EVALUATION OF RAPESEED MEAL AND PROTEIN FOR FEED USE

By Donald R. Clandinin and Alexander R. Robblee
Department of Animal Science, University of Alberta
Edmonton, Alberta, Canada, T6G 2E3

The most important factor that has contributed to expansion in usage of rapeseed meal (RSM) in feeds for livestock and poultry since our meeting in Giessen in 1974 has been the development of low glucosinolate (LG) type rapeseed meal (RSM) by Canadian and European plant breeders. While the release of LG varieties of rapeseed (RS) in Europe has been slower than in Canada, Canadian releases of LG-RS have had a decided effect on the acceptance of RSM as a feedstuff for livestock and poultry. In our opinion, as LG-RSM becomes more widely available a much improved image for RSM will develop.

COMPOSITION

The amino acid composition of the protein of LG-RSM does not differ from that of high glucosinolate rapeseed meal (HG-RSM). However, some evidence has been obtained by workers in France that the protein of LG-RSM is better utilized than that of HG-RSM. In addition, researchers at the University of Guelph have obtained data which suggest that the availability of amino acids is improved in LG-RSM compared to that in HG-RSM. From the point of view of amino acid composition of RSM versus that of soybean meal (SBM), it is well recognized that RSM is lower in lysine and higher in sulphur-containing amino acids than SBM. Nevertheless, at recommended levels of inclusion in practical type rations, protein from RSM has been shown by many researchers to give performance just as satisfactory as protein from SBM. Indeed, RS flour prepared from Echo and Tower RS by dehulling, myrosinase inactivation, washing with water to remove most of the glucosinolates and extraction with hexane was shown by Bell *et al* (1976) to have a protein efficiency equivalent to that of casein. Similar findings have been reported by Swedish workers relative to RS protein concentrate prepared by the Swedish process.

The glucosinolate content of LG-RSM is only about one-eight to one-tenth that of HG-RSM. While the glucosinolates present in LG-RSM do cause minor thyroid enlargement, the effect on the thyroid glands is not considered to have practical significance. Indeed, if as much as 30% of LG-RSM was included in a ration, the content of potential L-5-vinyl-2-oxazolidinethione (OZT) in the ration would be considerably less than that shown by Vogt and Stute (1974) to be necessary in the ration to cause undesirable effect in laying chickens (225-600 ppm) which have a lower tolerance for OZT than broiler chickens (700-1050 ppm).

LIVESTOCK

One of the main drawbacks of HG-RSM for ruminants and swine has been its low palatability. It is well known that if these classes of livestock have a choice between eating a ration containing HG-RSM or one containing SBM they will choose the latter. While it is true, that when there is no choice these classes of livestock readily consume rations containing recommended levels of HG-RSM one, nevertheless, has to recognize that the problem exists. Fortunately, this problem has, for all practical purposes, been resolved by the introduction of LG-RSM. Research in Canada at various Universities and Canadian Experimental Stations has shown that LG-RSM is much more palatable to cattle and swine than HG-RSM. Workers in France (Borgida and Viroben, 1976) have also reported that RSM from which most of the OZT and isothiocyanates have been destroyed by making an ensilage of RSM and corn is more palatable to pigs than the RSM in which the glucosinolates are present.

Cattle and Sheep. High glucosinolate RSM has been reasonably well accepted as a feedstuff for inclusion in rations for cattle. Canadian-type HG-RSM has been used successfully at levels of 20%, 5% and 10% of the dry matter in rations for calves, dairy cows and beef cattle. We would expect that usage levels of European-type HG-RSM, because of its higher glucosinolate content, may be slightly lower than the above. Efforts to decrease palatability problems by inclusion of molasses or "feed flavor" to HG-RSM by Ingalls and Sharma (1975) resulted in only a slight increase in feed intake of rations containing HG-RSM.

The latter workers also showed that the inclusion of up to 24% of LG-RSM (Bronowski) in the grain mix of dairy cows did not affect milk yield or composition adversely. Fisher and Walsh (1976) fed dairy cows grain mixtures which contained 0, 11, 22 and 34% LG-RSM (Tower) and concluded that RSM derived from the Tower variety could be included up to the 22% level in grain mixes for dairy cows without appreciably affecting productive traits. In an experiment with dairy cows Sharma *et al* (1977) have demonstrated that the inclusion of 25% of LG-RSM (Tower) had no adverse effects on feed consumption, milk yield or milk composition. On the other hand, Hoppe *et al*, in Poland, have reported that feeding dairy cows as much as 1.8 kg per cow per day of HG-RSM (containing 13.8 mg/g of potential OZT, 2 mg/g isothiocyanate (ITC) and 0.4 mg/g thiocyanate (SCN) did not affect milk yield and contents of fat, solids, lactose, citric acid or chloride ion in milk. Lindell and Knutsson (1976) have shown that 8% of HG-RSM of Swedish origin may be included in the concentrate mix of dairy cows without adversely affecting milk production and composition. It would appear from the above that LG-RSM may be safely fed in the grain mixture of dairy cows at twice the previously recommended level of HG-RSM.

Some research has been done on the effect of treating RSM with formaldehyde to improve its nutritional value for ruminants. In this regard, Verité *et al* (1977) have shown that such treatment decreases the *in vitro* digestion of RSM by rumen bacteria. In addition Verité and Journet (1977) have noted that when formaldehyde treated RSM and formaldehyde treated SBM are fed as a mixture, milk production in dairy cows is increased. In studies with sheep, Sharma and Nicholson (1975) reported that formaldehyde treatment of HG-RSM slightly reduced the apparent digestibility of crude protein, rumen ammonia and blood urea and tended to improve N retention compared with water-treated HG-RSM.

Use of dehulled HG-RSM or dehulled, heated, water-and solvent-extracted LG-RS (Bronowski) in calf milk replacers has been studied by Gorrill *et al* (1976). They came to the conclusion that the former was not a suitable source of nutrients for calf milk replacers, however, the use of the latter to supply 30% of the protein of the milk replacer had no significant effects on calf performance before or after weaning.

Work done by Gorrill *et al* (1976) have shown that LG-RS that has been dehulled, heated, water-extracted and colloid-milled is a good source of protein and energy for lamb milk replacers. Seoane *et al* (1976) have demonstrated that this product may be used to replace 25 to 50 of the milk protein and most of the fat in lamb milk replacers without adversely affecting animal performance.

Swine. In studies involving growing pigs, Bell *et al* (1976) made comparisons between *B campestris* type RSM of Canadian and *B napus* type meal of European origin and found the former superior. They reported that the European *B napus* meal contained over 4 times as much potential OZT as the Canadian *B campestris* meal.

At a symposium on RSM held in Canada last year Aherne *et al* (1977) reviewed the many published papers and progress reports to which he had access which dealt with the use of RSM in rations for growing pigs. After giving due consideration to the research reviewed he concluded that for, starting, growing and finishing pigs LG-RSM (Tower) could be included in starting and growing rations at the 10% level and as the sole source of supplementary protein in rations for finishing pigs. This recommendation relative to starting and growing rations appears conservative when one considers the study of Von Petersen and Schulz (1976), in Germany, in which levels up to 24.6% of LG-RSM (Erglu) were fed to starting and growing pigs without affecting growth or market quality adversely. Also, in this connection, the report of Marangos *et al* (1976) in England, seems pertinent. These workers concluded, on the basis of two experiments in which 10% of HG-RSM (containing 8.4 and 8.7 mg/g of potential OZT) was fed to pigs during the growing and finishing periods, that while the thyroid size was larger on the RSM-fed groups compared to the SBM-fed groups, no adverse effects on growth or carcass quality were observed as a result of including 10% of HG-RSM in the rations.

We are all aware of the bad image that HG-RSM has had as a feedstuff for breeding pigs. Results obtained in the past on RSMs of varying glucosinolate content have suggested that problems observed in breeding pigs have been related to the glucosinolate contents of the meals. This is borne out by two experiments recently conducted in Canada. In the first experiment Flipot *et al* (1977) fed gilts rations containing 10% of LG-RSM (Tower) or a comparable level of SBM throughout gestation and lactation and found that the gilts fed the LG-RSM-containing ration performed just as well as those fed SBM. In another study by Hartsock (unpublished) LG-RSM (Tower) was supplied as the sole source of supplementary protein from 60 kg liveweight through the first lactation. No significant differences were noted in services per conception or litter size at birth or at weaning between the LG-RSM-fed gilts versus the SBM-fed gilts. These results suggest that LG-RSM is a satisfactory source of protein for breeding pigs and that no reduction in performance is likely to occur from the use of high levels of same in rations for gilts and sows during gestation and lactation.

Studies by Borgida and Viroben (1976) and by Borgida *et al* (1977) on the utilization of RSM ensiled with corn have shown that ensilaging markedly reduces the goitrogenicity of the RSM making it resemble LG-RSM. In work with pigs these workers noted improvement in palatability, growth and feed conversion from the ensilaged meal as compared to the regular meal.

In a histopathological study Umemura *et al* (1977) noted a higher incidence of intravascular fat globules in the heart with mild interstitial oedema in boars fed a ration containing HG-RSM than in boars fed LG-RSM in their ration. Boars and gilts on the corn-SBM control ration showed no intravascular fat globules.

PETS

Dogs. In studies involving Beagles and Alaskan Malmutes, Brown *et al* (1976) have shown that HG-RSM (Span) may be included in the ration at the 20% level without adversely affecting hematological or thyroid parameters of the animals. The nitrogen digestibility of the RSM-containing ration was in the range reported for canines fed commercial type diets (75 - 85%). It was considered that the extrusion process, necessary in the production of dog foods based on vegetable products, had a beneficial value on the nutritive value of the RSM, possibly by inactivating deleterious factors in the meal.

POULTRY

A great number of reports have been published on work conducted in Canada at the University of British Columbia, University of Alberta, University of Manitoba and the University of Guelph on the use of LG-RSM in rations for various classes of poultry. It will be impossible for us, in the space allotted, to cite the individual workers, however, we will try to draw conclusions from their collective efforts, and, insofar as possible, give credit to the institutions where most of the work was done. In addition, we will cite European work that seems relevant.

Chicken Broilers. Extensive studies have been conducted with broiler-type chickens at the University of Alberta and the University of Guelph involving LG-RSM prepared from the Bronowski, Tower and Candle varieties of rapeseed. These studies have shown that up to 20% of LG-RSM may be included in rations for broiler chickens without adversely affecting growth or feed conversion, provided, of course, that the low energy value of RSM is compensated for by suitable energy adjustments in the rations. In a study reported by Marangos *et al* (1974), in England, it was shown that when moderately low, medium and high glucosinolate type RSMs were fed to broilers at the 12% level of inclusion similar growth and feed conversion responses were elicited. This agrees, of course, with Canadian data on similar type RSMs. Vogt and Stute (1974), in Germany, have related performances in broilers to the OZT content of the ration suggesting that broilers can tolerate 700 - 1050 ppm of OZT in the ration. This is well within the range that can be achieved by LG-RSM included in rations at the 20% level. Vogt (1977) has shown that 20% of LG-RSM (Erglu) can be used in broiler rations without adverse effects.

A report that has come to hand which indicates that workers in France have obtained superior results with LG-RSM prepared from a LG variety of RS provided by Morice. When this LG-RSM was included in a broiler ration at the 20% level, growth and feed conversion comparable to that of the birds fed a control diet based on SBM were obtained.

Turkey Broilers. A limited amount of work on the use of LG-RSM in rations for growing turkeys has been reported. Data from the University of Alberta, the University of Guelph and the Swift Current Research Station suggest that as much as 20% of LG-RSM may be included in the rations of turkey broilers without adversely affecting growth or feed/gain ratio.

Chicken Layers. Numerous studies conducted at the four Canadian universities referred to earlier have shown that at least twice as much LG-RSM may be included in rations for layers as previously found for Canadian-type HG-RSM. In some experiments levels of inclusion as high as 15% of LG-RSM have been found to cause no adverse effects on productive traits. However, in order to err on the conservative side, the 10% level of inclusion has to be selected as the recommended level for LG-RSM in chicken laying and breeding rations.

In Germany, Vogt and Torges (1976) and Vogt (1977) have reported that feeding up to 15% of LG-RSM (Erglu) had no significant influence on mortality or productive traits of white egg layers. On the other hand, feeding up to 15% of HG-RSM (Lesira) increased mortality and worsened performance.

Marangos *et al* (1974) and Marangos and Hill (1976) reported that on the inclusion of moderately low, medium and high glucosinolate RSM at the 12% level in rations for layers, as might be expected on the basis of other published data, performance was reduced from that of the birds fed the control ration based on SBM.

Fishy Eggs. Hobson-Frohock *et al* (1973) were the first to show that the fishy odor resulting from the inclusion of

RSM in the ration of brown-shelled egg layers was due to the presence of trimethylamine (TMA). Overfield and Elson (1975) demonstrated that the level of RSM in the laying ration of brown-shelled egg layers influenced the degree of fishy odor and suggested that the ability of the bird to metabolize TMA was genetically controlled. Bolton *et al* (1976) showed that predisposition to laying fishy eggs was the result of the presence of a semi-dominant gene that has variable expression depending on environmental factors. In the latter regard, our studies have shown that brown egg layers, fed rations containing RSM, which are kept in floor pens are more prone to lay fishy eggs than those maintained in laying batteries. Recently, Hobson-Frohock (1977) and Clandinin *et al* (1977) have reported that the source of the TMA in such eggs is sinapine which is present in rapeseed meal at a level of about 1 to 1 1/2% (Fenwick and Hogan, 1976 and our unpublished data). A paper by Mueller *et al* which will be presented during the conference will show that organisms present in the caeca of hens are capable of converting the choline moiety of sinapine to TMA.

Haemorrhagic Liver Syndrome. Since association of RSM with haemorrhagic liver syndrome (HLS) by Jackson (1969) and Hall (1972, 1974) and the suggestions by the latter that the haemorrhages could be causes by lysis of the reticular substance of the liver which weakened the structure of liver, further studies have been undertaken. Contrary to Hall's contention, studies by Yamashiro *et al* (1975) suggest that lysis of hepatocytes and perhaps vascular changes followed by distortion of reticulum in the liver leads to hepatic haemorrhage.

On the subject of the factor(s) in RSM which predisposes susceptible birds to HLS, Marangos and Hill (1974) reported a higher incidence of mortality in layers fed rations containing *B napus* rather than *B campestris* type RSM. Although the OZT content of the *B napus* meal was higher than that of the *B campestris* meal, the higher HLS from the former was not attributed to higher OZT since *B juncea* meal which has no OZT caused a high incidence of HLS. March *et al* (1975) and Olomu *et al* (1975) have observed that high levels of HG-RSM caused excessive mortality due to HLS in layers.

Clandinin *et al* (1974, 1977) reporting on their own data and those of Campbell indicated that, in addition to level of HG-RSM, the strain or breed of layers affected the incidence of HLS. Slinger (1976) made a similar observation with respect to two strains of Leghorns. Grandi *et al* (1977) have confirmed that level of glucosinolate in the rations affects the incidence of HLS.

While specific factors in RSM which are responsible for this problem have, as yet, not been identified it seems quite clear from work at the Universities of Alberta and Manitoba that the level of glucosinolates or their hydrolysis products is the prime causative factor of HLS. In this regard it has been shown that LG-RSM at high levels of inclusion in laying rations does not cause an increased incidence of HLS.

OTHER CONSIDERATIONS

Metabolizable Energy. A serious drawback to use of RSM in rations for swine and particularly for poultry has been the low metabolizable energy (ME) values assigned to this feedstuff for these classes of livestock. The value of 1760 kcal/kg for poultry has been of particular concern. Many researchers have felt that the value is too low. Certainly on the basis of recent ME data collected in Canada and in France, using mature males, the ME value used for calculating rations for mature poultry should be higher than the value of 1760 kcal/kg which was based primarily on chick data. The value of 1900 kcal/kg seems more appropriate for adult poultry.

Efforts to produce a RSM of ME content approaching that of SBM have been made in Canada, France and Sweden. The Canadian approach has been to remove by regrinding and air classification part of the hull from RSM. While the process has resulted in a product with protein and ME values equal to soybean meal, it has been found that the high protein meal product is so finely ground that it causes feeding problems. In contrast, French and Swedish workers have removed the hull from the seed before oil extraction and have been able to produce a high protein product that appears not to possess the undesirable characteristics of the Canadian product. One disadvantage of the European approach, however, lies in the fact that a small amount of oil is lost in the hull fraction. French and Swedish workers have both reported, however, that the fat content of the hulls enhances the feeding value of the hulls for ruminants.

Since tannins in RSM are considered to have anti-nutritional effects and since they are located in the hull of RS, an additional advantage in removing the hull from the RSM or RS lies in the fact that the hull-free meal would be essentially free of tannins. This may partially account for the increased nitrogen utilization from dehulled RSM noted recently by workers in France in studies with pigs.

Canadian plant breeders are also trying to improve the ME value of RSM by lowering the fibre content of RS. It is claimed that introduction of a yellow seed coat should reduce the fibre content of RSM from 12 to 9%. However, perhaps because of such factors as field contamination, inadequate seed cleaning and the stage of development of the yellow seeded variety we have not observed much difference in the fibre levels in RSMs derived from brown or yellow seeded RS.

Goitrogenicity. While the goitrogenic effect of RSM has not been considered a serious problem when RSM is included in rations at recommended levels for various classes of livestock and poultry, it has been of some concern, since, even at recommended levels of inclusion of RSM, some thyroid enlargement has been noted and, of even more concern, levels of iodine in milk and eggs have been reduced by the inclusion of HG-RSM in ration for cows (Iwarsson, 1973; Iwarsson and Nilsson 1973) and laying chickens (Roos and Clandinin, 1975). It has been indicated in Sweden that supplementing rations for dairy cows which contain HG-RSM with extra iodine results in the production of milk with higher iodine content. Goh and Clandinin (1977) have shown that while HG-RSM in the ration of layers results in a marked decrease in the amount of iodine transferred to eggs, LG-RSM causes only a slight reduction in same.

Rapeseed Gums. During the refining of RS oil a fraction is removed by steam stripping and centrifugation known as gums. Basically rapeseed gums consist of glycolipids and phospholipids with variable amounts of triglycerides, sterols, fatty acids, etc. totalling over 25 components. In studies designed to determine whether or not the addition of gums to rapeseed meal has any detrimental effects on the nutritional value of the resulting meal Clandinin *et al* (1977) fed rations to broiler chickens in which LG-RSM (Tower) containing 2 or 6% RS gums was included in the ration at the 20% level. No adverse effects from the gums on body weight, feed conversion, mortality and incidence of perosis were noted. In experiments with layers fed rations containing 10% of the same meals no adverse effects from the gums on hen-housed production, feed conversion, egg weight, egg Haugh units, egg specific gravity, egg grades and mortality were noted. As a consequence, these researchers concluded that inclusion of up to 6% of RS gums in RSM, which is four times the usual level added to RSM by some RS processors may be expected to have no adverse effects on the nutritional value of the resulting meal for growing and laying chickens.

In a paper, in press, Summers *et al* (1978) reported that no adverse effects in terms of productive performance accrued from the use of up to 15% of LG-RSM (Tower) containing 1 1/2% of RS gums, when fed throughout the commercial life cycle of egg strain birds.

Mineral Binding. Many studies conducted in Canada and Sweden have shown that RSM and rapeseed protein concentrate binds zinc and as a consequence makes the zinc less available nutritionally. Phytin appears to be the factor involved in the binding. Nwokolo and Bragg (1977) have shown that the phytic acid and fibre in rapeseed meal reduces the availability of P Ca Mg and Zn. In addition, it was shown that crude fibre also decreases the availability of Cu and Mn. Vermorel *et al* (unpublished) in a study involving rats showed that by reducing the fibre content of RSM by 60% by the French process of dehulling the digestibility of RSM protein and energy is increased to that of SBM.

Growth Depressant. In a follow-up to studies which demonstrated the presence in LG unheated RSM of a low molecular weight, heat labile, mouse growth depressant, Josefsson (1975) suggested that the factor(s) could be extracted with methylene chloride. The extract contained nitriles but no OZT or ITC suggesting that the growth depression was due to nitriles. Vermorel *et al* (unpublished) has shown that an 80% alcohol extract of RSM which contains nitriles is capable of killing rats.

Srivastava and Hill (1974) showed that the same amount of thiocyanate ion is produced from unheated HG-RSM (Zephyr) as from LG-RSM (Bronowski). Srivastava *et al* (1975) showed that analysis of unheated HG-RSM (Zephyr) produced nitriles which they found were more damaging to rats than chicks.

FULL-FAT RAPESEED

Ordinarily full-fat RS is not considered as a feedstuff for livestock and poultry. However, at certain times it could prove economically sound to include ground or unground full-fat RS in rations for various classes of livestock and poultry.

Most of the feeding studies on full-fat rapeseed have been done at the University of Guelph and the University of Alberta. Early work involving RS with moderately high or high glucosinolate content suggested that such full-fat rapeseed was not a satisfactory feedstuff for pigs and that only after heat-treatment was it a suitable feedstuff for inclusion in broiler rations up to the 10% level and in laying rations up to the 5% level. However, more recent work at the University of Guelph indicates that broiler chickens, broiler turkeys and laying hens may be fed up to 20%, 20% and 10%, respectively, of LG-RS (Tower) in their rations without adversely affecting productive traits. Grinding and heat treatment of the RS are recommended when full-fat RS is included in rations for chicken and turkey broiler rations but does not appear necessary when the full-fat RS is used in laying rations. However, the work of Josefsson and Uppstrom (1976) in which it was shown that even LG-RS (Bronowski) must be heat-treated to avoid nitrile formation suggests that for safety sake full-fat rapeseed should be heat-treated before being fed.

TABLE I. RECOMMENDED LEVELS OF USE FOR RAPESEED MEAL

	High glucosinolate, %	Low glucosinolate, %
Chickens		
Starter, grower	15	20
Layer, breeder	5	10
Turkeys		
Starter, grower	10	20
Breeder	10	10
Swine		
Starter, grower, finisher	5	10
Breeder	3	*
Cattle		
Calves (of dry matter)	20	20
Dairy cows (of dry matter)	5	10
Beef (of dry matter)	10	10

* May be used as the sole source of supplementary protein.