Recent Research on Canola Meal in Canada

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This presentation is an attempt to identify research projects that have been reported or undertaken since the International Rapeseed Congress in Saskatoon in 1991. Where possible the main findings and conclusions have been noted but for work in progress only the major objectives were available. This is undoubtedly an incomplete list but it provides a reasonably comprehensive overview of the topic.

Of several ways in which meal research could be classified, it was decided to organize it according to the animal species involved, namely poultry, swine and ruminants. Projects are identified by title, first author or researcher in charge and by institution.

CANOLA MEAL RESEARCH WITH POULTRY

Nutritive value of meal from tame mustard (*B. juncea*) of canola type

Seed derived from an interspecific cross involving Indian-type mustard (*B. juncea*) and canola (*B. campestris*), developed at the Agriculture Canada Research Station in Saskatoon by Love and co-workers was pilot-plant processed and is being evaluated using broiler chicks by Classen of the University of Saskatchewan. This potential oilseed crop produces oil and meal of canola type and offers several agronomic benefits including higher yield, better drought tolerance and greater disease resistance than canola cultivars. In addition to chemical analyses, the apparent metabolizable energy (AME_n), amino acid and phosphorus availability will be determined. In growth trials, the mustard meal will be compared to canola meal at dietary levels up to 30%. Growth rates and efficiency of feed utilization, incidence of leg abnormalities and thyroid activity (T_3 and T_4 plasma levels) will be obtained.

The influence of feeding full-fat canola seed to rats and chicks

Two studies were reported in 1991 from Sim's laboratory at the University of Alberta. In broiler chick trials 10% or 20% of raw or cooked ground canola seed or flax seed were fed in corn, barley, wheat diets (40, 9, 10% resp.). Use of whole seed was also compared with reconstituted mixtures of oil and meal. These levels of canola seed or equivalent oil-meal mixtures permitted weight gain, feed conversion and carcass yield similar to the soybean meal control diet and superior to flax seed responses. Animal tallow was equal to canola oil in the meal-oil mixtures.

In the second study the effects on plasma and tissue cholesterol, and fatty acid composition of rats fed canola and flax seeds or their oils, were assessed using isonitrogenous and isoenergetic diets. After six weeks plasma cholesterol levels were lower on flax or flax oil diets than on canola. The highest levels of tissue α-linoleic acid and eicosopentanoic acid (EPA) were found with flax. Canola was intermediate between flax and the control in these parameters and could be used to modify tissue and plasma lipids.

Nutritive value of 'front-end' dehulled canola meal

While further reductions in glucosinolate content of canola meal should improve the acceptability of canola meal for monogastric animals, changes in the carbohydrate content may have a greater impact. Campbell at the University of Manitoba evaluated 'front-end' dehulled canola meal in poultry diets, that is, meal dehulled before oil extraction. True metabolizable energy (TME) and true available amino acids were determined and production trials were conducted with laying hens. Chemical analysis also included glucosinolates, sucrose, oligosaccharides and polysaccharides. In a second phase, the effect of supplementary dietary enzymes will be assessed, comparing normal with dehulled canola meal.

Nutritive value of 'tail-end' dehulled canola meal

Despite potential improvement in 'front-end' dehulled canola meal for poultry diets, this dehulling process resulted in undesirable loss of oil retained in the hulls and in disposal problems with the hulls. As an alternative approach, meal was subjected to screening following conditioning to optimum moisture and milling in order to produce a high protein-low fibre fraction and a low protein-high fibre fraction. Classen of the University of Saskatchewan examined the low fibre fraction using broiler chicks. The study includes comparisons of meal before and after dehulling and derived from five different crushing plants in Western Canada. Availability of nutrients is being determined using young broilers to obtain apparent availability of energy (AME_n; apparent metabolizable energy, nitrogen-corrected) and availability of amino acids. In addition, the role of the hindgut in the breakdown of the non-starch polysaccharides will be assessed in relation to regular and dehulled canola meal fed to broiler chicks. Effects of hull reduction on phosphorus absorption also will be assessed using adult roosters.

Canola meal in turkey diets

Canadian research reported from 1979-83 indicated excellent growth responses in turkey broilers to 14 weeks of age when fed diets containing up to 30% canola meal. There were no adverse effects on sensory quality of the meat. Recent studies by Waibel and co-workers in Minnesota, U.S.A., involved Large White tom turkeys fed to 19 weeks on corn-based diets. Dietary levels of 20 and 26% canola meal in isocaloric diets resulted in better growth rates than were obtained with corn-soybean meal controls. Studies in progress include amino acid availability.

Enzyme supplementation of poultry diets containing canola meal

Enhancement of nutrient availability in canola meal for poultry has been a research priority for decades. Encouraged by the success of dietary enzyme supplementation in degrading polysaccharides in barley (β-glucan) and rye (arabinoxylan), Guenter and co-workers at the University of Manitoba have been studying the application of fungal enzymes to canola meal. The fibre components of canola meal comprise about 8% lignin, 4-6% cellulose, 13-16% non-cellulosic polysaccharides, 2.5% oligosaccharides, 20% cell wall protein (arabinoglactan-protein), plus phytate or polyphenols other than lignin, amounting to a total of 35-40% of matter with very limited nutritional value to monogastric animals. Certain combinations of enzymes, including pectinases, cellulase, protease and invertase have increased the content of soluble carbohydrate by up to 25% and the solubility of protein in water or buffer (pH7) by 11-23%. The studies include the use of supplemental phytase sources for improving availability of phosphorus in canola meal.

Inorganic sulfur in canola meal and interaction with calcium

Canola meal when used as the main protein supplement, results in reduced growth rate and greater incidence of leg problems in broilers. These responses are often associated with reduced feed intake. Summers and co-workers at the University of Guelph have reported that the relatively high level of inorganic sulfur in canola meal can markedly reduce the availability of calcium in the chick. The addition of inorganic sulfur to soybean meal diets to provide the same sulfate level as found in canola meal diets depressed growth similar to that of the canola meal diets. It was suggested that the interaction between calcium, sulfur and dietary protein may help to explain the variability evident in reports of the results of feeding trials with poultry fed canola meal.

CANOLA MEAL RESEARCH WITH SWINE

Composition and digestibility of canola press cake as a feedstuff for use in swine diets

Canola press cake, obtained after the expeller phase of prepress solvent extraction of crushed and cooked seed, were obtained from seven Western Canadian crushing plants. Bell and Keith reported dry matter composition, compared to a corresponding prepress-solvent extracted meal, as follows: protein 34.1 vs 41.9%; ether extract 21.2 vs 3.9%, gross energy 23.9 vs 20.4 MJ/kg. Myrosinase activity was 0.65% of that in the original seed compared to 0.15% for the meal. Total glucosinolates averaged 35.8 μmoles/g oil-free basis compared to 38.4 in the original seed and 21.1 in the final meal. Digestibility of energy of protein was 75% for pigs of about 60-70 kg. Diets containing 20 and 40% press cake were palatable, had an average digestible energy value of 17.9 MJ/kg dry matter and were dust-free.

Characteristics and nutritional quality of press cakes from enzyme-treated canola

Sosulski and co-workers at the University of Saskatchewan reported results of treating seed at elevated moisture content (30%) with carbohydrase enzymes for several hours then drying to 8.5% moisture prior to expeller processing. The resulting press cake contained 6.5-9.0% oil, 1.1-2.6% less fibre and 7-13% higher digestibility than cake not enzyme-treated. Lysine availability was 95%. Tobin (*B. campestris*) responded better than *B. napus* cultivars Westar and Regent to enzyme treatment, perhaps because of lower lignin content. The press cake tested was the result of studies on methods of improving the efficiency of expeller oil extraction to eliminate the need for subsequent solvent extraction.

Evaluation of canola-type mustard meal for pigs

This meal, previously described, is being evaluated under direction of Bell, University of Saskatchewan. It is higher in protein and lower in fibre than canola meal but its digestible energy value and amino acid profile may be inferior to canola meal, according to initial analytical and mouse growth trials. Studies are currently under way using meal derived from farm-grown seed that was pilot-plant processed. Conventional digestibility of energy and protein are being determined as well as ileal digestibility of protein and essential amino acids. In addition, a feeding trial with 23-100 kg pigs is in progress with the test meal replacing 0, 1/3, 2/3 and 3/3 of the soybean meal protein in diets containing two parts barley to one part wheat.

Nutritional evaluation of very low glucosinolate canola meal

Canola meal derived from two years production of *B. campestris* and containing under two µmoles of total glucosinolates per gram, oil-free basis, were evaluated by Bell and co-workers at the University of Saskatchewan in digestibility and feeding trails with growing pigs. Meal from Tobin cultivar from which the low glucosinolate strain was derived was included and soybean meal served as a control. Daily gains were similar for the low and normal canola meals and below those obtained with soybean meal as were feed intakes. Plasma thyroxine (T_4) values were similar for low glucosinolate and soybean meals and above those of pigs fed normal canola meal. Energy digestibility was greater for low glucosinolate canola meal than for normal meal. These experiments indicated marginal improvement resulting from reduction of glucosinolates below normal canola levels for pigs of 23-100 kg weight. In a palatability trial with weanling pigs, the low glucosinolate meal was preferred to normal meal and was similar to soybean meal.

Nutritional evaluation of dehulled canola meal for swine

Westar (*B. napus*) seed was 'front-end' dehulled and extracted to produce meal which was fed to 23-100 kg pigs in diets with canola meal protein replacing soybean meal protein at 0, 2.5, 5.0 and 7.5% of the diet, with and without supplemental lysine. Commercial Westar meal was used similarly and digestibility was determined. Bell and co-workers found that the meal contained 52% protein and 7.7% crude fibre, compared to 40% and 11.1% for commercial meal but lysine was lower, 4.96 vs 5.28% of the protein for dehulled vs regular meal. Pig performance was not improved by using dehulled meal but there was evidence of excessive heat having been applied in the desolventizer-toaster phase of processing. Digestibility of energy and protein was below 70% whereas values from a previous run were about 80%.

Trials with weanling pigs fed dehulled canola meal showed that both energy and protein digestibility in 4-week-old pigs fed diets containing 16 or 24% dehulled canola meal were significantly less digestible than with 6-week-old pigs.

A similar investigation is in progress but involving 'tail-end' dehulled meal as described above for Classen's poultry work. This includes ileal digestibility of protein and amino acids to obtain estimates of 'true' digestibility independent of hindgut fermentation action.

Combination of canola meal and field peas for market pigs

The relatively high lysine content of pea protein and its relatively high digestible energy content indicate that peas and canola meal compliment one another for use as protein and amino acid supplements for barley which tends to be low in energy and lysine for growing pigs. Bell and Keith, University of Saskatchewan, reported on the efficacy of various pea-canola meal combinations when used with either low or high protein barley. Diets formulated to meet protein and lysine requirements, using good quality grain, peas and canola meal for which the protein and lysine levels are known or reliably estimated can be expected to permit growth and feed efficiency comparable to soybean meal-supplemented diets.

CANOLA MEAL RESEARCH WITH RUMINANTS

The use of canola meal in creep feeds for suckling beef calves

Spring-born beef breed calves are normally weaned in the autumn. The quality of pasture grass normally declines during late summer thereby stressing the cow and her calf at a time when the calf's growth requirements are high. Bailey and co-workers at Lethbridge Research Station in Southern Alberta tested four creep feed treatments: nil, a canola meal-barley-oats mixture, a distillers' grains and fishmeal mixture, and canola meal alone, offering to suckling calves from 10 weeks of age until weaning. Best performance was obtained with the distillers' grains-fishmeal mixture which was degraded less extensively in the rumen than canola meal (20 vs 50%).

Evaluation of a high fibre low protein fraction of canola meal

Canola meal from five Western Canadian crushing plants was separated into two fractions differing in fibre and protein contents. Under direction of Christensen and McKinnon, University of Saskatchewan, the high fibre fractions are being evaluated for used in ruminant diets. Lactating dairy cows in early to mid-lactation are being fed such meal in comparison to regular meal (before fractionation) and soybean meal to examine effects on milk production and composition. Using fistulated cows, rumen disappearance of dry matter and protein will be determined. Digestibility of protein, energy, dry matter, organic matter, acid and neutral detergent fibre will be determined by conventional methods using growing lambs.

Effect of moist heat treatment of canola meal on the availability of protein and amino acids in dairy cattle

Ingalls and co-workers, University of Manitoba, treated commercially produced canola meal with moist heat at 127°C under steam pressure for up to 90 minutes. The effects of these treatments on rumen and post-rumen digestion were measured in cannulated steers. Nitrogen disappearance in the rumen decreased from 74 to 19% and increased in the duodenum from 16-64%, comparing 45 min heat treatment to control meal. Heat treatment improved the 'rumen by-pass' value of the meal without impairing intestinal digestion of protein. These studies are continuing with emphasis on availability of essential amino acids.

Influence of heat on ruminal, intestinal and total tract disappearance of canola meal

Canola meal was heated at 125 or 145°C for 10, 20 or 30 min and evaluated using cannulated steers by McKinnon and co-workers, University of Saskatchewan. It was concluded that temperature was more important than duration of heating and that 145°C reduced both ruminal and total tract availability compared to untreated meal. However, heating to 125°C for 20 min improved by-pass value but did not affect protein digestion in the total tract of the ruminant.

Effects of acid treatment of canola meal and 'jet-sploding' and extrusion of canola seed on nutritive value for lactating dairy cows

A series of experiments reported by Kennelly and co-workers, University of Alberta, dealt with alternative methods of improving rumen by-pass value of canola meal. Meal was sprayed with dilute solutions of HCl, acetic acid, formic acid or propionic acid and then dried at 105°C. A water-treated meal was a control. The organic acids, but not HCl, improved by-pass value of the meal protein. Acetic acid was most effective, using 2.5%. Further study of acetic acid-treated meal confirmed the improvement in rumen by-pass value but there was no net improvement in the overall protein digestion because the acetic acid reduced the microbial protein production in the rumen. The use of acetic acid-treated canola in diets of early lactation cows effected only marginal increases in milk production but increased the lactose content of the milk.

Two heating processes applied to whole canola seed were examined. Seed was 'jet-sploded' (hot air-heated to achieve a seed temperature of 125°C, then the seed laden with superheated moisture is passed through rollers. This process improved rumen by-pass value of meal protein but resulted in some depression of intestinal digestion of protein. Some changes were observed in milk composition, especially for fatty acids in milk fat. Extrusion of either meal or seed had no influence on ruminal breakdown of protein. The maximum effective dietary level of 'jet-sploded' seed was 4.5% of the dry matter fed.

Variability in nutritive value of canola meal for ruminants

Kendall and co-workers, University of Manitoba, examined the rumen degradability or by-pass value and the post-ruminal digestion of canola meals obtained from five crushing plants and compared these with soybean meal. Significant differences were found among the canola meal samples but all had lower by-pass value than soybean meal. The fate of the essential amino acids was also examined and differences among meals were found.

Ammoniated canola hulls for ruminants

Canola hulls obtained by 'front-end' dehulling were compared untreated, solvent extracted (hexane), ammoniated (3% anhydrous, w/w), and solvent extracted and ammoniated using both *in vitro* and nylon bag rumen fermentation by McKinnon and Cohen, University of Saskatchewan. Using lambs, voluntary intake and digestibility were assessed using 0, 25, 50 and 75% replacement of alfalfa hay with hulls in pelleted diets. Preliminary results indicate that ammoniation had no beneficial effect regardless of the presence of about 15% residual oil in the hulls. About 35% of the dry matter was digested *in vitro*. In the lamb trial, increasing the % untreated hulls in the diet depressed dry matter intake and digestibility.

GENERAL RESEARCH WITH CANOLA MEAL

Variation in the chemical composition of commercial canola meal

Samples of canola meal were obtained by Bell and co-workers, University of Saskatchewan, from seven canola crushing plants in Western Canada over four successive weeks. Samples were analyzed for moisture, crude protein, ether extract, crude fibre, acid and neutral detergent fibre, gross energy, eleven mineral elements, amino acids, available lysine, myrosinase and glucosinolates. Differences among meals from different plants were found for many of the nutrients and possible causes of differences were discussed. Summary tables in the published paper provided means and standard errors for meal components.

Effects of indole glucosinolates on chick embryos and growing mice

Goitrogenicity and toxicity of rapeseed glucosinolates have been attributed largely to the effects of the aliphatic types. Little is known about the effects of indole types which may comprise about one-half of the glucosinolates in canola since most of the glucosinolate reduction occurred with the aliphatic types. Darroch and co-workers, University of Saskatchewan, using a purified extract of Brussels sprouts (*B. oleracea*), containing primarily indolyl-3-methyl glucosinolate, fed mice diets containing graded levels from 0.2-8.2 µmol/g of dietary dry matter. The indoles had no effect on thyroid weight, histology or thyroxine output (T_3, T_4) nor any effects on liver or kidney weights or morphology. Increasing levels of indoles caused reduced feed intake and reduced growth. At 8.2 µmol mortality occurred, believed caused by refusal to eat, suggesting a palatability problem. Levels below 3 µmol/g diet had no adverse effect and may have improved feed efficiency.

In a second experiment, indole glucosinolates were injected into egg yolk and into blood of developing chick embryos on day 10 of incubation and compared with thiourea and saline injections. Thiourea produced typical antithyroid effects. Indoles did not affect thyroid function but increased chick embryo mortality, perhaps due to toxic, non-goitrogenic breakdown products. The indole glucosinolate injections were several-fold greater than would be encountered when feeding canola meal to domestic animals, on a µmol/g body weight basis.

Effects of indole glucosinolates on laying hens, cockerels and rats

Breakdown products of indole glucosinolates, namely thiocyanate, 3-indoleacetonitrile and 4-hydroxy-3-indoleacetonitrile were fed to layers, cockerels and growing rats at levels corresponding to a 30% canola meal diet. Campbell and Slominski, University of Manitoba, found no effects on feed intake, weight gain, thyroid or liver sizes, plasma enzyme activities or liver glutathione levels. It was concluded that these breakdown products do not adversely affect quality of canola meal fed at normal dietary levels.

Canola protein products in finfish diets

The expansion of fish farming is creating a need to find alternatives to fish protein for use in fish diets. About two-thirds of the cost of salmon food stems from fish meal ingredients. Higgs and co-workers, Dept. of Fisheries and Oceans, British Columbia, recently reported that canola/rapeseed protein contains amino acids that conform closely to the amino acid requirements of salmonids and that protein and energy digestibility of canola protein concentrates, dephytinized, were similar to fish meals and could comprise up to 40% of the dietary protein of rainbow trout.