oil and meal from canadian rapeseed

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Publication 1183
Revised 1967

A summary of research on quality and use

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Prepared at the request of the
Associate Committee on
Animal Nutrition
National Coordinating Committee
on Agricultural Services

HIGHLIGHTS

High-quality edible oils are being produced by modern processing of Canadian rapeseed. The meal is now recognized as an acceptable component of protein supplements for all species of livestock and poultry, but it is not recommended for very young birds or for pregnant or lactating sows.

Varieties of *Brassica napus* and *B. campestris* produce 1,500 to 2,500 pounds of seed per acre in southern Manitoba and north-central Saskatchewan and Alberta. Seed for export is graded by government inspectors and certified as to oil and weed seed content by the exporter.

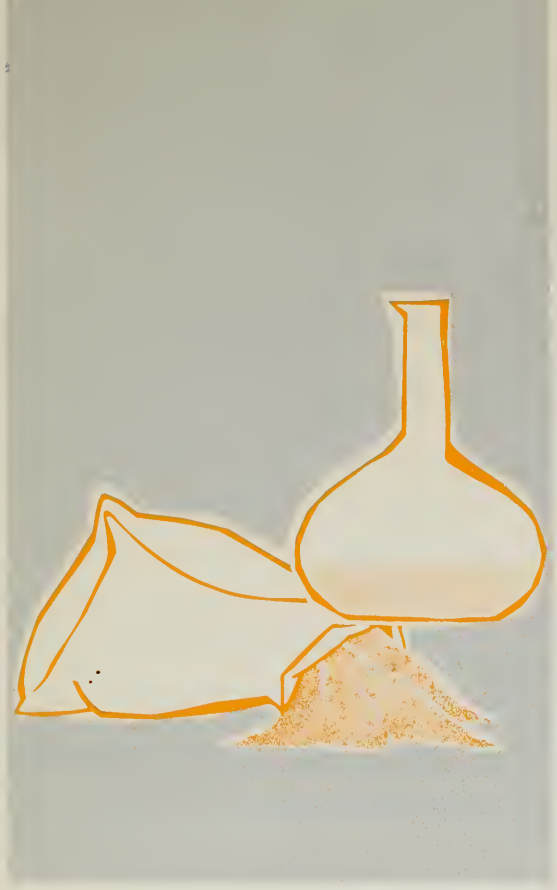
Myrosinase in the seed is inactivated to prevent formation of isothiocyanates, which formerly prevented satisfactory hydrogenation of the oil for edible purposes. Geneticists have isolated plants and developed strains that do not synthesize erucic acid.

Rigid temperature control during extraction of the oil prevents hydrolysis of lysine in the meal. This meal compares favorably with soybean meal; it contains slightly less protein, more ash and crude fiber, more choline and niacin, similar amounts of riboflavin, and somewhat less pantothenic acid and thiamine.

Up to 10 percent of high-quality meal is satisfactory in rations for pullets and laying hens, market turkeys and turkey hens. Because the meal contains 10 percent or more of crude fiber and because of the low tolerance to goitrogenic compounds by young birds, do not feed it to broilers or to turkey poults less than 8 weeks old.

Rapeseed meal is satisfactory for young pigs at levels up to 4 percent of the daily ration and for market pigs (45 to 200 pounds liveweight) at 10 percent of the ration. The meal should be fed with caution to pregnant or nursing sows.

Pregnant ewes lamb successfully when fed a daily ration containing 20 percent rapeseed meal. Dairy and beef cattle producers may feed the meal to their cattle at levels up to 10 percent of the total ration.



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INTRODUCTION

Canadian rapeseed is a major item in the edible-oil markets of the world. Exports have averaged over 200,500 shorts tons a year since 1961—more than the total exports of rapeseed from all other countries—and the average annual production is 377,775 short tons (16). Although home consumption of rapeseed oil and meal has increased to 33 percent of production, the markets of Asia, Europe, and Africa will continue to be the chief outlets.

Rape is grown mainly in north-central Sakatchewan and Alberta (52-54° N) and in southern Manitoba (see the map on the next page). In these favorable areas, yields are often 1,500 to 2,500 pounds of seed per acre (1,700 to 2,800 kilograms per hectare), and the seed contains 42 to 48 percent oil. Because a considerable acreage is grown outside the area of adaptation and on cereal stubble, the average for the country is 805 pounds per acre. This seed contains an average of 43 percent oil (dry basis) and 42 percent protein in the oil-free meal (11).

The rape crop is sown in May and harvested in August or September. No variety of winter rape or turnip rape consistently survives Western Canadian winters. The names rape and rapeseed, as used in this publication, refer to *Brassica napus* L. and *B. campestris* L. Plants of *B. napus* are called rape or colza in Europe and Argentine-type rape in Canada. Common names for the *B. campestris* species are turnip rape, navette, and rübsen in Europe, and Polish-type rape in Canada. The varieties Echo and Arlo (*B. campestris*) are grown on the greatest acreage in Canada, whereas the *B. napus* varieties Target, Tanka, and Nugget are grown to a lesser extent (31).

This publication gives technical information on Canadian grades of rapeseed and on the quality of oil and meal. The greatly increased use of rapeseed meal for livestock and poultry feeding in Canada is attributed largely to the findings summarized in this bulletin.

A field of swathed rape being harvested by combine.

Areas of Western Canada (orange) that are adapted to rapeseed production. Research on rapeseed and its products is conducted by universities and the Canada Department of Agriculture at the centers shown.

GRADING COMMERCIAL RAPESEED IN CANADA

Canadian statutory grades for rapeseed (Table 1) are based on: weight per unit of volume, degree of soundness, general color (indicating ripeness), condition (indicated by temperature and odor), and impurities, expressed as percentage dockage. Dockage includes foreign material that may be separated by cleaning or that may be inseparable but conspicuous. The Board of Grain Commissioners has defined dry rapeseed as that containing less than 10.5 percent moisture. Off-grades are provided for seed containing foreign matter or excessive moisture.

When seed is loaded for export the final certificate of grade must be issued immediately to accommodate shippers, exporters, bankers, and others. The certificate is issued before tests have been made for percentage and acidity of oil and the presence of inconspicuous seeds of weeds such as wild mustard, *Brassica kaber* var. *pinnatifida*, because these factors do not affect the definitions of grades. With few exceptions, the Canadian exporter sells No. 1 Canada grade, 98 percent pure rapeseed, with a stated minimum oil content. Severe discounts are usually made for lower grades and for excessive foreign matter.

As indicated in Table 1, Canada No. 1 rapeseed may not contain over 3 percent damaged seeds. These are defined as seeds that are shrunken or shriveled, as from frost; distinctly green, or otherwise discolored; broken or otherwise damaged.

Since the definitions of grades may cover only part of the exporter's contract requirements, certification of content of oil and of weed seeds is supplied by the exporter if required. The documents covering these characteristics normally follow the seed shipment by some days, and may be the basis of price adjustments.

Government agencies and private traders are intent on supplying the best product possible to the world market. To accomplish this, the quality of Canadian rapeseed is carefully guarded between the farm and the country elevator, and through to the point of export.

A buyer of Canadian rapeseed can protect himself with regard to the content of mustard seed by negotiating with the Canadian exporter and by requiring documentary proof of the actual content of admixture. The Canada Department of Agriculture provides this service and issues a Seed Analysis Certificate at a nominal cost (Page 20).

RAPESEED OIL

Commercial lots of rapeseed from Western Canada sampled during the past 10 years had an average oil content (dry basis) of 43 percent, most of the samples ranging from 38 to 46 percent. Under favorable harvesting conditions, rapeseed oils contain less than 0.5 percent free fatty acids and range in iodine value between 95 and 115. Seed of varieties of *B. napus* had oil contents higher than those found in *B. campestris*. Iodine number was

TABLE 1.—STATUTORY DEFINITIONS OF GRADES OF RAPESEED
Amendment to Schedules One and Two, Canada Grain Act, Effective August 1, 1962

Canada grade rapeseed	Standard of quality		Standard of cleanness (see note)
	Minimum pounds per bushel	Degree of soundness	
No. 1	52	Reasonably sound; cool and sweet; may contain not over 3 percent damaged seeds including not over 0.1 percent heated. Of good natural color.	May contain not more than 1 percent of other seeds that are conspicuous and that are not readily separable from rapeseed, to be assessed as dockage.
No. 2	50	Cool and sweet; may contain not over 10 percent damaged seeds, including not over 0.2 percent heated.	May contain not more than 1.5 percent of other seeds that are conspicuous and that are not readily separable from rapeseed, to be assessed as dockage.
No. 3	48	May contain not over 20 percent damaged seeds, including not over 0.5 percent heated. May have the natural odor associated with low quality seed, but shall not be distinctly sour, musty, rancid, nor have any odor that would indicate serious deterioration or contamination.	May contain not more than 2 percent of other seeds that are conspicuous and that are not readily separable from rapeseed, to be assessed as dockage.

NOTE: Assignment of rapeseed to the above grades shall not imply any guarantee of content of other seeds that blend with rapeseed.

The percentage of "other seeds that are conspicuous and that are not readily separable" shall include weed seeds that do not blend with rapeseed and whole or broken kernels of other grains, when these are not removable by means of appropriate sieves and other cleaning devices.

Dockage shall be assessed on rapeseed for foreign material readily separated from the mass by ordinary mechanical cleaning methods, including any small whole or broken rapeseed removed with such foreign material, plus any other seeds, up to the limits established in the respective grades, that are conspicuous and remain in samples after ordinary mechanical cleaning methods have been applied, these to be added together and expressed as a percentage by weight of the whole; except that a reasonable allowance may be made for broken rapeseed not to be assessed as dockage in commercially clean rapeseed when this can be attributed to attrition in normal handling after cleaning.

not a reliable index of the fatty acids in the oil. Table 2 gives the characteristic fatty acid patterns of varieties of *B. napus* and *B. campestris* grown in Canada (23). Minor amounts (1 percent or less) of other normal fatty acids are also found.

Plant breeders have isolated rape plants with seed oils that contain no erucic and limited amounts of eicosanoic acid (Canbra oil), these being replaced by increased amounts of oleic and linoleic acids (25). Strains are being developed from these plants.

Rapeseed oil is used in Canada for the production of salad and cooking oils, margarines, and shortenings. The consumption has increased rapidly in recent years, accounting for 18 percent of total fat consumption compared to 30 percent for soybean oil in 1966. Rapeseed oil accounted for 23 percent and soybean oil 39 percent of the vegetable oil consumed in 1966. Now that rapeseed can be processed by methods that inactivate myrosinase, the enzyme responsible for the release of isothiocyanates and oxazolidenethione, the oil hydrogenates as readily as soybean oil.

In nutritional studies, rapeseed oil has had digestibility coefficients of 95-98 percent for humans and 80 percent for rats. There is general agreement that the oil retards the growth of rats in proportion to the amount in the diet (36). The oil is absorbed slowly and depresses the appetite. The lower food intake is probably responsible for the 20 to 25 percent increase in longevity of rats fed rapeseed oil. These results have been attributed to erucic acid in the oil (37), but recent studies indicate that the growth rate and food intake are related to the low content of saturated acids, especially palmitic acid. When palm oil or other oils rich in palmitic acid are added to rapeseed oils high in erucic acid, growth rates are similar to those for diets containing other vegetable oils. Conversely, when saturated acids are removed from palm and other vegetable oils, the dietary

A modern solvent-extraction plant showing receiving and storage facilities, solvent plant, oil plant and refinery buildings (in background: a large flour mill). Photo courtesy of Saskatchewan Wheat Pool.

TABLE 2.—PERCENTAGES OF FATTY ACIDS IN CANADIAN RAPESEED OILS

Fatty Acid	Species and Oil Type			
	B. napus		*B. campestris*	
	Percentage in Rape oil	Percentage in Canbra oil	Percentage in Rape oil	Percentage in Canbra oil
Palmitic	3–4	5	2–3	4
Stearic	1–2	2	1–2	1
Oleic	13–24	63	23–26	55
Linoleic	13–16	20	12–18	31
Linolenic	6–12	9	7–12	10
Eicosanoic	10–15	1	8–12	0
Erucic	36–45	0	22–23	0

Interior view of a modern solvent-extraction plant, showing filtration equipment in the foreground and extractor at the right.
Photo courtesy of Saskatchewan Wheat Pool.

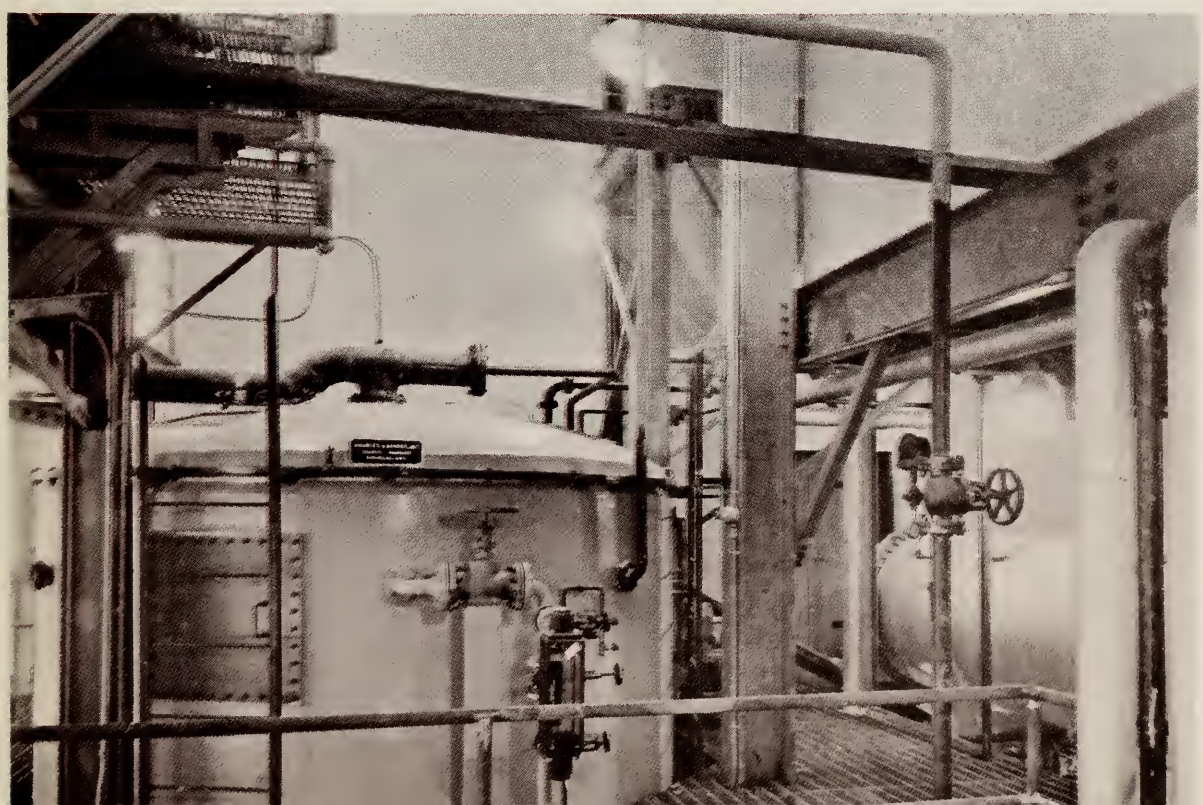


TABLE 3.—AVERAGE NUTRIENT CONTENTS OF RAPESEED MEALS AND SOYBEAN MEAL

	Expeller-processed meals 1954–55		Solvent-processed meals	
	Argentine type *B. napus*	Polish type *B. campestris*	Polish type (1962)	Soybean meal
	Proximate analysis (%)			
Protein (N × 6.25)	43.9	35.2	40.5	45.8
Ether extract	6.4	7.0	1.1	0.9
Ash	5.9	6.8	7.2	5.8
Crude fiber	13.7	15.5	9.3	5.8
Moisture	6.8	6.0	8.0	10.7
Nitrogen-free extract	23.3	29.5	33.9	31.0
	Minerals (%)			
Calcium	0.57	0.71	0.66	0.32
Phosphorus	1.07	1.00	0.93	0.67
	Amino acids (gm/16 gm N)			
Arginine	5.9	5.6	6.0	8.2
Glutamic acid	19.6	18.2		
Glycine	5.9	5.9		
Histidine	2.6	2.6	3.7	2.5
Isoleucine	4.4	4.6	4.1	5.4
Leucine	6.9	6.7	6.1	7.7
Lysine	3.8	4.3	5.6	6.6
Methionine	1.7	1.7	1.5	1.4
Phenylalanine	3.9	3.9	3.7	5.0
Threonine	4.1	4.4	4.1	3.2
Tryptophan	1.3	1.3	1.3	1.4
Tyrosine	2.5	2.6		
Valine	5.0	5.1	7.9	5.4
	Vitamins (mg/kgm)			
Choline	7000	6440		2740
Niacin	167	152		26.8
Pantothenic acid	9.9	8.6		14.5
Riboflavin	4.2	3.3		3.3
Thiamin	1.9	1.7		6.6

effect is similar to that observed with rapeseed oil (4).

Some studies have indicated that levels of serum cholesterol in rabbits are reduced equally by rapeseed and corn oils (41).

RAPESEED MEAL

NUTRIENT CONTENT

Rapeseed meal is a high-protein feed. It can be used as a substitute for linseed meal, soybean meal, and other plant-protein supplements in livestock and poultry rations. As with several other protein supplements in common use today, special attention must be given during manufacture to obtaining meal of high quality and palatability. Lysine is destroyed at excessively high processing temperatures (22). The meal contains some compounds that are potentially toxic to certain ages or classes of livestock and poultry, but recent experiments have shown several ways to use the meal without detriment to animals. Under these conditions the decision on choice of meal becomes one of economics and relative nutrient content.

Typical nutrient contents of Argentine and Polish types of meal, as produced in recent years with modern equipment, are shown in Table 3. The meal ranks between soybean and linseed meals in protein content and contains slightly more crude fiber than typical soybean meal.

Produced under rigid temperature control, modern rapeseed meal contains protein of high quality with more lysine than formerly. A recent study of solvent-processed meal (Bell, J.M., unpublished) showed its protein to have a biological value, based on amino acid comparisons, of 95 percent of that of soybean meal. However, digestibility must also be considered and, although there is evidence that the protein in rapeseed meal is 82-86 percent digestible by ruminants, it may not be as well digested by very young pigs, which need high dietary levels of protein of top quality. Older pigs evidently digest the meal well.

Rapeseed meal appears to have more choline and niacin than soybean meal, about the same amount of riboflavin, and less pantothenic acid and thiamine contents (28). It contains about 0.6 percent calcium and 1.0 percent phosphorus compared with 0.3 and 0.7 percent for typical soybean meal and 0.4 and 0.8 percent for linseed meal.

THIOGLUCOSIDES

The thioglucosides in rapeseed meal yield oxazolidinethione and isothiocyanates when hydrolyzed by certain enzymes. L-5-vinyl-2-oxazolidinethione, which is present in rapeseed, apparently inhibits the uptake of iodine by the thyroid (5). 3-butenyl isothiocyanate and 4-pentenyl isothiocyanate, the chief mustard oils in the meal, may or may not be toxic, but their homologue allyl isothiocyanate, found in brown mustard (*B. juncea*), is very toxic.

Unheated rapeseed contains the enzyme myrosinase, which hydrolyzes the thioglucosides and releases various sulphur compounds. Detoxification techniques are based on the properties of myrosinase. One method involves moistening the ground seed and allowing the enzyme to hydrolyze the thioglucosides. The meal is then treated

Laying hens may be fed rations containing up to 10 percent rapeseed oil meal.

with live steam to remove the isothiocyanates; oxazolidinethione remains in the meal. This treatment improves the quality of the meal but usually impairs the quality of the oil. The favored method now used leads to the inactivation of the enzyme, and keeps the hydrolysis of the thioglucosides to a minimum (13). In general, the quality of rapeseed meal has been steadily improving, undoubtedly because of improved processing methods.

There is some variation in the mustard oil content of rapeseed grown in Western Canada. The Argentine type (*B. napus*) has an oxazolidinethione content of 0.5 to 1.0 percent on an oil-free basis, which is statistically greater than the 0.2 percent found in the Polish type (*B. campestris*). This difference can be used to distinguish between the two types. The isothiocyanate content (0.5 percent), is approximately the same for the two types (40). Climatic and other environmental conditions do not significantly influence the thioglucoside content of rapeseed varieties in Canada.

USE IN POULTRY RATIONS

Starting and growing chickens— Much of the rapeseed meal produced in Canada before 1958 was decidedly inferior to soybean meal as a protein feedstuff for chicks. It was soon learned (22) that the use of high temperatures during the cooking and conditioning of rapeseed in the expeller process resulted in meals of inferior feeding value; the low feeding value of overheated meals was associated with a reduction of more than 25 percent in the lysine content of the protein of such meals as compared to meals subjected to less drastic heat treatment.

Processors in Western Canada have converted from expeller processing to prepress-solvent or solvent methods of processing. This change has occurred because processors realize that maximum oil yield may be obtained by solvent methods without risk of heat damage to the protein of the by-product. However, evidence has been obtained (17) that, for chick growth alone, low-temperature expeller-pro-

Turkeys fed rations containing 12.5 percent rapeseed oil meal grow normally from 8 weeks of age to market weight.

cessed rapeseed meal can give just as satisfactory results as prepress-solvent meal, and in growth promotion value both types of meal may be expected to be similar to solvent-processed soybean meal.

In recent studies (21), 14 samples of commercial prepress-solvent and solvent-processed rapeseed meals were included in 23 percent protein broiler rations at the 15 percent level as a replacement for part of the soybean meal in the ration. The rations were kept isonitrogenous and isocaloric. Growth of chicks and feed conversion were as good on the rations containing rapeseed meal as on those containing soybean meal.

Top-quality expeller-processed and prepress-solvent and solvent-processed rapeseed meal approach or equal soybean meal in value for growth of chicks because the essential amino acid content of the protein of good-quality rapeseed meal compares favorably with that of the protein of soybean meal (30). The two most limiting amino acids in chick starters based on vegetable protein supplements are lysine and methionine. Rations supplemented with rapeseed meal are likely to be similar or higher in methionine and somewhat lower in lysine content than those supplemented with soybean meal.

Laying and breeding chickens— Experiments designed to assess the suitability of expeller-processed rapeseed meal as a replacement for soybean meal in laying rations for chickens have been reported (34). In addition to the vegetable protein supplement, the rations contained either 1.5 percent or 3 percent animal protein (2 meat: 1 fish). No significant differences between treatments for percentage production, amount of feed required to produce a dozen eggs, or in hatchability of eggs produced were observed. Five to 10 percent expeller-processed rapeseed meal can probably be used as a replacement for soybean meal in chicken laying and breeding rations.

No experimental work has been reported on the use of Canadian prepress-solvent or solvent-processed rape-

seed meals in chicken laying and breeding rations. However, such meals might give just as satisfactory results in chicken laying and breeding rations as expeller-processed rapeseed meal.

Starting and growing turkeys—When rapeseed meal, presumably expeller-processed meal, was used instead of meat meal in a turkey starting ration (9, 10), the growth rate was reduced and white barring was noticed. Both detrimental factors may have been due to low lysine content in the rapeseed meal.

The feeding values of rapeseed meal prepared by prepress solvent or solvent extraction were compared by using isonitrogenous and isocaloric turkey starter rations fed to young poults. Growth rates were similar and were equal to those obtained with rations supplemented with soybean meal (unpublished).

Laying and breeding turkeys—In a two-year study duplicate groups of Broad Breasted turkeys were fed, in each year, a breeding ration containing soybean meal as the main supplementary source of protein and a ration in which 10 percent solvent-processed rapeseed meal replaced most of the soybean meal in the ration. There were no adverse effects on egg production, feed conversion, or percentage hatch as a result of the substitution.

Goitrogenic effects of rapeseed meal in poultry—Several workers (8, 24, 26, 28, 38, 42) have reported thyroid enlargement as a result of feeding rapeseed meal to poultry. In general, meal produced from Argentine-type seed *(Brassica napus)* has been shown (24, 38) to cause a greater degree of enlargement than meal produced from Polish-type seed *(Brassica campestris)*. This is attributed to the higher goitrin ((-)-5-vinyl-2-oxazolidinethione) content of rapeseed meal produced from *B. napus* seed as compared to that produced from *B. campestris* seed (19, 40)

Efforts to counteract the thyroid enlargement of chickens fed rapeseed meal by feeding supplementary iodine have been only partially successful (18, 24, 28, 29). On the other hand,

Rapeseed oil meal is satisfactory in a mixed supplement for market pigs.

feeding Protamone or Thyradin (dried thyroid) or injecting L thyroxine has resulted in a reduction of the thyroid-to-body-weight ratio of rapeseed-meal-fed poultry (10, 18, 28, 29, 39).

Although the initial effect of feeding rapeseed meal to poultry is that of causing thyroid dysfunction, workers (20) have shown that within three or four weeks compensatory changes that permit normal functioning occur in the thyroid glands of poultry. It is perhaps because of this thyroid readjustment that economic traits of poultry are unaffected by the inclusion of moderate amounts of rapeseed meal in poultry rations.

USE IN SWINE RATIONS

Rapeseed meal may be used as part of the supplemental protein for growing market pigs. No adverse affects were observed when solvent-extracted meal composed 4 percent of the total ration for young pigs from 10 to 45 pounds (4.5 to 20 kg) in weight (12, 32). For market pigs from 45 to 200 pounds (20 to 90 kg) liveweight, the meal may comprise up to 10 percent of the total ration (12, 14, 27, 33). Feed intake and rate of gain may be reduced slightly when the ration contains more than 4 percent rapeseed meal, but efficiency of feed utilization is not affected. When the meal has been used to replace soybean meal, it has had little effect on digestibility coefficients for energy or protein (33) or on carcass quality of market pigs (12, 32). In recent experiments (14, 15) satisfactory performance was obtained when 8 percent solvent-extracted meal replaced an equivalent level of soybean meal in pregestation, gestation, and lactation rations for mature sows. Birth weights of pigs and number of pigs weaned from gilts receiving rapeseed meal were slightly reduced. Breeding boars were unaffected by levels of rapeseed meal as high as those recommended for market pigs (32).

Caution should be used when feeding the meal to breeding females.

USE IN SHEEP RATIONS

Rapeseed meal and linseed meal gave

Beef cattle may be fattened with rapeseed oil meal as supplementary protein.

Threshing rape with a combine harvester.

A field of rape in the swath.

similar results when fed to sheep at rates up to 20 percent of the total ration. This applied to the body weight gained by ewes during pregnancy (7), the quantity and quality of wool produced by ewes, the weight of lambs at birth and at 6 weeks of age (8), and the daily gain in body weight of weaned lambs on pasture (35). However, when the level of rapeseed meal was increased to 30 percent of the ration, palatability was affected and the amount of food eaten was markedly reduced. As a result, ewes lost weight during pregnancy, lambs were lighter at birth and at 6 weeks of age than when a 20 percent level was fed, and the weight of clean wool was also less (8, 35).

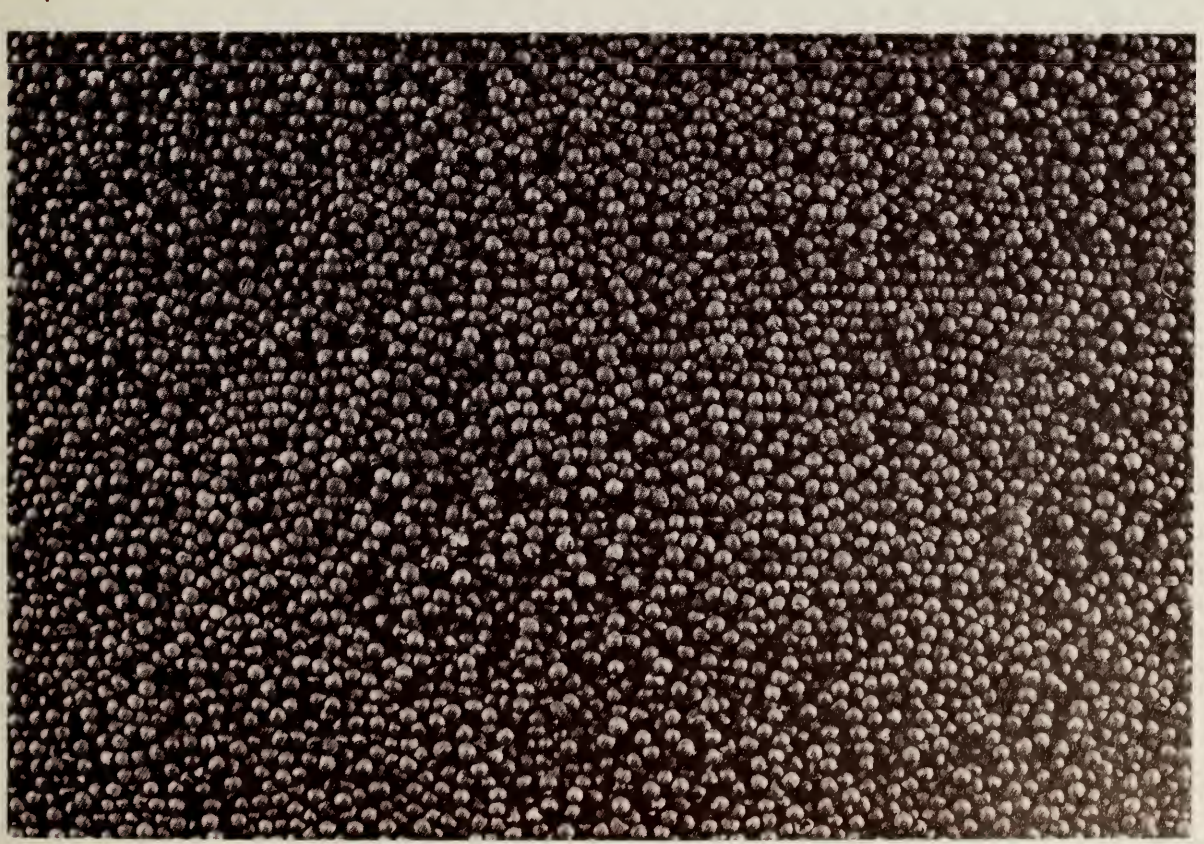
When rapeseed screenings were fed to weaned lambs, the greatest daily gains were obtained when the screenings constituted about 12 percent of the total ration (6). When the level of screenings was increased to 24 percent, daily gains decreased (6).

No goitrogenic effects were observed in sheep fed rapeseed meal.

USE IN CATTLE RATIONS

When extracted by the solvent or prepress solvent process, rapeseed meal is a satisfactory protein supplement for dairy cows. It is used rather extensively in Western Canada and has for many years been used in dairy cattle feeds in Europe. In short-term experiments, rapeseed meal at levels as high as 10 percent of the total dry-matter intake was equivalent to linseed meal in feeding value (1, 2). No evidence was found of lower consumption of rapeseed meal than of linseed meal by cows in drylot or on

Rapeseed.



pasture (3). No flavor defects atttributable to the feeding of rapeseed meal were detected in milk.

Results obtained with dairy cattle and practical experience in feeding beef cattle indicate that rapeseed meal is a satisfactory protein supplement for beef cattle.

REFERENCES

1. Asplund, J. M. 1961. Rapeseed oil meal for dairy cattle. Univ. Alberta, 40th Annu. Feeders' Day Rep.
2. Asplund, J. M., and L. W. McElroy. 1961. The effect of high levels of rapeseed oil meal in dairy cow rations on milk production. J. Dairy Sci. 44:2338. (Abstr.)
3. Asplund, J. M. 1962. Rapeseed oil meal for dairy cows on pasture. Univ. Alberta, 41st Annu. Feeders' Day Rep.
4. Beare, Joyce L., J. A. Campbell, C. G. Youngs, and B. M. Craig. 1963. Effect of saturated fats in rats fed rapeseed oil. Can. J. Biochem. Physiol. 41:605-612.
5. Bell, J. M. 1955. The nutritional value of rapeseed oil meal. A review. Can. J. Agr. Sci. 35:242-251.
6. Bell, J. M., and J. H. Linton. 1961. Digestibility and feedlot studies on rapeseed screenings for feeder lambs. Can. J. Anim. Sci. 41:230-235.
7. Bell, J. M., and J. A. Weir. 1952. Supplementation of alfalfa and marsh hays with linseed, rapeseed and mustard oil meals in gestation rations for ewes. Sci. Agr. 32:496-501.
8. Bezeau, L. M., S. B. Slen, and F. Whiting. 1960. The nutritional value of rapeseed oil meal for lamb and wool production in mature range ewes. Can. J. Anim. Sci. 40:37-43.
9. Blakely, R. M., and R. W. Anderson. 1948. Studies with rapeseed oilcake meal. I. The effect of various levels of rapeseed oilcake meal in the diet on the weight of the thyroid glands of turkey poults. Sci. Agr. 28:393-397.
10. Blakely, R. M., and R. W. Anderson. 1948. Studies with rapeseed oilcake meal. II. The effect of the inclusion of protamone in the diet, on the thyroid enlargement induced by the feeding of rapeseed oilcake meal to turkey poults. Sci. Agr. 28: 398-402.
11. Board of Grain Commissioners for Canada. 1966. Canadian flax and rapeseed. Crop Bull. 99. Grain Research Laboratory, Winnipeg.
12. Bowland, J. P. 1965. Feeding value of rapeseed meal for swine. *In* Rapeseed Meal for Livestock and Poultry—A Review. Can. Dep. Agr. Pub. 1257. p. 69-80.
13. Bowland, J. P., D. R. Clandinin, and L. R. Wetter. 1965. Rapeseed meal for livestock and poultry—A Review. Can. Dep. Agri. Pub. 1257. p. 24.
14. Bowland, J. P. and F. W. Schuld. 1966. Rapeseed meal for gilts to market weight. Univ. Alberta, 45th Annu. Feeders' Day Rep. p. 6-7.
15. Bowland, J. P., and F. W. Schuld. 1967. Rapeseed meal for sows during two reproductive cycles. Univ. Alberta, 46th Annu. Feeders' Day Rep. p. 28.
16. Canada Department of Industry. 1967. Fats and oils in Canada. Vol. 2, No. 1. Edible Oils Section, Food Products Branch. Ottawa.
17. Clandinin, D. R. 1962. The status of research on rapeseed oil meal as a feedstuff for poultry. Proc. 12th World's Poultry Congr. p. 259-263.
18. Clandinin, D. R., and Louise Bayly. 1960. Rapeseed oil meal studies. 2. Effects of feeding rapeseed oil meal on the structure of the thyroid glands of chickens. Poultry Sci. 39:1239. (Abstr.)
19. Clandinin, D. R., and Louise Bayly. 1963. Effect of variety and growing conditions on the protein and amino acid composi-

tion of rapeseed. Can. J. Anim. Sci. 43:65-67.

20. Clandinin, D. R., Louise Bayly, and Alma Caballero. 1966. Rapeseed meal studies. 5. Effects of (±)-5-vinyl-oxazolidine-thione, a goitrogen in rapeseed meal, on the rate of growth and thyroid function of chicks. Poultry Sci. 45:833-838.

21. Clandinin, D. R., and A. R. Robblee. 1966. Rapeseed meal for poultry—a review. World's Poultry Sci. J. 22:217-232.

22. Clandinin, D. R., Ruth Renner, and A. R. Robblee. 1959. Rapeseed oil meal studies. I. Effects of variety of rapeseed, growing environment and processing temperatures on the nutritive value and chemical composition of rapeseed oil meal. Poultry Sci. 38:1367-1372.

23. Craig, B. M. 1961. Varietal and environmental effects on rapeseed. III. Fatty acid composition of 1958 varietal tests. Can. J. Plant Sci. 41:204-210.

24. Dow, D. S., and C. E. Allen. 1954. Rapeseed oil meal in broiler rations with observations on the nature and control of its metabolic inhibitors. Can. J. Agr. Sci. 34:607-613.

25. Downey, R. K. 1966. Towards a better rapeseed. Agr. Inst. Rev. 21:16-18.

26. Frolich, A. 1953. Experiments with different treatments of rapeseed meal. Kungl. Lantbrukshogskolans Ann. 20:105-116.

27. Hussar, N., and J. P. Bowland. 1959. Rapeseed oil meal as a protein supplement for swine and rats. I. Rate of gain, efficiency of food utilization, carcass characteristics and thyroid activity. Can. J. Anim. Sci. 39:84-93.

28. Klain, G. J., D. C. Hill, H. D. Branion, and Jean A. Gray. 1956. The value of rapeseed oil meal and sunflower oil meal in chick starter rations. Poultry Sci. 35:1315-1326.

29. Kratzer, F. H., P. N. Davis, D. E. Williams, and B. J. Marshall. 1954. Factors influencing the growth of chicks and poults fed rations containing rapeseed oil meal. J. Nutrition 53:407-418.

30. Lyman, C. M., K. A. Kuiken, and F. Hale. 1956. Essential amino acid content of farm feeds. J. Agr. Food Chem. 4:1008-1013.

31. Malaher, W. G. 1966. Rapeseed production in Western Canada. Searle Grain Co., Bull. Winnipeg.

32. Manns, J. G., and J. P. Bowland. 1963. Solvent-extracted rapeseed meal as a protein source for pigs and rats. I. Growth, carcass characteristics and reproduction. Can. J. Anim. Sci. 43:252-263.

33. Manns, J. G., and J. P. Bowland. 1963. Solvent-extracted rapeseed oil meal as a protein source for pigs and rats. II. Nitrogen digestibility and retention; energy and dry matter digestibility. Can. J. Anim. Sci. 43:264-270.

34. O'Neil, J. B. 1957. Rapeseed oil meal as a vegetable protein supplement in the diet of laying and breeding hens. Poultry Sci. 36:1146. (Abstr.).

35. Palmer, A. E. 1949. Progress Report, 1937-1946. Experimental Farm, Lethbridge, Alta. p. 55.

36. Thomasson, H. J. 1955. The biological value of oils and fats. I. Growth and food intake on feeding with natural oils and fats. J. Nutrition 56:455-468.

37. Thomasson, H. J., and J. Boldingh. 1955. The biological value of oils and fats. II. The growth-retarding substance in rapeseed oil. J. Nutrition 56:469-475.

38. Turner, C. W. 1946. Effect of rapeseed on the thyroid of the chick. Poultry Sci. 25:186-187.

39. Uesaka, S., R. Kawashima, K. Katoh, T. Osaki, and Y. Okada. 1964. Effects of feeding rapeseed oil meal and dried thyroid powder on growth and thyroid of domestic fowl. Jap. J. Zootechnical Sci. 35:167-174.

40. Wetter, L. R., and B. M. Craig. 1959. Varietal and environmental effects on rapeseed. I. Isothiocyanate and thiooxazolidone content. Can. J. Plant Sci. 39:395-399.

41. Wigand, G. 1959. Production of hypercholesterolemia and atherosclerosis in rabbits by feeding different fats without supplementary cholesterol. Acta Med. Scand. 166:3-91.

42. Witz, W. M., M. M. Carpenter, and J. W. Hayward. 1950. Nutritional studies with rapeseed meal. Poultry Sci. 29:786. (Abstr.)

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Form I-41

CANADA DEPARTMENT OF AGRICULTURE

SEED ANALYSIS CERTIFICATE

No.

THIS IS TO CERTIFY that a sample of RAPESEED

submitted by the BOARD OF GRAIN COMMISSIONERS FOR CANADA

identified as _____

for account of _____ Fee $ .00

has been analyzed with respect to inconspicuous admixtures, with the following results:

% mustard seed (wild and/or domestic types)

% other seeds

....
PLACE DATE OFFICIAL ANALYST

NOTE--Conspicuous admixtures are determined by grain inspectors of the Board of Grain Commissioners, and are considered as dockage and/or grading factors.

Conspicuous inseparable admixture in this instance contains _____% of mustard seed, in addition to the percent indicated above.

.....
GRAIN INSPECTOR

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Copies of this publication may be obtained from:

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OTTAWA

First printed 1963 (Original title: Oil and Oilmeal from Canadian Rapeseed)
Revised 1967
Reprinted 1968

5M—34314—6:68 Cat. No. A53-1183

oil and meal from canadian rapeseed