat, solids–nonfat) has been reported to result from RSM-feeding. Both HG- and LGRSM increase milk SCN^- and decrease milk-I contents, the milk-I, however, to a minor extent. A minute part of the OZT has been found to be carried over into milk resulting in levels much below the safe level for human consumption. Inclusion of "gums" at levels up to several times the amount corresponding to normal production has not been found to impair production traits of dairy cattle or growing cattle. Microbiological degradation of RSM in the rumen can be minimized by formaldehyde treatment, which has been reported to increase milk production. Rapeseed and rapeseed expeller seem to be prospective fat and protein sources to dairy cattle, especially in rations low in crude fat (<15 g dig. fat/kg milk). The inclusion of these products increases blood cholesterol and plasma glycerides. The iodine number of milk fat is increased.

INTRODUCTION

In many countries, rapeseed meal (RSM) is a well established protein feedstuff in the livestock industry. The acceptability of high glucosinolate (HG) rapeseed meal and the content of glucosinolates have been of major concern to the feed industry. The development by plant breeding of low glucosinolate (LG) rapeseed (RS) varieties during the last decade has stimulated research in the use of LGRSM to cattle. This literature review considers mainly the work published at and after the 5th International Conference on Rapeseed, Malmö, Sweden, when the earlier literature was reviewed by Clandinin and Robblee (1). Another review on the toxic effect of RSM has recently been published (2). In this study, major emphasis has been placed on the effect of RSM feeding on acceptability, performance, milk composition and physiological traits. Finally, some reports on the use of fullfat RS and semidefatted RS products are considered, since RS fat in the future may be of interest for feeding purposes under certain conditions.

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DIGESTIBILITY

Only few investigations have been undertaken lately to determine the digestibility of rapeseed products. Recently, Canadian workers (3) compared the digestibility of Tower and Candle RSM in experiments with sheep. Apparent digestibility values of Candle RSM were shown to be superior compared with those of the Tower RSM, obviously a result of the lower hull percentage and thus crude fiber content of the Candle variety. Production-like experiments by these authors with lambs and sheep also suggest that Candle RSM is equal to, if not better than, Tower meal. Recent studies with bull calves (4) also suggest slight superiority of the energy digestibility of Candle over Tower RSM.

In comparing commercial and Bronowski RSM in calf rations, Schingoethe et al. (5) demonstrated somewhat superior digestibility of nutrients for the Bronowski meal. In experiments (6) with increasing RSM contents of the grain mixture up to 24% substituting SBM, this interchange did not significantly affect the apparent digestibility of the entire diets (DM, CP, ADF, energy).

PALATABILITY

The palatability or acceptability of grain mixtures based on RSM as a protein source depends mainly on the level of inclusion, the type of and levels of glucosinolates and the process to which the RSM had been subjected. The acceptability is of great importance for high-producing animals, such as fast-growing young animals and high-lactating cows, particularly during peak lactation.

In experiments with commercial RSM fed to calves from birth to 14 weeks, significantly lower daily grain mixture intakes were noticed (7), i.e., 0.67 kg of the RSM starter mixture (26% RSM) against 0.99 kg/calf of the SBM starter mixture (18% SBM). As a result of this difference in feed intake, daily weight gains and feed efficiency ratios were influenced. In comparing Target (HG-type) with Tower RSM at a rate of inclusion in the diet of 25%, a lowered feed intake of the Target treatment group was demonstrated (8). In an experiment with commercial and Bronowski RSM fed to young calves, superior palatability and hence improved performance for the Brownowski treatment group was recognized (5). Limited palatability of RSM has also been reported by a Swedish worker (9) who investigated 6.5 and 13% of a HGRSM (*Br. napus* winter type, 11 g OZT, 5-vinyloxazolidine-2-thione, and 4 mg ITC, isothiocyanates, per kg d.m.) in comparison with SBM in two starter mixtures to calves under 70 kg. The daily feed intakes for the SBM- and the 13% RSM-treatment groups were 0.89 and 0.80 kg/calf, respectively. This difference also influenced daily weight gains and, to a minor extent, feed conversion ratios. Contrary to these findings, other Swedish workers (10) were unable to confirm these results when including 15% HGRSM in a grain mixture.

In recent experiments with weaning calves (11), it was found that Tower RSM used as the sole protein supplement in a calf starter ration did not adversely affect feed intake up to an age of 12 weeks. During the period 2 days-5 weeks of age, a small, but statistically not significant, adverse effect on concentrate intake was noted.

From experiments with growing bulls (>100 kg live weight) it was concluded (9) that HGRSM can be included in grain mixtures up to a level of 12% without negatively affecting feed intake and production traits. As an upper limit of HGRSM (European type) for larger animals, this author recommended 0.2 kg and for smaller animals 0.3 kg of HGRSM/100 kg live weight. Other workers (12) arrived at a similar conclusion, i.e., levels of up to 16% RSM may be successfully fed to growing steers at an age of 60-140 days. According to (3) the palatability of Candle RSM to lambs and steers may be superior to that of Tower meal.

The fermentation process described by French workers has been shown to lower the goitrogeneity of rapeseed products. In this way, treated RSM given together with maize grain resulted in a superior feed intake in comparison to the untreated RSM (13). The goitrogenic effect measured by the weights of thyroid glands at slaughter was not fully overcome since their average weight was in between the RSM- and SBM-treatment groups.

The major part of the information on the palatability of RSM to dairy cows documents fairly acceptable palatability of RSM in relation to the requirement of protein supplementation under practical conditions. A daily intake of ca. 1 kg HGRSM (corresponding to a content of RSM in the grain mixture of ca. 10% and resulting in a daily intake of 10 g OZT and 4 g ITC under peak lactation) in long term experiments (14-16) did not limit the feed intake. Similar results have been reported (17) with a RSM-like product containing 15 g OZT/kg. In a short-term experiment (Latin Square, 4-week periods), Miller (18) used diets containing up to ca. 15% of an HGRSM (4 g OZT/kg, 3 g ITC) without demonstrating any inappetance. However, negative responses could not be excluded in long-term experiments.

Canadian short-term experiments with HGRSM (Span) and LGRSM (1788) with 17% inclusion in the grain mixture did not reveal any negative effects on the feed intake (19). Similar results were recently reported (8) when comparing 25% Tower and Turret RSM of the grain mixture. Other short-term changeover experiments with LGRSM (1788 and Tower) in comparison to commercial RSM at a level up to 25% of the grain mixture did not reveal any limiting influence on feed intake of any of the three RSM types tested (20). Similarly, the inclusion of 25% Tower or 20 and 30% Candle in dairy cattle grain mixtures did not reveal any negative effect on feed intake (21). However, in an earlier investigation by this group, (6) a lowered feed intake was noticed when using commercial RSM at the inclusion rate of 14% in the grain mixture. By increasing the amount of RSM (1788) up to 34% of the grain mixture a lowered rate of feed consumption at this very high level was demonstrated (22). The question may be raised on the representativity of the RSM used in this particular experiment (ether extract 11%).

The palatability of grain mixtures containing RSM depends on the age of the animals. Only limited amounts of RSM, at least of HG-type, are recommended for animals below 100 kg live weight. Beyond this weight, substantial amounts of RSM can be used without impairing consumption. For dairy cows, there is a potential risk of HGRSM limiting the palatability of the grain mixture at a level of inclusion of ca. 15%. This level may be somewhat lower for HGRSM of European type. LGRSM can be used at higher levels of inclusion, probably up to a level of 25%.

PERFORMANCE OF GROWING ANIMALS

The protein requirement for growing dairy and beef cattle has undergone a reevaluation. However, there is still a need for protein supplementation. RSM is one of the protein feedstuffs for this type of production which is worth recognition.

As stated earlier, the palatability of RSM is influenced by its content of glucosinolates. Hence, the usefulness of this feedstuff for growing animals depends on the content of glucosinolates. Somewhat inferior performance was noticed with young calves fed a 26% commercial RSM grain mixture compared to an SBM control (7). According to Olsson (9), performance in the first 7 weeks of age was depressed by using 6 and 13% HGRSM calf starters vs the SBM control. However, the 13% level resulted in performance equal to the SBM control when used from a live weight of 80 kg up to slaughter at ca. 240 kg.

The use of LGRSM in comparison to commercial RSM gave superior performance when fed to young calves, but was still not equal to calves fed SBM (23). Candle RSM fed to lambs after weaning tended to result in faster growth and superior feed efficiency ratios than for animals fed Tower RSM (3). From experiments with weaning calves, it was concluded (11) that Tower RSM is comparable to SBM when used in calf starter rations and can provide 100% of the supplemental protein. Target, compared to Tower RSM, resulted in histological changes of the thyroids of calves and also influenced weight gains and certain blood parameters adversely (8).

Feeding a 15% HGRSM grain-based ration to beef cattle (6 months to slaughter at ca. 415 kg) was reported (10) to result in a significant increase of thyroid gland weights of the RSM-fed animals (38 g) vs the SBM control animals (20 g). Surprisingly, the RSM animals revealed significantly superior weight gains, feed efficiency ratios and subcutaneous and abdominal fat deposition. The authors suspected a slightly altered hormone secretion rate which might have lowered the basal metabolic rate.

Efforts to compare Candle and Tower RSM when fed to growing beef steers seem to reveal equal, if not superior, results by using Candle RSM (3).

In the search to establish the carry-over of glucosinolates and their split products their deposition in beef cattle tissue was investigated (24). These authors were unable to detect a number of compounds which would be expected to be transferred into the tissues.

The influence on performance of RSM to growing dairy and beef cattle, the statement made for palatability, is also applicable here. RSM of LG-type is to be preferred for young calf starters (below 80 kg). Only part of the required protein supplement should be given as RSM if LGRSM is not fed to animals of this category. Low-fiber RSM (Candle) seems to be expected to give superior performance compared to the ordinary fiber type. Substantial amounts of RSM can be used as protein feedstuff and as the sole protein supplement under many practical conditions for animals over 100 kg. Enlargement of the thyroid may occur without impairing performance results.

PERFORMANCE OF DAIRY COWS

Production Traits

In evaluating the effect of different feeding regimes on dairy cows, one has to consider the complexity of the metabolic systems of ruminants. In cattle, the body deposits of nutrients are considerable and may mask certain effects when only short-term experiments are performed. This means that the animals' reserves influence their ability to withstand stress situations. It may be of interest to notice that the reduction in thyroxine level may take up to six weeks to appear (20). Therefore, long-term experiments bring about clear advantages and give a full picture, including the peak lactation, regarding the feeding effects on different traits such as milk yield and composition, feed efficiency, fertility and health problems. It should be pointed out that most experimental work with RSM in dairy cows has been undertaken in relatively short experiments, partly because of the high cost of experiments, but also from an experimental analysis point of view.

Experiments with RSM of HG-type have been reported (14-17). These reports demonstrated that milk yield and feed efficiency ratio were uninfluenced by inclusions of up to 10% RSM in the grain mixtures (daily intakes of 10 g OZT and 4 g ITC). Furthermore, in two short-term experiments with HGRSM, also of Swedish origin, at a level of up to ca. 15% of the entire ration, a residual effect of a higher level of RSM on subsequent milk production was suspected (18), suggesting the presence of a toxic factor affecting milk synthesis. This hypothesis has not been corroborated by other observations and does not seem very likely since, in cases where a decrease in the performance as an effect of RSM feeding was demonstrated in earlier reports, the decrease in milk production seems to have been proportional to the decrease in feed intake.

During the last few years in Canada, a number of experiments have been performed mainly with RSM of LG type. In order to facilitate a general conclusion from the existing information, regarding both HG- and LGRSM feeding on performance, this has been condensed in Table I.

This compilation includes a total of 17 experiments. Within each, the main result was interpreted, showing unchanged milk yield in 14 experiments with RSM-feeding compared with the control treatment without RSM (6,8, 14-18, 20 and 25 in 1 of 2 experiments), an increased milk yield in two experiments (25, in 1 of 2 experiments and 19) and two experiments with a decreased milk production (6, in 1 of 3 experiments, and 22). The Fisher and Walsh reported a significant drop in milk yield at 34% RSM inclusion when using a product which also depressed feed intake and feed digestibility. As pointed out earlier, there is some discussion about the representativity of this particular RSM batch containing 11% ether extract. In some of the reports claiming no changes in milk yield there has been a tendency for improved results when using RSM of LG type vs the commercial type, but this has not been included in Table I.

The information indicates no deleterious effect on performance of feeding HGRSM (of the European type) at a level of at least 10% of the grain mixture. Based on short-term experiments, LGRSM may probably be included in grain mixtures at a rate of up to 25% without depressing performance.

Effect on Milk Composition

Most reports on RSM feeding to dairy cows include results on the effect of milk composition. Primarily, the effect on butterfat, protein and SNF contents is of major concern. Secondarily, the carry-over of glucosinolates and split products or other changes are of great interest.

Results from published data of RSM feeding on milk composition and daily yields of nutrients have been compiled in the same way as for milk yield and entered into Table I. As can be seen, the major part of the experiments resulted in an unchanged composition of the milk (8,14-18, 20,25 and 6 in 2 out of 3 experiments).

TABLE I

Effect of RSM Feeding on Milk Yield, Composition and Daily Nutrient Yield Based on the Literature (1975-79), Number of Experiments

	Unchanged	Increase	Decrease	Total
Milk yield	14	1	2	17
Butterfat (%)	12	3	2	17
Butterfat yield/day	8	4	1	13
Protein (%)	16	–	–	16
Protein yield/day	13	–	2	15
SNF (%)	13	–	–	13

An increasing effect on butterfat content has been reported in three experiments (6, in 1 of 3 experiments, 19,25) using LG-type RSM. A decreasing effect by RSM feeding on butterfat percentage was found (22 and 25, in 1 of 2 experiments). Besides this effect a significant decrease in the daily yields of butterfat and protein was noticed (22). As pointed out by other workers, the reason for the depressing effect of high levels (22 and 34% RSM) reported by these workers may have been a result of the high fat content of the RSM in question (11% ether extract). The difference in butterfat content noticed (25) was statistically not significant.

It is a well established fact that the milk-I content is lowered by feeding RSM unless supplemental iodine is provided. The SCN level of milk is increased by the ITC content of the RSM (8,17,25). Papas et al. (25) reported a very limited carry-over of 5% of the isothiocyanates into the milk as SCN^-, and this level has also been confirmed (21). From a food hygienic point of view, this level is regarded as safe. According to Papas et al. (25) reported a able amounts of intact glucosinolates were detectable in the milk when feeding Tower and 1821 RSM at levels of 30 and 26% in the grain mixture, respectively. However, in recent work (8) small amounts of unsaturated nitriles and inorganic SCN in the milk of RSM-fed dairy cows were noticed.

Summarizing the effect of RSM feeding on milk composition, the literature on experiments with nutrient supply according to accepted standards does not indicate any harmful or negative effects on milk composition and daily yields of nutrients. Earlier literature cited (25) led to the same conclusion. The use of LGRSM is advantageous in comparison to HGRSM. Feeding of the former RSM-type does not adversely affect milk gross composition.

Physiological Parameters

The glucosinolate content of the ration influences the level of thyroxine in the blood. In comparing 8.5% Span (HGRSM, containing 8 g ITC and 3 g OZT/kg) in the entire diet with 1788 RSM (LG-type) and the control diet without RSM, physiological changes were noticed which were interpreted as evidence for hypothyroidism of the Span-fed animals. Differences in blood thyroxine levels as caused by feeding of different types of RSM have also been reported (8,20). The significance of the differences observed, however, need further research. From earlier experiments with growing animals, it is known that performance is uninfluenced within a certain range of change of the thyroid gland activity.

When investigating 20 and 30% 1821 RSM and 26% Tower meal, Papas et al. (25) could not recognize any differences in thyroxine levels or other blood parameters which would indicate any signs of hypothyroidism. This RSM material contained low levels of OZT.

Experiments with ewes fed differently treated RSM (26) indicate a carry-over effect from the dams to the lambs since thyroid gland weights and the functional stage of the thyroid cells were influenced by the feeding regimen of the dams.

Reproductive Performance

Information on the effect of RSM feeding on fertility is very scarce due to the limited number of long-term experiments. The reports (14,15) do not fully exclude the possibility of a minor RSM treatment effect on fertility. However, the limited number of animals does not allow any definite conclusion to be drawn in this respect. Much more detailed research is needed. Using an RSM product with a semi-high fat content (not heat-treated), statistically significant treatment effects ($p<0.05$) were demonstrated (17) between the control and the RSM treatment group of 1.2 against 1.9 inseminations (a.i.) per pregnancy, respectively.

Contrary to these reports, Frank (27) did not notice any clear signs of impaired fertility in experiments with RS and expeller processed RS of HG type.

FORMALDEHYDE-TREATED RSM

In order to decrease the breakdown of protein by rumen microorganisms, treatment of protein feedstuffs such as RSM with formaldehyde (FA) has been tried by different workers. By feeding RSM treated with 7 g of FA/kg crude protein (or levels of this magnitude) a reduction of the ammonia formation in the rumen has been reported by many workers. Minor, negative effects on the digestibility of nutrients were reported (7,28) from experiments with calves and young steers and (29) from research with dairy cows. In using growing steers, more clear-cut negative results on the digestibility of nutrients were reported (30). FA-treated casein increased the amount of amino acids leaving the rumen (28). However, when using FA-treated RSM in comparison to untreated RSM only, a trend in this direction could be noticed. For growing cattle, no beneficial effects of FA treatments of RSM on performance could be verified (7,28,30).

In experiments with FA-treated RSM in dairy cows, an increase of milk yield of more than 1 kg/cow/day compared with the untreated controls was noticed (31). These workers also pointed out that for maximal milk secretion under the high lactation phase, the cows require a high protein supply. Part of the N-supplement should be of a low degradable supply. Part of the N-supplement should be of a low degradable type. The feeding of FA-treated RSM to dairy cows as compared to untreated cows caused an increase of certain free amino acids in the blood as a result of the increase in the amounts of most essential amino acids disappearing from the intestine (32). These authors also stress the necessity for a new system of N-evaluation of feedstuffs.

GUMS

The amount of RS-oil soapstock (gums) appearing in the RSM process corresponds usually to 1.5-2% of the RSM. Concern has been expressed from different parts of the livestock industry regarding the use of gums. In an Alberta experiment with steers (33), the effect of increasing levels of added gums providing 0, 0.1, 0.2 and 3% of the entire ration which also included 5% RSM was studied. The gum levels given corresponded at the 5% RSM inclusion to contents in the RSM of 0, 2, 3.9 and 38%, respectively. A feeding period of 127 days was used before slaughter. This experiment (Table II) did not reveal any statistically significant effects of the gums on the digestibility of nutrients and gross energy or on the performance results or carcass quality grade.

TABLE II

Rapeseed Gums in Finishing Diets for Steers (33)

	Level of gums in total ration (%)				
	0	0.1	0.2	3.0	
Digestibility (%)					
Gross energy	72	73	71	70	NS
ADF	29	24	20	22	NS
Crude protein	62	67	59	63	NS
Performance result					
Avg. daily gain (kg)	1.41	1.28	1.35	1.32	NS
Avg. daily feed (kg)	10.1	9.7	9.7	9.2	NS
Feed/gain	7.1	7.6	7.2	7.0	NS

TABLE III

Effect of Gums on Feed Intake, Milk Yield and Composition (25)

		Tower RSM + % gums		
	SBM	0	4	8
Feed intake (kg d.m./day)				
Grain mixture	9.1	9.1	8.8	8.8
Roughage	9.6	9.9	10.0	10.5
Milk yield (kg/day)	23.9	24.6	24.2	24.2
Butterfat (%)	3.56	3.32	3.43	3.52
Protein (%)	3.47	3.46	3.49	3.51
Solids—nonfat (%)	8.83	8.67	8.74	8.70

In an experiment with 6-month-old Hereford steer calves, a high-urea protein supplement containing 6% RS-gums and 13% urea was investigated (34). The author concluded from the trials that sufficient control of supplement intake could be attained by using this particular concentrate mixture to permit ad libitum feeding, without any toxic effects.

In further experiments (25) with gums (0, 4 and 8% of the grain mixture), only small and nonsignificnat differences in daily feed intake, milk yield and composition were found, indicating these levels of inclusion to be possible (Table III).

FULLFAT AND PARTIALLY DEFATTED RAPESEED

In dairy cattle, feeding certain types of rations results in deficit of crude fat. Under Swedish conditions, it has been shown (35) that high-yielding dairy cows require daily intakes of ca. 28 g of digestible crude fat/kg milk (4% FCM). In the search for cheaper fat sources (36), roller milled, unprocessed RS of a Swedish LG-type (*Br. napus*, spring type, cv. Sv 71/6, with a semi-low erucic acid content) in the grain mixture was investigated at a level of 8.4% (ether extract content of the grain mixture 6.3%). The control treatment group was fed a commercial-type grain mixture containing 5.7% RSM (ether extract content 3.1%). The experiment consisted of a total of 28 first lactating dairy cows. Both treatment groups were provided with a low-fat, high-straw forage ration. The ration of the control treatment resulted in a calculated amount of 17 g dig. crude fat against 28 g/kg milk for the RS-group.

The RS-animals consumed, on average, 0.75 kg rapeseed/day (275 g oil). The decrease in milk yield (uncorrected and FCM) was significantly ($p<0.01$) lower (persistency of lactation was superior) for the RS- than for the control-group animals and hence was associated with better per-

TABLE IV

Rapeseed as a Fat Source for Dairy Cows (Changeover Experiment) (36)

	Group A			Group B			
	w.9-20 RSM	21-32 RS	Diff.	w.9-20 RS	21-32 RSM	Diff.	
No. of cows	16	17		17	16		
Decrease of:							
Milk, 4 % FCM (kg)	5.6	2.2	3.4	3.8	3.4	0.4	xx
Butterfat (g/day)	224	85	139	148	128	20	xx
Butterfat (%)	0.05	-0.04	0.06	0.00	-0.04	0.08	NS
Milk composition							
Butterfat (%)	3.66	–	–	3.76	–	–	–
Protein (%)	3.28	–	–	3.25	–	–	–
Total solids (%)	12.33	–	–	12.30	–	–	–
Fat, iodine value	33.7	–	–	36.9	–	–	–

formance results (Table IV). Milk composition showed no effects of the treatments. There was a significant effect on butterfat fatty acid composition (C18-acids increased from 43 to 51%) by feeding RS. A limited increase of the blood cholesterol content was also noticeable when using RS. The OZT estimates of milk did not allow any final conclusions to be made.

In a further trial, Frank (27) compared RS and expeller-processed rapeseed (RSE) at levels of 9 and 19% of the grain mixtures, respectively, with a 5.2% RSM control grain mixture to give the described differences in crude fat supply. The RS was of 00-type (*Br. napus*, summer type) whereas the RSM and the RSE were of commercial 0-type (*Br. napus*, winter type). The crude fat contents of the grain mixtures (based on RS, RSE and RSM) were 6.5, 6.1 and 2.7% (on a d.m. basis), respectively.

Despite the very high level of RSE inclusion (corresponding to an RSM level of 13-14% in the concentrate feed mixture or to 1.1 kg RSM on average/cow/day), the feed intake was uninfluenced (Table V). The higher fat supply of the RS and RSE treatment groups resulted in an improvement of FCM production by 3 and 7% over the RSM control group which, however, was statistically not significant ($0.3 < p < 0.2$). No statistically significant effects were noticeable in the milk composition, except for a slight decrease in the crude protein content (but not daily amount) of the RSE treatment group. As in Frank's experiment (36), the increased supply of RS fat increased the content of C-18 fatty acids (especially of 18:1) at the expense of C-16 fatty acids.

The content of 22:1 was less than 0.01% of the butterfat. The daily ingestion of glucosinolates varied between 0.5 over 3.7 to 14.9 g/day for the RS, RSM and RSE treatment groups, respectively, which resulted in OZT contents of the milk of 1.0, 1.0 and 17.5 mg/kg milk, respectively. Blood parameters showed, again, a significant increase of cholesterol for the high-fat groups (RS and RSE). The blood PBI content of the RS was significantly increased over the RSE and RSM groups which indicates a less impaired function of the thyroid gland of the animals receiving RS of 00-type.

In a Danish experiment (37), RSE of 00-type was investigated with dairy cattle at the rate of 0, 25, 50 and 75% of the grain mixture. The rate of feed intake was significantly lowered at the two highest levels. The milk yield between treatments remained uninfluenced. The authors recommend a maximal level of 25% RSE in the grain mixture since the highest levels tested resulted in off-flavor of the milk.

Canadian workers (38) compared in a 4 × 4 Latin square trial a high forage ration with a low forage ration supplied with protected (formaldehyde-treated) tallow and RS fat. The experiment was aimed at studying the effect of protected lipids on milk yield and composition. The fats were included at a level of 5% of the total ration. The low- and high-forage rations contained 35 and 50% chopped hay, respectively. The fat supplements increased the FCM yield/cow/day over the low and high forage control groups and the persistency of the FCM yield was superior for the fat-supplemented groups, with the greatest persistency for the RS fat-supplemented ration. The butterfat content of the RS fat-supplemented group was equivalent to the high forage group. The milk crude protein content of the lipid-supplemented animals was inferior to that of the two control groups. The RS fat-supplemented ration resulted in significantly higher blood cholesterol values than the controls.

In a second trial, these authors investigated the inclusion of RS at levels to give crude fat contents in the dairy cow rations between 2.2 and 8.0% (RS levels 0 to 12.6%). Milk production and milk composition were not affected by the level of RS. The conclusion of the authors was that the inclusion of RS did not affect production, digestibility or the normal metabolic response of the animals. The use of 5-10% RS oil to replace other fat sources in milk replacers for calves has also been proposed (39).

A general evaluation of these experiments with unprocessed RS and RSE indicates that these products seem to be useful to cover part of the fat requirement of dairy cows on rations low in fat. Under certain conditions, the use of RS

TABLE V

Rapeseed and Partially Defatted Rapeseed as Fat Sources for Dairy Cows (27)

	RSM 5.2%	RS 9.0%	RSE 19.0%	
No. of cows	12	12	12	
Performance (w. 9-40)				
Milk (kg/day)	16.5	17.4	18.0	
4 % FCM (kg/day)	15.8	17.0	17.4	
Butterfat (g/day)	614	672	678	
Solids (g/day)	2093	2181	2215	
Milk composition (w. 9-40)				
Butterfat (%)	3.73	3.87	3.75	
Protein (%)	3.57	3.58	3.40	x
Solids (%)	12.46	12.62	12.39	
Fat, iodine value	31.0	35.4	36.6	xx

fat is economically justified. The advantage of LG- over HGRS is clearly demonstrated by the lowering effect on the OZT content of the milk. Further research is needed with high-yielding cows and on the necessity of inactivating the myrosinase and stabilizing the fat of products rich in fat. Work in progress with mature cows (30% beyond the yield of first lactating cows) seems to verify the results reported earlier (27,36) which means that RS is a suitable lipid source for cattle on high-straw diets (crude fiber content 20-22% on a d.m. basis).

FINAL REMARKS

RSM is a by-product from the vegetable oil industry which can be put to good use by feeding to beef and dairy cattle as a protein supplement. As has been shown by recent research, the development of LG-type cultivars is increasing the potential of rapeseed products for cattle feeding, also. Substantial parts of the protein supplement requirement for high lactating cows can be furnished by RSM without impairing milk yield and composition. The main part of the protein supplement to growing cattle on normal type feed rations may be supplied by RSM. Rapeseed and expeller-processed rapeseed seem to be prospective fat and protein sources to dairy cattle, especially in fat-deficient rations. However, there are still questions which need to be clarified.

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