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WHOLE-FAT RAPESEED MEAL FOR GROWING AND FATTENING DAIRY BULLS

BY

DONALD NORMAN MILLIGAN

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "Whole-Fat Rapeseed Meal for Growing and Fattening Dairy Bulls"

submitted by Donald Norman Milligan, B.Sc. (Ag)

in partial fulfilment of the requirements for the degree of Master of Science in Animal Nutrition.

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ABSTRACT

Twenty-four Holstein x Brown Swiss bulls were fed three levels of whole-fat rapeseed meal (0, 10, and 15 percent), two levels of molasses (0 and 5 percent) and two levels of alfalfa pellets (0 and 10 percent). In an attempt to establish an optimum level of rapeseed, the rapeseed, molasses and alfalfa pellets were substituted in place of barley in the rations. Digestibility studies were conducted midway through the trial to determine coefficients of apparent digestibility of dry matter, gross energy, nitrogen and ether extract.

Average daily gains obtained were 1.16, 1.20 and 1.11 kg., respectively, for the 0, 10 and 15 percent levels of whole-fat rapeseed, 1.09 and 1.22 kg., respectively for the 0 and 10 percent levels of alfalfa pellets and 1.08 and 1.39 kg., respectively, for 0 and 5 percent levels of molasses. There were no significant (P<0.05) differences among the rapeseed treatments. However, there was a significant difference in average daily gain of bulls fed the two levels of molasses and the two levels of alfalfa pellets. When the rapeseed, molasses and alfalfa pellets were fed in combination, there was no significant interaction (P<0.05) in average daily gain.

There were no significant differences (P<0.05) in daily intake of dry matter, gross energy or digestible energy

by bulls on any of the treatments. When rapeseed, molasses and alfalfa pellets were fed in combination, there were no significant (P<0.05) interactions for daily intake of dry matter, gross energy, or digestible energy.

The efficiency of utilization of dry matter and energy was not significantly different (P<0.05) for any of the treatments, and there was no significant interaction when the three ingredients were fed in combination.

The inclusion of rapeseed or molasses or alfalfa pellets in diets did not result in any significant differences (P<0.05) in the coefficients of apparent digestibilities of dry matter, digestible energy, crude protein or ether extract. When rapeseed, molasses and alfalfa pellets were fed in combination, no significant interactions (P<0.05) were found in the coefficients of apparent digestibility.

No significant differences (P<0.05) were obtained in carcass weight or dressing percentage, or in percentage fat and percentage lean in rib sections.

It was calculated that energy and protein in whole-fat rapeseed meal had digestibility coefficients of 87.2 and 86.8%, respectively.

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INTRODUCTION

The world annual production of rapeseed has increased from 2.8 million tons in the period of 1948-1952, to over 6 million tons in 1970. In Canada, rapeseed has become a major crop. Annual production has increased from 9,000 tons in 1948-1952 to over 1.6 million tons in 1970; production in 1973 was approximately 1.3 million tons. As a result of the increase in production, large quantities of rapeseed meal, a by-product from the oil extraction process, are available for use in animal feeds.

Undoubtedly, with increasing rapeseed production, there will be years when there will be an excess of rapeseed required for the extraction of oil. Also, since rapeseed is grown in many areas of unpredictable frosts, there may be years when large quantities of the grain will be frozen before maturity. If the seed is frozen, processors are reluctant to accept it for oil extraction. These two factors suggest the need for alternate uses of whole rapeseed, such as full-fat rapeseed meal in feeds for livestock.

Combined with the above reasons and the fact little or no work had been done with ruminants fed full-fat rapeseed meal, a study was undertaken at the University of Alberta, using rapeseed that had been damaged by frost in the fall of 1972. Since rapeseed meal has been considered to be relatively unpalatable to ruminants, molasses and alfalfa pellets were included in some of the experimental rations to study their effect on increasing feed intake, which might be adversely affected by full-fat rapeseed meal alone. In addition, full-fat rapeseed meal would add fat to the diet, and molasses and alfalfa pellets have been found useful in improving utilization by ruminants of diets containing fats and oils.

REVIEW OF LITERATURE

1. The Rapeseed Plant

Rapeseed is a member of the cruciferae family (mustard is the common name for this family), of the genus Brassica. There are two types of rapeseed grown in Canada; Brassica napus and Brassica campestris, commonly called Argentine rape and Polish rape, respectively (Downey, 1965). Brassica napus has a greater potential in yield of seed and oil, but has a longer maturation period (Downey and Bolton, 1961), as compared with Brassica campestris. For this reason, Brassica campestris comprises approximately 80% of Canada's total production of rapeseed (Downey, 1965).

11. Problems Associated with Feeding Rapeseed Meal

A. Goitrogens

Rapeseed, like many other plants of the Brassica genus, contains glucosinolates. These glucosinolates, when hydrolysed in the presence of the enzyme, myrosinase (also present in rapeseed), produce isothiocyanates, goitrin and nitriles (Bell and Belzile, 1965). In Brassica napus, progoitrin (2-hydroxy-4-pentenyl glucosinolate) is the predominant glucosinolate, while in Brassica campestris, gluconapin (3-butenyl glucosinolate) predominates (Clandinin et al., 1959; Wetter and Craig, 1959; Appleqvist and Ohlson, 1972).

The effect of progoitrin has been studied most because it has been implicated in the goitrogenicity of rapeseed meal. Progoitrin is hydrolyzed by the enzyme myrosinase, to yield 2-hydroxy-3-butenyl isothiocyanate, which is unstable and breaks down to 5-vinyl-2-oxazolidinethione (goitrin). Goitrin has been shown to be the principal compound responsible for thyroid enlargement and depression of thyroid function in animals (Greer, 1962) and chicks (Clandinin et al., 1966).

The first work in isolation of the goitrogenic properties in rapeseed was done by Kennedy and Purves in 1941. They found enlarged thyroids in rats that were fed rapeseed meal. Similar findings were reported in 1948 (Blakely and Anderson) from a study in which turkey poults were fed a ration containing 20% rapeseed oilmeal. Clandinin (1961) noted that chicks fed expeller-processed rapeseed meal had a two-fold increase in thyroid to bodyweight ratio. Similar results were obtained in further studies using rations containing 5% Argentine rape or 15% Polish rape. From this, he concluded the levels of goitrogens were different in the two varieties of rapeseed. This was also shown by Klain et al. (1956), who reported that Argentine rape (*B. napus*) had a higher content of goitrogenic compounds than Polish rape (*B. campestris*). The major goitrogenic compound was found to be 5-vinyl-2-oxazolidinethione (Astwood et al., 1949; Carroll, 1949; and Wetter and Craig, 1959).

It has been shown that the goitrogenic properties of rapeseed meal are associated with growth depression in monogastric species (Carroll, 1949). The goitrin apparently inhibits production of the hormone thyroxine, which is necessary for growth, and results in impaired function of the thyroid gland. Belzile, Bell and Wetter (1963) found that the addition of the enzyme myrosinase did not increase the toxicity of rapeseed meal. Thus, they concluded that the seed contained sufficient myrosinase to hydrolyze the glucosinolates that were present. They also reported that there was a depression in growth of 25% when mice were fed rapeseed meal. Bell (1965) showed that 5% rapeseed meal in the ration of growing pigs resulted in depressed rate of gain.

Clandinin, Bayly and Caballero (1966) added 0.15% of 5-vinyl-2-oxazolidinethione to chick rations and found depressed growth rates and thyroid enlargements in the chicks. It was also reported that the chicks achieved a physiological equilibrium, since normal growth took place after 4 weeks on the diets. Similar results were found by Matsumato, Itoh and Akida (1968). In 1972, Akiba and Matsumato reported an experiment where they withdrew the goitrogen, 5-vinyl-2-oxazolidinethione, from chick rations following a 21-day feeding period. Within two days the thyroid was functioning normally, whereas thyroid function had been abnormal prior to withdrawal of the goitrogen. They also noted that the enlarged thyroid condition persisted for longer periods following the withdrawal from goitrogen even though the thyroid was functioning normally.

B. Goitrogen in Relation to Ruminants

There have been few reports of adverse effects of goitrogens on ruminants by feeding rapeseed meal. Research in

Scotland (Russell, 1967), showed that lambs grazing on forage rape (B. napus) had significantly larger thyroids than those grazed on grass. Work in France (Grenet, 1970) has been reported in which rations containing rapeseed meal were compared to rations containing linseed meal. Ewes fed the rapeseed meal rations had significantly heavier thyroid glands as compared to those fed linseed meal rations.

In a review by Bell (1955), it was noted that work in Montana and Lethbridge failed to show any ill effects from feeding rapeseed meal to ruminants. Appelqvist and Ohlson (1972) cited work by Virtanen, Kreula and Kiezvaara (1963), who fed 5-vinyl-2-oxazolidinethione and its precursor to a cow and discovered only trace amounts of oxazolidinethione in the milk. They concluded that either progoitrin was not hydrolysed in the rumen or that any oxazolidinethione that was formed was destroyed.

Bezeau et al. (1960) found that levels of 10, 20 and 30% rapeseed meal in rations fed to ewes had no enlargement effect on the thyroid. The difference between reports may be due to a difference in varieties of rapeseed fed. Saskatchewan research showed average levels of oxazolidinethione in Bronowski, Target and Nuggett varieties of rapeseed meal were 0.20, 10.40 and 8.90 mg/g, respectively (Bell, Young and Downey, 1971).

C. Palatability of Rapeseed

Ruminants have been shown to reduce their feed intake when rapeseed meal levels are increased beyond 10 percent of the diet (Ingalls et al., 1972), but cattle will adapt to consuming rapeseed meal after a period of time (Appelqvist and Ohlson, 1972; Virtanen et al., 1963; Grenet, 1970; Bezeau et al., 1960; and Ingalls et al., 1968). Schwarze (1948) reported that the unpalatability effect of rapeseed meal was due in part to a bitter compound known as sinapin. Clandinin (1961) studied sinapin and found it had no growth depressing effects even though it is a thiocyanate.

Part of the reduced palatability of rapeseed meal could be due to tannins. Clandinin and Heard (1968) showed levels of quantannic acid to be 3.03% in rapeseed meal. Vohra, Kratzer and Joslyn (1966) showed decreases in feed intake in chicks from 320 gm/15 days, with no tannic acid, to 120 gm/15 days, at a level of 3% tannic acid in the diet.

111. Feeding Rapeseed Meal and Rapeseed

Less research attention has been directed towards using rapeseed products in rations for ruminants as compared to studies with poultry and swine. Besides the effect on palatability at higher levels, rapeseed meal has not the adverse effects on growth rate in ruminants that has been observed with monogastric species.

A. Rapeseed Products Fed to Dairy Cows

Jarl (1951) fed rapeseed oil cake to milking cows at levels of 0, 25, 50 and 60% of the concentrate ration. The cows fed the higher levels of rapeseed cake (50 and 60%) had a lower milk production (0.5 kg less/day) than those fed the rations with lower levels of rapeseed. He also reported that as the level of rapeseed increased the percent of fat in milk decreased, but only slightly. He noted that in order for rapeseed meal to be palatable, it had to be fed dry. Both Nordfeldt (1958) and Homb, Orud and Walden, (1961) found that supplemental rapeseed meal increased milk yield, but fat percentage of milk decreased. In neither case was milk flavour affected. Whiting (1965) cited work by Seale (1952) who obtained results indicating that the feeding of rapeseed increased milk production slightly with the butterfat level remaining the same as that with the control linseed meal ration.

Asplund (1961, 1962) found that when rapeseed meal was substituted for linseed meal, dairy cows rejected the ration during the first week it was fed. He felt that the rejection was not due to the rapeseed alone as the rations were initially ground and this resulted in the cows licking the grain. The licking caused the grain to become wet and unpalatable. To alleviate this, the diets were coarsely rolled. Milk production in both studies varied with the levels of rapeseed used. Cows fed 20% rapeseed meal produced less milk than those fed 10% rapeseed meal and they declined in milk production twice as fast as the rest. The cows fed 10% rapeseed meal produced as much milk as cows receiving control diets. There were no adverse milk flavours attributed to the rapeseed. Witt, Huth and Hartman (1959) used a ration that contained 10-15% rapeseed meal (25% of the concentrate mixture). Their results showed an increase in milk production of about 0.35 kg per day. In a long term experiment, Homb, Orud and Walden (1961) compared cows fed 10 and 15% rapeseed meal and cows fed linseed meal, together with various levels of fat in the rapeseed meal rations. They reported that between the rations there were no significant differences in milk production, milk fat levels or weight gains by the cows. Similar results were noted (Chomyszym and Beza, 1965) when rapeseed was fed at levels as high as 50% of the concentrate diet of milk cows. This work showed inconclusive results in terms of milk fat content, but there was a tendency for lower values with rapeseed meal as compared with the control rations. Grenet (1970) observed that when rapeseed meal was toasted, after extraction, acceptability by dairy cows increased. He also noted that the nutritive value of the rapeseed meal was not adversely affected by toasting and the utilization of nitrogen was slightly increased.

A study was conducted to determine the results of using rapeseed meal and urea, singly and in combination, on the ad libitum grain intake of dairy cows (Ingalls, Seale and McKirdy, 1968). The results indicated that grain consumption was decreased when 12 to 13% rapeseed meal was used in place of soybean meal, but there was no effect on milk production, or milk protein. Grieve (1973) studied the effect of substituting urea and rapeseed meal for soybean meal in dairy rations. It was found that a combination of 8.5% rapeseed meal and 0.75% urea could be used in place of soybean meal with no decrease in feed intake. Similar results have been reported elsewhere (Ingalls and Waldern, 1972).

B. Rapeseed Meal in Calf Rations

It was reported in experiments with calves (Ingalls and Waldern, 1972) that the digestible energy value of rapeseed meal was equal to that of soybean meal, and there was little difference between the digestibilities of the protein. With calf starters containing 20% rapeseed meal in place of soybean meal, the calves had similar weight gains and feed intake. However, at 30% rapeseed meal, feed intake and weight gains were depressed. Bell and Devlin (1972) reported that calves fed diets low in roughage, and with the concentrate containing up to 50% rapeseed meal, derived about 2370 kcal of metabolizable energy per kg of rapeseed meal (10% moisture basis). This metabolizable energy value was compared to soybean meal having a value of 2159 kcal of metabolizable energy per kg of meal. It was also reported that when comparing rapeseed meal and soybean meal, growing calves gained slightly better with soybean meal (1.03 kg/day vs. 0.96 kg/day). Whiting (1965), in a review, cited work by Clark and Bezeau (1964), comparing linseed meal to expeller-extracted rapeseed meal and solvent-extracted rapeseed meal. Initially, calves fed the rapeseed meal rations did not consume as much feed as those fed linseed meal. However, at the end of sixteen weeks, their feed consumption and rate of gain was the same as those fed the linseed meal rations. In an experiment in Chile, Latrille and Ferguson (1968) compared lucerne hay, rapeseed meal and dried beet pulp in concentrate rations for growing calves. Hay was fed at levels of 20% and 30%, the rapeseed meal at a level of 25% and beet pulp at a level of 25%. Another group received 15% rapeseed meal and 20% beet pulp. There were no significant differences obtained among any of the groups. Recently it has been reported (Grieve, 1974) that rapeseed meal and urea, or rapeseed meal alone, can be used as a replacement or in substitution for soybean meal in rations fed to calves.

C. Rapeseed Meal in Rations for Steers and Beef Cows

Whiting (1965) noted that Seale (1952) in Manitoba had fed rations containing rapeseed meal to steers for 140 days. Three rations were compared, containing 10% linseed, rapeseed or mustard seed meal as the protein supplement. Results showed that the steers fed rations containing rapeseed or mustard seed meals rejected their feed initially, but after a time, the animals became accustomed to the rations and consumption was as good as with linseed meal. The steers fed linseed meal gained somewhat better than those on the other two rations (0.12 kg more daily). Burkitt et al., (1954) from Montana, conducted a study comparing linseed meal and rapeseed meal as supplements for low protein roughages for pregnant beef cows, yearling steers and calves. As others have reported, this study found the animals consumed less feed when rapeseed was used due to the palatability factor. However, no differences were noted in overall performance. Bell and Devlin (1972) reported a study in which a diet containing 10.5% rapeseed meal was compared with one containing 7.5% soybean meal and with a control ration of barley, with no protein supplement. The results indicated no differences in weight gains and feed conversion. Whiting (1965) cited work from the University of Alberta in which it was noted rapeseed meal provided more efficient gains when compared to rapeseed screenings and rapeseed meal plus urea. The rapeseed screenings gave the most economical gain, but it was not certain that this would always be the case.

D. Rapeseed Meal in Sheep Rations

Bezeau, Slen and Whiting (1960) conducted two experiments on feeding rapeseed meal to pregnant and lactating ewes. In the first study, the rapeseed meal was at 10 and 20% levels and in the second, levels of 10, 20 and 30% rapeseed meal were used. In each case, linseed meal was used as a control ration. In both experiments ewes receiving 10 or 20% rapeseed meal consumed equally as much feed as the ewes getting linseed meal, and there were no differences in weight gains, lamb birth weights, growth of lambs or wool production. However, the ewes fed the 30% rapeseed meal ration consumed less than those in the control group, their weight gains were less, their lambs lighter at birth and their wool growth poorer than the control group. Burkitt (1951) observed palatability problems when rapeseed meal was fed with grass hay. It was noted that digestibility of the ration was not affected significantly by the addition of rapeseed meal.

IV. Fats and Oils in Livestock Rations

In 1929, Burr and Burr found that diets completely lacking in fat caused certain abnormalities. These included skin problems, poor growth rate and reproductive problems. It was concluded from their study that fat was a necessary component of an animal's diet. This was demonstrated to be true for dairy calves specifically (Lambert et al., 1954). It was later discovered that it was not necessarily fat that was essential, but rather its components, namely fatty acids. Not all fatty acids were required; only a certain number were essential to animal diets (Burr and Burr, 1930). Maynard and Loosli (1969) indicated that ruminants have a requirement for the fatty acids arachidonic, linoleic, and linolenic, but primarily for linoleic, which agrees with studies by Lambert et al. (1954). In addition to the essential fatty acids contained in it, fat serves as a carrier for fat soluble vitamins (vitamins A, D, E and K), promotes the absorption of vitamin A and carotene, and makes the use of carbohydrate energy more efficient (Russell et al., 1942).

A. Fat in Calf Rations

Newborn calves have difficulty digesting vegetable oil. Adams et al. (1959 a, b) studied growth rate in calves fed milk rations in which butterfat was substituted with vegetable oils. When vegetable oils were used in place of butterfat, growth rates of calves were reduced, they suffered diarrhea, were more susceptible to pneumonia, and utilized feed poorly. The calves fed rations with vegetable oil, excreted much of the fecal fat in the form of soaps, whereas this was not the case with calves fed skim milk or milk containing butter oil. Adams et al. (1959 c) noted that if rations were prepared daily rather than weekly, diarrhea decreased and digestibility increased. Chandler et al. (1968) studied the effect of adding 10% lard to starter rations for calves. They observed that feed intake, growth rate and digestibility of dry matter and energy were all depressed by the addition of lard.

B. Fat in Steer Rations

It was shown that steers fed high levels of fat (7.1% of the diet) had improved feed efficiency over steers fed low levels of fat (2.8% of the diet) (Willey et al., 1952). The rate of gains and carcass grades were not significantly different in any of the groups. In accordance with other findings, they reported that the absorption of vitamin A and carotene increased (Bender and Maynard, 1932; Russell et al., 1942 and Parham, Colby and Riggs, 1950). By adding 4% tallow, or 4% hydrolized vegetable oil plus animal fat, to high concentrate rations, digestibilities of ration components were not affected (Esplin et al., 1963). Fecal soaps increased as fat level increased, but the absolute increase was small. Thus they concluded that the loss did not represent a major energy loss from added fats. They noted that 4% fat could be added to a fattening ration, without depressing the utilization of ration components and with good utilization of the added fat.

Roberts and McKirdy (1964) conducted a study to determine the effects of sunflower seed oil, rapeseed oil and animal tallow as dietary sources of fat in feedlot rations. They noted no significant differences in rates of gain. However, the animals fed sunflower seed oil gained 0.2 kg more weight daily and consumed 7% more feed daily than the animals on the rest of the treatments. The digestibilities of dry matter and energy were not affected by these treatments. The sunflower seed oil resulted in higher crude fat excretion and lower crude fat digestibility. The authors suggested that the cause was due to higher amounts of linoleic acid in the sunflower seed oil, which resulted in the formation of salts in the rumen, which were poorly digested. It was concluded that these three products could be used at 5% of the ration with satisfactory results in fattening steers.

A study was conducted to observe the effects of adding urea and fat to feedlot rations (Bradley et al., 1966). The rations contained 1.5% urea and 5% fat together and singly. In addition, corn distillers dried grains with solubles were added to the rations to determine if the results concurred with those of Grainger et al., (1961), who found that the addition of corn distillers dried grains with solubles had a beneficial effect on cellulose digestion when 7% corn oil was added to the diet. It was observed that as urea and fat were added singly or together the rate of gain was depressed, with the greatest depression occurring when the two were in combination. The reason for the depression in rate of gain was due to reduced feed intake. The corn distillers dried grains had no effect on their results. The reduced intake and gain was in contradiction to results reported by Wise, Bluner and Barrick (1963), who found that intake decreased with the addition of urea and fat to feedlot rations, but rate of gain was not depressed. The reason for the difference in results would seem to be that higher levels of urea and fat were used in the earlier work. Bradley et al. (1966) found the addition of fat caused significant decreases in the digestibilities of dry matter, energy and nitrogen-free extract. When urea was added, the digestibility of crude protein was reduced. The addition of corn distillers dried grains did not improve the digestibility coefficients. Similar results were reported by Thompson, Bradly and Little, (1967). They observed that when urea and fat were included in the diets, animals fed pelleted rations had better performance than those fed meal rations. The conclusion was that the urea was released slower in the pelleted feed. Hatch et al., (1972) also found a depression in feedlot performance when fat and urea were added to rations. Although it was found that digestibilities of dry matter and energy were lowered with 3% fat and 1.3% urea in the rations, this was not the case with other treatments. They also noted that the animals adjusted to the rations in terms of feed intake. The addition of calcium above N.R.C. requirements did not improve performance when fat was included in the diets.

C. Fat in Rations for Sheep

i. Lambs on Milk Diets

Lambs fed high-fat milk replacers (30% fat) were shown to increase their weight gains and feed efficiency over suckling lambs and lambs fed low-fat milk replacers (Welch, 1962). In a study with lambs fed corn oil or tallow in milk substitutes (Bouchard and Brisson, 1970), it was noted that the lambs with tallow in their ration performed twice as well as those fed corn oil or whole milk. The performance of the control group of suckling lambs ranged between those fed tallow and corn oil. The digestion coefficients seemed to indicate the source of fat in the milk had no effect on the coefficients for dry matter, crude protein, crude fat and energy.

ii. Growing and Fattening Lambs

Davison and Woods (1963) studied the effect of adding corn oil and calcium to rations for growing and fattening lambs. When alfalfa was the source of roughage, corn oil improved the performance of the fattening lambs. However, with other roughages, the addition of corn oil, stabilized white grease and/or calcium resulted in no improvement in performance. This was also shown by Davison (1961). He found feed efficiency was improved with the addition of 7%

fat to a ration containing alfalfa as the source of roughage, but not when other sources of roughage were used in the ration. The conclusion was that the improvements noted were due to an improved cellulose digestion in ruminants. If tallow is hydrogenated, its digestibility is increased (MacLeod and Buchanan-Smith, 1972), as it resists dispersion, hydrolysis in the rumen and solubilization in the small intestine. Using high roughage and high concentrate rations with and without added fat, Johnson and McClure (1972) found lambs fed high concentrate rations didn't gain as well as those fed high roughage rations with added fat. However, high concentrate rations proved better than rations with high roughage and no added fat. They noted that the addition of 6% fat had no effect on gains, but the addition of 8% fat decreased gains. Fat additives did not affect the digestibilities of any of the ration components.

V. Whole-Fat Rapeseed Meal

Very limited research has been carried out with whole-fat rapeseed meal. Olomu (1974) fed raw whole-fat rapeseed meal to chicks and found that they had lower gains than those fed meal that had been heated in an autoclave (120° C for 10 minutes). The chicks fed the raw rapeseed meal were found to have larger thyroids and leaner carcasses than those fed control rations. Chicks fed autoclaved rapeseed meal had carcass weights between those in the control group and those fed raw rapeseed meal. The use of ground rapeseed (whole-fat) in the ration was found to cause a reduction in the utilization of dietary energy when compared with the control group. This in turn caused the metabolizable energy value of the rapeseed ration to be lower than that of the control ration. In laying hen rations, the inclusion of 5, 10 and 15% whole-fat rapeseed meal did not affect egg production or egg quality significantly. There was a slight decrease in egg production as the level of rapeseed increased. There were significant increases in mortality rates due to fatty liver syndrome, and thyroid weights increased as the level of rapeseed meal increased.

In studies at the University of Manitoba and the University of Alberta (Bowland and Bell, 1972), it was reported that levels of up to 10% whole-fat rapeseed meal could be used in diets for pigs from 8 kg liveweight to market weight. Whole-fat rapeseed had a calculated DE of 5360 kcal/kg on an "as-fed" basis.

In work at the University of Guelph, (Clandinin, Robblee and Slinger, 1972), it was determined that full-fat rapeseed meal contained 4400 kcal of metabolizable energy per kg. Heat treatment of whole raw rapeseed improved weight gain and feed utilization by chicks. The optimum response was obtained by heating at 750° F for 10 seconds, probably because the high temperature inactivated the myrosinase in the seed. Van Etten et al. (1966) found that myrosinase activity was destroyed when rapeseed meal was heated at a temperature of

140 to 160° C for 12 hours.

VI. Molasses and Alfalfa in Ruminant Rations

Scott (1953) concluded that molasses increased the palatability of low quality roughages and provided a source of highly digestible energy. He also concluded that molasses reduced the dustiness of ground feeds and had a tonic or laxative effect. Bell and Devlin (1972) reported that molasses could be used to offset the unpalatability of rapeseed meal in rations for ruminants.

Molasses is essentially an energy source and the main constituents are sugars. The sweet taste makes it appealing to most species, and it reduces dust (Church and Pond, 1974).

It has been noted that ruminants on dry feed are less tolerant of high fat levels than are monogastric animals (Church and Pond, 1974). Concentrations of more than 7% are apt to cause reduced feed intake, and digestive disturbances. Klosterman <u>et al</u>. (1953) noted that alfalfa ash and molasses fermentation solubles, or a trace mineral mixture improved feed intake and utilization of oil-containing rations for fattening cattle. Similar results with alfalfa ash were obtained by Ward <u>et al</u>. (1957).

Combinations of alfalfa and molasses are palatable and are often used in limited amounts in rations for ruminants to increase feed consumption (Morrison, 1958). Work at Nebraska (Klopfenstein and Schneider, 1973) indicated that the addition of 10% alfalfa pellets was the optimum level in an all-concentrate ration, as measured by feed intake, rate of gain and freedom from digestive disturbances.

EXPERIMENTS AT THE UNIVERSITY OF ALBERTA

INTRODUCTION

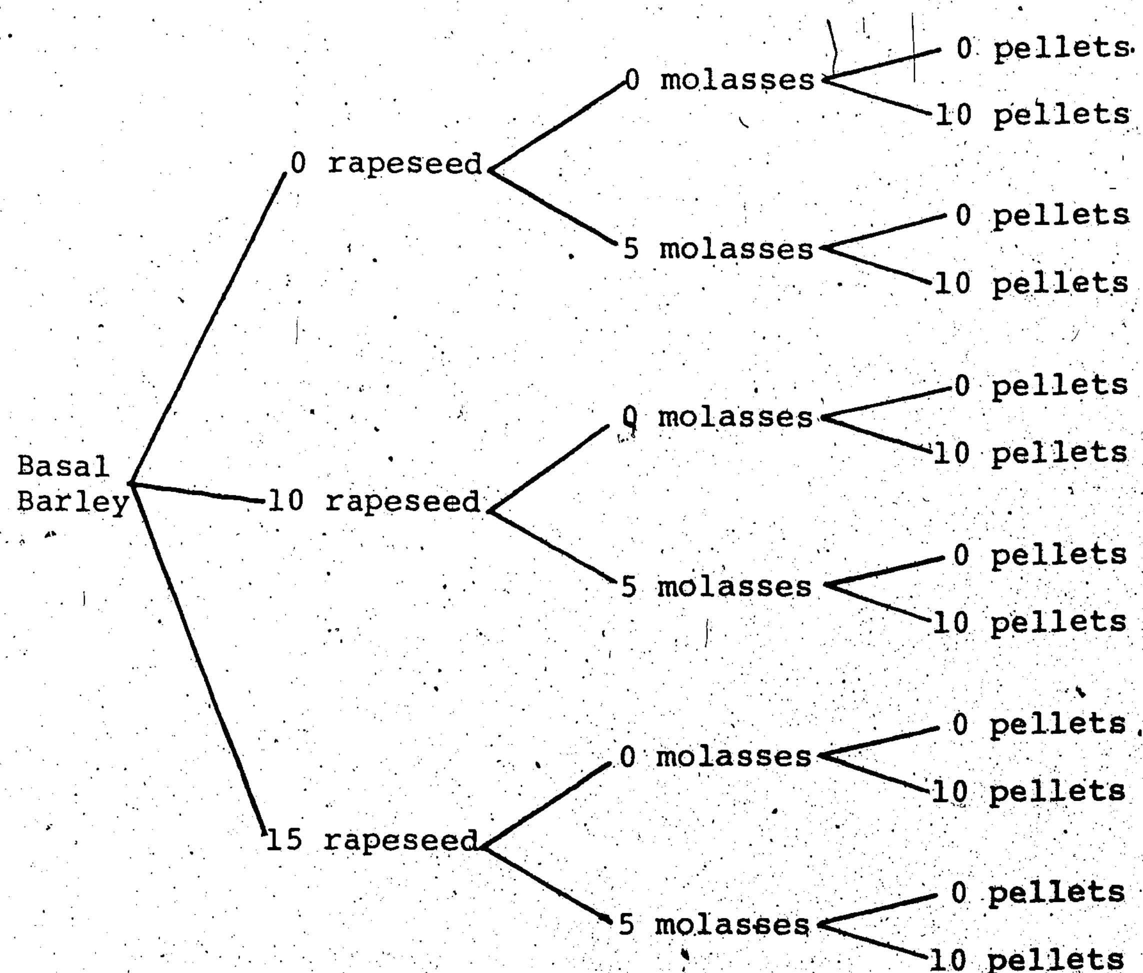
In the fall of 1972, rapeseed crops in scattered areas of central and northern Alberta were touched with frost. When the seed from these crops was harvested, it was not readily accepted for trade by the usual market channels. Consequently, it seemed desirable to study its value as a feed for ruminants. Because of its content of protein and oil, the seed could be considered to provide supplemental protein and energy to a diet.

It was appreciated that ground whole-fat rapeseed might accentuate unpalatability problems associated with rapeseed meal fed to ruminants, and that the oil might reduce feed utilization as is sometimes the result when corn oil is added to the diet. Since molasses and alfalfa have been shown to improve feed intake and feed utilization by ruminants fed diets containing oil, it seemed desirable to study their effects on diets containing whole-fat rapeseed meal.

Consequently, an experiment was carried out to study the effects of adding whole-fat rapeseed meal alone, and in combinations with alfalfa pellets and molasses, to high-concentrate barley-based rations fed to growing and fattening ruminants. Studies were carried out on growth rate and feed consumption by the animals, digestibility of the rations, and carcass data and composition of the animals at slaughter.

EXPERIMENTAL DESIGN

The experimental design chosen was factorial, with three levels of full-fat rapeseed meal, two levels of molasses and two levels of alfalfa pellets, for a total of twelve treatments as follows:



Two bulls were used for replication in each of the 12 treatments. Eight bulls were used on each level of rapeseed meal, and twelve bulls were used for each level of molasses and alfalfa pellets.

Animals and Management

Twenty-four Holstein x Brown Swiss crossbred bulls were assigned to the various treatments on the basis of age and weight. The bulls were raised from birth at the University of Alberta Dairy Cattle Research Unit. The initial weights of the bulls ranged from 68 to 339 kg. Sixteen were available at the start of the experiment and eight were added as they reached two and three months of age. Since calves are born in the dairy herd throughout the year, a large discrepancy in range of initial age and weight seemed inevitable. However, since this was primarily a test of feed intake and possible side-effects, a range in weight and age was not considered to be detrimental to the experiment.

The animals were housed in the Dairy Cattle Research Unit and were tied in individual stalls over slatted flooring. Fresh water, cobalt-iodized salt and calcium phosphate were available free-choice.

The experimental rations were initially offered to the bulls on the basis of 1.5 percent of the animal's body weight, in two equal feedings on the first day. Then, each bull was increased by 0.2 kg of feed per feeding until full-feed was reached in about 7 days. The rations were fed in equal portions at 8:00 a.m. and 5:00 p.m. daily. All feed and unconsumed feed was weighed and recorded daily.

The bulls were weighed approximately every four weeks throughout the trial. They were weighed in the morning before feeding and after water had been withheld for three hours.

Experimental Rations

Twelve rations were formulated (Table 1). The basal ration was composed of barley with mineral and vitamin supplements (to supply 8800 I.U. of vitamin A, 1450 I.U. of vitamin D, and 9 I.U. of vitamin E per kg of ration). This was a high concentrate ration similar to those previously used in the Dairy Cattle Research Unit (Malmberg, 1972; Moon, 1972), and was considered to be borderline or deficient in crude protein for the animals in the experiment. Ground whole-fat rapeseed meal, molasses and alfalfa pellets were added, as required, in place of barley.

In order to crack the rapeseed hulls, the rapeseed was mixed with barley in the ratio of 3:1 (w/w) and ground in a portable New Holland hammermill mixer unit, using a 3/8" screen and 1000 rpm. All rations were mixed in the portable mixer to prevent contamination of equipment in the feed mill through the use of whole-fat rapeseed meal.

The variety of rapeseed was Zephyr, a cultivar of Brassica napus, and it is regarded to be a "low erucic acid rapeseed" (LEAR type). The rapeseed was obtained from a farm at Spruce Grove, Alberta. The seed contained 0.3 to 0.6 percent oxazolidinethione and 0.01% erucic acid.

Digestion Studies

Digestion studies were conducted on each of the twenty-four bulls. The trials were carried out with six animals each time.

Table 1. Formulation of Experimental Rations

Ingredients kg	0% Rapeseed				10% Rapeseed				15% Rapeseed			
	A*	B*	C*	D*	A	B	C	D	A	B	C	D
Barley Rolled	98	93	88	83	88	83	78	73	83	78	73	68
Ground Rapeseed	0	0	0	0	10	10	10	10	15	15	15	15
Wet Molasses	0	5	0	5	0	5	0	5	0	5	0	5
Alfalfa Pellets	0	0	10	10	0	0	10	10	0	0	10	10
Trace-min Salt**	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Ground Limestone	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Vitamin Supplement***	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Total	100	100	100	100	100	100	100	100	100	100	100	100
Calculated Analysis****												
Dry Matter, %	86.5	86.0	86.9	86.4	87.0	86.5	87.5	87.0	87.2	86.7	87.7	87.2
Crude Protein, %	11.7	11.4	11.9	11.6	12.5	12.2	12.7	12.4	12.9	12.7	13.1	12.8
Digestible Energy (Mcal/kg)	2.96	2.94	2.89	2.87	3.19	3.18	3.12	3.10	3.31	3.29	3.24	3.22

*A is ration containing 0% Molasses and 0% Alfalfa Pellets
B is ration containing 5% Molasses and 0% Alfalfa Pellets
C is ration containing 0% Molasses and 10% Alfalfa Pellets
D is ration containing 5% Molasses and 10% Alfalfa Pellets

**Trace mineral Salt contained 0.4% zinc, 0.16% iron, 0.12% manganese, 0.033% copper, 0.01% iodine, 0.004% cobalt and 96.5% sodium chloride.

***Vitamin Supplement supplied 8800 I.U. of vitamin A, 1450 I.U. of vitamin D and 9 I.U. of vitamin E per kg of ration.

Cont'd.

Table 1. Formulation of Experimental Rations Cont'd.

****On the as-fed basis rapeseed contained 91.6% dry matter, 20.3% crude protein and 39.6% ether extract; barley contained 86.2% dry matter and 11.9% crude protein; molasses contained 77.0% dry matter and 6.7% crude protein; alfalfa pellets contained 90.8% dry matter and 13.8% crude protein. Digestible energy values (NRC, 1971; Bowland and Bell, 1972) used in calculations were 5.36, 3.02, 2.68 and 2.29 Mcal/kg for rapeseed, barley, molasses and alfalfa pellets, respectively, on the as-fed basis.

The fecal collection was based on collection bags developed by Malmberg (1972), Moon (1972) and Noller et al. (1959). The polyethylene bags used in this study measured 40 cm by 85 cm and were put in canvas bags strapped to a harness. The total feces were weighed and recorded twice daily at 8:00 a.m. and 8:00 p.m. throughout the five-day trial. Five percent of the feces collected each time was retained and frozen. At the end of the trial the composite sample from each bull was dried in a forced-draught despatch oven, at 70° C, for 72 hours and then pulverized in a Waring blender. The samples were then stored for later analysis.

Samples of the experimental rations were collected daily during digestion trials, composited, ground in a Wiley laboratory mill and retained for later analysis.

Samples of unconsumed portions of the rations were collected daily before fresh feed was offered during the digestion trials. This feed was dried as a composite sample in a forced-draught despatch oven at 70° C for 72 hours. It was then ground in a Wiley laboratory mill and retained for later analysis.

Carcass Measurements

Farm weights of all the bulls were recorded before they were trucked to Gainers Packing Plant for slaughter. Feed and water were withheld for a 12 hour period before weighing. The viscera were examined at slaughter and abnormalities recorded. Warm carcass weights were recorded and carcasses were graded by Canada Department of Agriculture standards twenty-four hours after slaughter. The 9-10-11 rib section was removed from the right side of each carcass. The tenth rib section was then separated from the standing rib by a standardization procedure described by Malmberg (1972). The standardized tenth rib was physically separated into separable fat, lean and bone.

Analytical Methods

Dry matter, crude protein and ether extract were determined on feed, unconsumed feed and feces by AOAC (1965) methods. Gross energy of feed, unconsumed feed and fecal samples was determined by combustion in a Parr oxygen bomb calorimeter. All samples were combusted at 25 atmospheres and only the unconsumed feed samples were pelleted to facilitate complete combustion.

Statistical Analysis

An I.B.M. 360/67 computer in the Department of Computing Services at the University of Alberta was used in analysis of the data. Analyses of variance were computed using the University of Alberta Computing Services program C.S. 2834 (ANOFPR) written by Weingardt (1973). Mean squares are presented in Appendix Table A.

RESULTS

OVERALL COMPARISON

Means of daily gain, feed consumed per day and feed consumed per unit gain by the bulls in the twelve treatments are shown in Table 2. No statistically significant ($P<0.05$) interactions were obtained in the overall comparison.

The lowest average daily gain and highest consumption of feed per unit gain was obtained with the basal ration that had no rapeseed, molasses or alfalfa pellets. The addition of 10 or 15 percent whole-fat rapeseed meal, in place of barley, appeared to improve rate of gain and efficiency of feed conversion. There was no indication that whole-fat rapeseed meal had any adverse effect on daily feed consumption.

The addition of molasses or alfalfa pellets improved daily gain and efficiency of feed conversion as much as did the [illegible]f rapeseed. When added together, molasses and alfa[illegible]s improved daily dry matter intake, rate of gain and e[illegible]y of feed conversion. The beneficial effects of the ad[illegible] of both molasses and alfalfa pellets were also appare[illegible]th rations containing 10 or 15% rapeseed.

[illegible]With increasing age and weight, protein requirements decline[illegible]rom 14% to 12% (NRC, 1971). Moon (1972) and Malmberg (1972) [illegible]d some difficulty in clearly demonstrating the need for supplemental protein. In this experiment, the barley contained 12% crude protein, thus protein intakes would have

Table 2. Means for Results of the Twelve Treatments

Level of Rapeseed	0	0	0	0	10	10	10	10	15	15	15	15
Level of Molasses	0	5	0	5	0	5	0	5	0	5	0	5
Level of Alfalfa	0	0	10	10	0	0	10	10	0	0	10	10
Initial Wt. kg	233	156	206	178	172	188	211	161	210	171	153	182
Initial Age, days	186	134	172	147	170	152	194	160	177	150	152	152
Days on Test	188	234	262	234	262	220	192	234	192	262	248	220
Daily Gain, kg	1.02	1.15	1.08	1.39	1.08	1.23	1.12	1.37	1.08	1.00	1.12	1.23
Feed/Day, kg D.M.	5.4	4.5	5.6	6.9	5.5	6.2	5.4	6.4	5.4	5.2	5.2	6.2
D.M./Unit Gain	5.3	3.9	5.2	5.0	5.1	5.0	4.8	4.7	5.0	5.2	4.6	5.0

been adequate in the control ration over a large part of the feeding period.

In the remainder of the sections on results and discussion, data will be confined to the main effects due to rapeseed, molasses and alfalfa. Data of the performance of individual animals are shown in Appendix Table C.

AVERAGE DAILY GAIN

The animals fed the 0, 10, and 15% levels of full-fat rapeseed meal gained an average of 1.16, 1.20 and 1.11 kg per day, respectively (Table 3). These rates of gain were not significantly different ($P<0.05$). The ether extract contents of the diets in this study containing 0, 10 and 15% rapeseed were 1.59, 4.67 and 6.78% respectively. Dyer et al. (1957) found no increase in gain when 7% fat was included in feedlot diets, whereas Erwin et al. (1956) found an increase in rate of gain with the inclusion of 5% fat.

When 5% molasses was included in the diet, there was a significant ($P<0.05$) increase in the daily gain, as compared with no molasses in the diet. The animals fed the diet with molasses gained 0.15 kg per day (14%) more than the ones fed no molasses.

The inclusion of 10% alfalfa pellets in the diets resulted in a significant ($P<0.05$) increase in rate of gain over diets with no alfalfa pellets. The average increase was 0.13 kg per day (12%).

The results of feeding rapeseed and molasses together showed no significant interaction (P<0.05) (Table 4) for rate of gain, although a trend appeared. Without molasses, the addition of rapeseed tended to increase rate of gain whereas with molasses the addition of 15% rapeseed tended to decrease rate of gain.

Table 3. Average Daily Gain (kg)

Treatment	% Level of Diet	Average Daily Gain (kg)	Number of Observations
Ground Rapeseed	0	1.16[a]	8
Ground Rapeseed	10	1.20[a]	8
Ground Rapeseed	15	1.11[a]	8
Molasses	0	1.08[b]	12
Molasses	5	1.23[c]	12
Alfalfa Pellets	0	1.09[d]	12
Alfalfa Pellets	10	1.22[e]	12

[a,b,c,] Means in the same group followed by a common superscript are not significantly different ($P<0.05$).

The combination of alfalfa pellets and rapeseed resulted in no significant interaction ($P<0.05$) in rate of gain (Table 4). Without alfalfa pellets, the addition of 10% rapeseed tended to increase rate of gain, whereas there was no effect with alfalfa pellets in the diet. The addition of alfalfa pellets tended to increase rate of gain with 0, 10 and

15% rapeseed rations. Davison and Woods (1963) found an increase in animal performance when fat was included in diets with alfalfa as the roughage source.

Table 4. Average Daily Gain (kg) when Ground Rapeseed, Molasses and Alfalfa Pellets were Fed in Combination

Treatment	% Level of Diet	Molasses 0	Molasses 5	Alfalfa Pellets 0	Alfalfa Pellets 10
Rapeseed	0	1.05	1.27	1.08	1.24
	10	1.10	1.30	1.16	1.24
	15	1.10	1.12	1.04	1.18

DAILY FEED INTAKE

There were no significant differences ($P<0.05$) between treatments in daily intake of dry matter (D.M.), gross energy (G.E.) or digestible energy (D.E.) (Table 5). The D.M. intake per day was slightly more (5%) for the 10% rapeseed level than for the 15% rapeseed level. Burkitt et al. (1954), Ingalls et al. (1968), and Grenet (1970) reported that consumption decreased when either rapeseed or rapeseed meal was included in the diets of ruminants. Seale (1952), Clark and Bezeau (1964), and Bell and Devlin (1972) reported that animals initially rejected rations containing rapeseed meal, but after a period of time consumed as much as with the control rations.

The G.E. and D.E. intakes per day (Table 5) were slightly higher for the animals receiving the 10 and 15% rapeseed in their diets, as compared to the animals receiving the 0% rapeseed diet. There was a tendency for animals fed molasses or alfalfa to consume more D.M., G.E. and D.E. This could account, in part at least, for improved rates of gain noted earlier.

There were no significant differences in D.M., G.E., or D.E. intakes when ground rapeseed, molasses and alfalfa pellets were fed in combination (Table 6).

Table 5. Daily Feed Intake

Treatment	% Level of Diet	D.M. (kg)	Gross Energy (Mcal)	Digestible Energy (Mcal)
Ground Rapeseed	0	5.59[a]	24.68[d]	20.22[g]
Ground Rapeseed	10	5.84[a]	26.44[d]	22.70[g]
Ground Rapeseed	15	5.54[a]	26.58[d]	21.59[g]
Molasses	0	5.43[b]	24.65[e]	20.16[h]
Molasses	5	5.89[b]	27.15[e]	22.60[h]
Alfalfa Pellets	0	5.40[c]	25.49[f]	20.47[i]
Alfalfa Pellets	10	5.92[c]	26.31[f]	22.29[i]

a,b,c,d,e,f,g,h,i, Means in each treatment group followed by a common superscript are not significantly different ($P<0.05$).

FEED UTILIZATION

There were no significant differences ($P<0.05$) among any of the treatments for D.M. per unit gain and D.E. per unit gain (Table 7). Bell and Devlin (1972) noted steers fed rations containing rapeseed meal were not significantly (P<0.05) different in feed conversion than steers fed barley alone or with soybean meal in the diet. The 0% rapeseed diet resulted in a lower D.E. per unit gain when compared to the 10 and 15% rapeseed diets. The D.E. per unit gain was slightly better when molasses or alfalfa pellets were included in the diet compared to no molasses or no alfalfa pellets in the diets.

When rapeseed, molasses and alfalfa pellets were in combination, there was no significant interaction (P<0.05) for D.M. per unit gain or D.E. per unit gain (Table 8).

APPARENT DIGESTIBILITY

There were no significant differences (P<0.05) in digestion coefficients of dry matter (D.M.), digestible energy (D.E.), crude protein (C.P.) or ether extract (E.E.), as a result of the treatments (Table 9). Ingalls and Waldern (1972) and Bezeau et al. (1960), found digestibilities of the ration components to be the same for rapeseed meal diets as for a control ration containing barley and linseed meal. Albin and Durham (1967) found that the inclusion of fat in the diet did not affect the digestibilities of D.M. and energy, but increased the ether extract digestibility. Esplin et al., (1963) found that 4% vegetable oil in the diet had no effect on digestibility coefficients. Adams et al. (1959a) observed that the addition of vegetable oils to diets of calves decreased digest-

Table 6. Mean Daily Intake When Ground Rapeseed, Molasses and Alfalfa Pellets were Fed in Combination

	Treatment	% Level of Diet	Molasses 0	Molasses 5	Alfalfa Pellets 0	Alfalfa Pellets 10
Dry Matter	Rapeseed	0	5.48	5.70	4.96	6.22
Intake (kg)		10	5.43	6.26	5.85	5.84
		15	5.38	5.70	5.38	5.70
Gross Energy	Rapeseed	0	23.6	25.7	21.4	27.9
Intake (Mcal)		10	25.1	27.7	27.5	25.4
		15	25.2	27.9	26.6	25.6
Digestible	Rapeseed	0	18.4	21.3	17.7	21.9
Energy Intake		10	21.3	24.1	22.8	22.6
(Mcal)		[illegible]	20.7	22.4	20.9	23.3

ibility.

The inclusion of molasses in the diets, compared to no molasses in the diets, resulted in minor increases in the digestibilities of D.M., D.E., C.P. and E.E.

There was no significant (P<0.05) interaction in digestibility of ration components when ground rapeseed, molasses, and alfalfa pellets were fed in combination (Table 10).

Table 7. Feed Utilization

Treatment	% Level in Diet	Dry Matter Per Unit Gain	Digestible Energy Per Kg Gain (Mcal)
Ground Rapeseed	0	4.82[a]	17.43[d]
Ground Rapeseed	10	4.87[a]	18.92[d]
Ground Rapeseed	15	4.99[a]	19.45[d]
Molasses	0	5.03[b]	18.67[e]
Molasses	5	4.24[b]	16.26[e]
Alfalfa Pellets	0	4.95[c]	18.78[f]
Alfalfa Pellets	10	4.85[c]	18.27[f]

a,b,c,d,e,f, Means of each treatment group followed by common superscript are not significantly different (P<0.05).

Table 8. Feed Utilization When Ground Rapeseed, Molasses and Alfalfa Pellets were Fed in Combination

Treatment		% Level in Diet	Molasses 0	Molasses 5	Alfalfa Pellets 0	Alfalfa Pellets 10
D.M. Per	Rapeseed	0	5.2	4.5	4.6	5.0
Unit Gain		10	4.9	4.8	5.0	4.7
		15	4.9	5.1	5.1	4.8
D.E. Per	Rapeseed	0	17.5	16.8	16.4	17.7
kg Gain		10	19.4	18.5	19.6	18.2
(Mcal)		15	18.8	20.0	20.1	19.7

Table 9. Coefficients of Apparent Digestibility

Treatment	% in Diet	Dry Matter	Digestible Energy	Crude Protein	Ether Extract
Ground Rapeseed	0	80.6[a]	81.3[d]	77.6[g]	78.7[j]
Ground Rapeseed	10	82.2[a]	83.1[d]	79.5[g]	87.3[j]
Ground Rapeseed	15	80.1[a]	81.3[d]	78.9[g]	87.4[j]
Molasses	0	80.7[b]	81.4[e]	78.5[h]	83.8[k]
Molasses	5	81.3[b]	82.5[e]	78.9[h]	85.1[k]
Alfalfa Pellets	0	81.7[c]	82.6[f]	79.4[i]	84.9[l]
Alfalfa Pellets	10	80.3[c]	81.2[f]	77.9[i]	84.0[l]

a,b,c,d,e,f,g,h,i,j,k,l, Means of each treatment group followed by a common superscript are not significantly different ($P<0.05$).

SLAUGHTER AND CARCASS DATA

There were no significant differences ($P<0.05$) for any of the treatments, in final liveweights, carcass weight, dressing percentage or fat and lean percentages in rib sections (Table 11). There was no significant interaction ($P<0.05$) when ground rapeseed, molasses and alfalfa pellets were fed in combination.

The animals fed the 10 and 15% ground rapeseed diets had slightly higher (approximately 4%) percentage fat than those receiving 0% ground rapeseed. This was also true for animals fed no molasses.

The incidence of liver abscesses in this study was 25% (6 animals). This coincides with data reported by Foster and Woods (1970), Rowland (1970) and Harvey et al. (1968). They found an average of 22 to 23% liver abscess in slaughter animals that were examined. They also reported the incidence of liver abscesses was higher in cattle fed all-concentrate diets than in cattle fed roughage in their diet.

There was one animal (4%) which had urinary calculi. The rest of the viscera examinations resulted in no discovery of abnormalities.

All the carcasses graded A1 or B1 and there was no pattern as to diet. The animals that graded B1 did so because they did not have the minimum amount of fat cover (Canada Department of Agriculture, 1973).

Table 10. Coefficients of Apparent Digestibilities When Ground Rapeseed, Molasses and Alfalfa Pellets were Fed in Combination

Treatment	Ground Rapeseed in Diet %	Molasses 0	Molasses 5	Alfalfa Pellets 0	Alfalfa Pellets 10
Dry Matter (%)	0	78.1	83.1	82.7	78.5
	10	84.3	80.1	82.4	82.1
	15	79.7	80.4	79.9	80.2
Digestible Energy (%)	0	78.3	84.2	83.2	79.3
	10	84.9	81.4	83.1	83.1
	15	80.9	81.8	81.6	81.1
Crude Protein (%)	0	75.4	79.7	80.3	74.8
	10	81.1	77.9	79.1	80.0
	15	78.8	78.9	78.6	79.2
Ether Extract (%)	0	71.9	85.5	86.9	70.4
	10	92.0	82.0	82.5	92.1
	15	87.4	87.4	85.2	89.6

Table 11. Slaughter and Carcass Data

Treatment	% in Diet	Final Live Wt. (kg)	Carcass Wt. (kg)	Dressing %	Rib Section Lean %	Rib Section Fat %
Ground Rapeseed	0	460.4^{a}	266.6^{d}	57.8^{g}	76.1^{j}	23.9^{m}
Ground Rapeseed	10	457.8^{a}	261.4^{d}	57.0^{g}	72.5^{j}	27.5^{m}
Ground Rapeseed	15	446.0^{a}	260.4^{d}	58.5^{g}	74.0^{j}	26.0^{m}
Molasses	0	450.6^{b}	261.2^{e}	58.0^{h}	75.3^{k}	24.7^{n}
Molasses	5	458.8^{b}	264.4^{e}	57.5^{h}	74.8^{k}	25.2^{n}
Alfalfa Pellets	0	436.8^{c}	252.0^{f}	57.8^{i}	74.1^{l}	25.9^{o}
Alfalfa Pellets	10	472.6^{c}	273.6^{f}	57.8^{i}	74.2^{l}	25.8^{o}

a,b,c,d,e,f,g,h,i,j,k,l,m,n,o, Means of each treatment group followed by a common superscript are not significantly different ($P<0.05$).

DISCUSSION

There were no detrimental effects from including whole-fat ground rapeseed at either 10 or 15% levels in all-concentrate rations that were fed to growing and finishing dairy bulls. In fact, when rapeseed was added to rations without molasses, there was a tendency for improved rates of gain and feed conversion. The work by Dyer, Ensminger and Blue (1957) and Erwin, Dyer and Ensminger (1956) pointed out rate of gain increased at a level of 5% added fat in the ration. The rapeseed rations in the present study added approximately 5% fat at the 15% level of rapeseed. Several researchers have shown that although cattle initially rejected rations containing rapeseed products, they consumed amounts similar to controls after a period of time (Seale, 1952; Clark and Bezeau, 1964; and Bell and Devlin, 1972). Thus, unlike what has been found with poultry and swine (Carroll, 1949; Belzile _et al_., 1963; and Clandinin _et al_., 1966) no growth depression due to the goitrogenic effects of rapeseed seemed to occur with the bulls in this study.

The significant ($P<0.05$) increase in rate of gain when molasses was included in the diet would seem to be due to the increases in daily intake of D.M., G.E. and D.E. In addition, the digestibilities of D.M., D.E., C.P. and E.E. were increased slightly, which would help to account for the increased gain.

The significant ($P<0.05$) increase in rate of gain when alfalfa pellets were included in the diet would also seem to be due to increased daily intake for D.M., G.E. and D.E. The [illegible]ition of alfalfa had no apparent effect on the usefulne[illegible]eseed.

[illegible]tly poorer feed conversions found with the 0% [illegible]se[illegible]may be explained by the report of Willey *et al.* [illegible]952[illegible]ey found efficiency increased as the level of f[illegible]inc[illegible]sed.

[illegible]e inclusion of molasses or alfalfa pellets resulted in imp[illegible] feed conversions. This would appear to be related to the [illegible]reased rate of gain and intakes of D.M. and D.E.

The fact that there were no significant differences ($P<0.05$) [illegible] any of the treatments for rib section percentage lean and [illegible], implies that the total body lean and body fat were not significantly ($P<0.05$) different. Epley *et al.* (1970), Moody *et a*[illegible] (1970) and Busch *et al.* (1968) pointed out that dissectio[illegible]e rib section is a fairly accurate measure of the body [illegible]an and fat. The animals in this study had what seemed to be a higher percentage of lean than what has been found elsewhere (Moon, 1972; Malmberg, 1972). This is not likely due to the diets, but more likely due to the youthfulness of the animal and the breed (Holstein x Brown Swiss).

When calculation by difference was used, (Appendix, Table B), apparent digestible energy coefficients of 93.6 and 80.9% were obtained for the 10 and 15% levels of rapeseed. The average of the two values was 87.2 percent. This would appear to be an apparent digestibility coefficient that could be applied to the gross energy in whole-fat rapeseed. Similar calculations resulted in apparent digestible protein coefficients of 90.2 and 83.5% for the 10 and 15% rapeseed levels, respectively. The average value of 86.8% would appear to be the apparent digestibility coefficient of protein in whole-fat rapeseed. The digestibility of rapeseed appeared to decrease at the 15% level as compared to the 10% level of addition indicating that 10% rapeseed may be a more suitable level of addition.

CONCLUSION

The major overall conclusion that can be drawn from this study is that ground full-fat rapeseed can be used at levels up to 15% in ruminant rations. If available at an economical price as in cases of over-production of rapeseed or in cases when the seed is damaged by frost, the product can be used as feed for ruminants. The use of ground full-fat rapeseed meal at a level of 10% resulted in a slight improvement in overall performance as compared with all-barley rations, and 15% rapeseed did not depress performance as compared with barley alone.

The inclusion of either molasses or alfalfa pellets in all-concentrate rations for dairy bulls resulted in improved rates of gain, feed intake and feed conversion. These effects were more apparent when rapeseed was not included in the diets.

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Appendix

Table A. Mean Squares Obtained by Analysis of Variance

Variable	Source of Variation	Degrees of Freedom	Mean Squares
Average Daily Gain	Rapeseed	2	0.018579
	Molasses	1	0.11620
	M x R	2	0.025279
	Pellets	1	0.097538
	P x R	2	0.0014625
	P x M	1	0.037604
	R x M x P	2	0.0020391
	Error	12	0.034304
	Total	23	
D.E. Per Gain	Rapeseed	2	10.520
	Molasses	1	2.5807
	M x R	2	4.7259
	Pellets	1	2.7135
	P x R	2	1.8988
	P x M	1	8.6760
	R x M x P	2	2.2723
	Error	12	19.247
	Total	23	
D.M. Per Gain	Rapeseed	2	0.046667
	Molasses	1	0.88167
	M x R	2	0.87167
	Pellets	1	0.16667
	P x R	2	0.081666
	P x M	1	0.80667
	R x M x P	2	0.44667
	Error	12	2.1408
	Total	23	

Variable	Source of Variation	Degrees of Freedom	Mean Squares
Dressing Percent	Rapeseed	2	4.9880
	Molasses	1	1.5505
	M x R	2	3.1703
	Pellets	1	0.00041697
	P x R	2	1.0329
	P x M	1	3.3004
	R x M x P	2	.15542
	Error	12	19.932
	Total	23	
Final Weight	Rapeseed	2	468.79
	Molasses	1	408.38
	M x R	2	379.13
	Pellets	1	7668.4
	P x R	2	2344.6
	P x M	1	126.04
	R x M x P	2	1176.8
	Error	12	3297.3
	Total	23	
Carcass Weight	Rapeseed	2	90.167
	Molasses	1	63.375
	M x R	2	243.50
	Pellets	1	2795.0
	P x R	2	576.17
	M x P	1	165.37
	R x M x P	2	406.50
	Error	12	1600.1
	Total	23	
D.M. Digestibility	Rapeseed	2	9.9957
	Molasses	1	1.8097
	M x R	2	42.159
	Pellets	1	11.971
	P x R	2	11.765
	M x P	1	3.9611
	R x M x P	2	7.6551
	Error	12	38.700
	Total	23	
Ether Extract Digestibility	Rapeseed	2	198.96
	Molasses	1	10.245
	M x R	2	276.83
	Pellets	1	4.2841
	P x R	2	380.28
	P x M	1	101.85
	R x M x P	2	45.02
	Error	12	93.82
	Total	23	

Variable	Source of Variation	Degrees of Freedom	Mean Squares
D.M. Intake per Day	Rapeseed	2	0.206
	Molasses	1	1.265
	M x R	2	0.21153
	Pellets	1	1.6380
	P x R	2	0.88699
	P x M	1	2.4130
	R x M x P	2	0.40268
	Error	12	1.4856
	Total	23	
Lean Percentage	Rapeseed	2	25.613
	Molasses	1	32.667
	M x R	2	44.400
	Pellets	1	0.08167
	R x P	2	13.528
	P x M	1	35.042
	R x M x P	2	22.400
	Error	12	17.277
	Total	23	
Fat Percentage	Rapeseed	2	25.613
	Molasses	1	32.667
	M x R	2	44.400
	Pellets	1	0.08167
	R x P	2	13.528
	P x M	1	35.042
	R x M x P	2	22.400
	Error	12	17.277
	Total	23	
D.E. Intake per Day	Rapeseed	2	16.473
	Molasses	1	35.697
	M x R	2	0.94190
	Pellets	1	19.966
	P x R	2	49.407
	P x M	1	2.4067
	R x M x P	2	20.775
	Error	12	13.193
	Total	23	
G.E. Intake per Day	Rapeseed	2	8.9427
	Molasses	1	37.350
	M x R	2	0.25788
	Pellets	1	3.9691
	P x R	2	49.407
	P x M	1	2.4067
	R x M x P	2	20.775
	Error	12	30.724
	Total	23	

Variable	Source of Variation	Degrees of Freedom	Mean Squares
D.E. Digestibility	Rapeseed	2	9.067
	Molasses	1	7.2269
	M x R	2	44.055
	Pellets	1	12.804
	P x R	2	8.8093
	P x M	1	1.8648
	R x M x P	2	8.9500
	Error	12	38.579
	Total	23	
C.P. Digestibility	Rapeseed	2	7.9518
	Molasses	1	1.1268
	M x R	2	27.806
	Pellets	1	11.179
	P x R	2	25.730
	P x M	1	1.0334
	R x M x P	2	8.5762
	Error	12	43.041
	Total	23	

Appendix

Table B. Calculations of Apparent Digestible Coefficients of Energy and Protein, in Whole-Fat Rapeseed.

	Average Gross Energies of Rations (Mcal)	Average Digestible Energies of the rations Mcal	Average Crude Protein of Rations (%)	Average Digestible Protein of Ration (%)
0% Rapeseed	4.44	3.61	13.47	10.45
10% Rapeseed	4.67	3.88	14.26	11.34
15% Rapeseed	4.80	3.90	14.79	11.67

	Amount Supplied by Barley in Ration		Amount Supplied by Barley in Ration	
	G.E. (Mcal)	D.E. (Mcal)	C.P. (%)	D.C.P. (%)
10% Rapeseed Ration	3.99	3.25	12.12	9.41
15% Rapeseed Ration	3.77	3.07	11.45	8.88

Differences

	G.E. (Mcal)	D.E. (Mcal)	C.P. %	D.C.P. %
10% Rapeseed	.67	.63	2.14	1.93
15% Rapeseed	1.03	.83	3.34	2.79

Thus:

Energy

.1 kg rapeseed contains .674 Mcal of G.E., .631 Mcal of D.E.

1 kg rapeseed contains 6.74 Mcal of G.E., 6.31 Mcal of D.E.

$\frac{6.31}{6.74}$ x 100 = 93.6% digestible

.15 kg rapeseed contains 1.026 Mcal of G.E. and .83 Mcal of D.E.

1 kg rapeseed contains 6.84 Mcal of G.E. and 5.53 Mcal of D.E.

$\frac{5.53}{6.84}$ x 100 = 80.9% digestible

Average = 87.2% digestible

Protein

In the 10% rapeseed ration, 10 kg rapeseed supplies 2.14 kg C.P. and 1.93 kg D.C.P.

Digestibility of C.P. = $\frac{1.93}{2.14}$ x 100 = 90.2%

In the 15% rapeseed ration, 15 kg rapeseed supplies 3.34 kg C.P. and 2.79 kg D.C.P.

Digestibility of C.P. = $\frac{2.79}{3.34}$ x 100 = 83.5%

Average digestibility = 86.8%

APPENDIX

Table C. Data of Performance of Individual Animals

Level of Rapeseed	0		0		0		0	
Level of Molasses	0		5		0		5	
Level of Alfalfa	0		0		10		10	
Bull No.	209	247	238	220	230	229	239	218
Initial Wt., kg	339	127	79	233	194	218	68	288
Initial Age, Days	280	91	69	199	166	177	53	241
Days on Test	181	196	288	181	288	237	288	181
Daily Gain, kg	0.70	1.35	1.15	1.14	1.04	1.12	1.29	1.49
D.M./Day, kg	5.6	5.2	4.0	5.0	5.0	6.1	5.2	8.6
D.M./Unit Gain	8.0	3.9	3.5	4.4	4.8	5.4	4.0	5.8
Level of Rapeseed	10		10		10		10	
Level of Molasses	0		5		0		5	
Level of Alfalfa	0		0		10		10	
Bull No.	231	228	240	217	245	210	235	225
Initial Wt., kg	164	181	90	286	92	330	136	186
Initial Age, Days	162	178	62	243	91	277	119	201
Days on Test	288	237	260	181	203	181	288	181
Daily Gain, kg	1.15	1.01	1.15	1.31	1.33	0.94	1.36	1.38
D.M./Day, kg	5.6	5.4	4.4	7.9	4.7	6.0	6.2	6.6
D.M./Unit Gain	4.9	5.4	3.8	6.0	3.5	6.4	4.6	4.8
Level of Rapeseed	15		15		15		15	
Level of Molasses	0		5		0		5	
Level of Alfalfa	0		0		10		10	
Bull No.	244	214	234	226	233	227	241	215
Initial Wt., kg	111	308	132	210	136	270	86	278
Initial Age, Days	92	262	120	181	124	180	56	247
Days on Test	203	181	288	237	288	237	260	181
Daily Gain, kg	1.24	0.93	0.97	1.02	1.11	1.13	1.35	1.11
D.M./Day, kg	4.5	6.4	4.5	6.0	5.3	5.2	5.5	6.8
D.M./Unit Gain	3.6	6.9	4.6	5.9	4.8	4.6	4.1	6.1