Usage of Rapeseed Meal in feed formulation

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Introduction

Feed business is not a rocket science, it's much complicated than that! Oilmeals are integral part of animal feeds. How much of oilmeals are used in animal feeds? This is inexact science. This figure is arrived by doing calculations, as it is impossible to measure actual use. It is expected that by 2025-26, compound cattle feed production will be around 15-20 million tons (Vs. 8.3 MMT in 2017) depending on several factors. In 2025-26, it is estimated that requirement of broiler feeds will be 26 million tonnes (Vs. 12 MMT today) and 13 million tonnes of layer feeds (Vs. 9 MMT today). It is estimated that 710,000 tons of pellet feed is produced and marketed for the culture of freshwater fish. It is estimated that by 2025-26, at least 5-6 million tons of pelleted fish feed will be sold in India. The Shrimp Feed Industry (5 lakh tonnes per year) is a technologically mature industry in India and produces world class standard feeds through some of the leading aqua feed manufacturers. It is expected that by 2025-26, shrimp feed production will be around 8-10 lakh tons.

Rapeseed meal, called canola meal in North America, Australia and some other countries, is the by-product of the extraction of oil from rapeseed (*Brassica napus* L., *Brassica rapa* L. and *Brassica juncea* L., and their crosses). It is a protein-rich ingredient that is widely used to feed all classes of livestock. The use of rapeseed meal as an animal feed was also limited by the presence of glucosinolates, which are antinutritional factors detrimental to animal performance. In the 1960-1970s, low-erucic varieties ("0") and low-erucic, low-glucosinolate varieties ("00", double-zero, double low, canola) were developed, allowing rapeseed oil to become a major food oil, and rapeseed meal and rapeseeds to grow in importance as fed to livestock. The first 00 varieties were introduced commercially in Canada in the mid-1970s. In some countries, such as France, 00 varieties became commercially available in the late 1980s. Low-erucic, low-glucosinolate varieties are now the main types grown worldwide for edible oil, biofuel, industrial oil and lubricants. There are also high-erucic varieties grown for specific industrial purposes. While solvent-extracted rapeseed meal remains the main type of rapeseed meal commercially available, oil-rich rapeseed meals obtained by mechanical pressure have gained popularity since the turn of the century with the development of organic farming and on-farm oil production.

Solvent-extracted rapeseed meal

Rapeseeds contain 40-45% oil and yield about 55-60% oil meal when fully extracted by crushing followed by solvent extraction. Temperature is one of the main factors affecting the quality of rapeseed meal. Solvent-extracted rapeseed meal should not contain more than 2-3% oil.

Expeller or cold-extracted rapeseed meal

- **Expeller rapeseed meal** results from the mechanical extraction of seeds previously conditioned by a heat treatment. It is also called rapeseed press-cake, canola press-cake or double-pressed canola.

- **Cold-extracted press-cake**: with the growing interest of consumers for cold-pressed rapeseed oil, another process consisting in pressing the seeds at low temperature (60°C) yields cold-pressed rapeseed press-cake.

These types of rapeseed meal may contain highly variable amounts of residual oil, usually more than 5% and up to 20% or more. They are particularly valuable in organic farming (where the use of hexane is prohibited) as a source of protein.

Heat treatments

Heating deactivates myrosinase, the enzyme that breaks glucosinolates into toxic aglycones, and results in their 30-70% degradation. High temperatures affect protein quality, which is deleterious to monogastrics as it reduces amino acid digestibility, but beneficial to ruminants as it reduces rumen protein degradability. However, excessive heat processing of rapeseed meal suppressed phytate degradation in the rumen and led to lower availability of dietary phosphorus. Steam treatment also reduced protein digestibility in poultry. Overheating may occur during desolventizing and temperatures should not be higher than 100°C. Cold-pressed rapeseed meal may contain higher amounts of glucosinolates than solvent-extracted meal as glucosinolates need heat for their degradation and subsequent deactivation of myrosinase.

Dehulling

Dehulling rapeseeds before crushing results in a rapeseed meal containing more protein and less fibre, thus improving its digestibility and nutritional value. This technology was implemented industrially in France in the 1980s, but abandoned after a few years due to significant oil losses in the hull fraction and limited market interest in the dehulled meal. However, the search for alternative proteins to the soybean has sparked renewed interest in the technology since the 2000s.

Enzyme treatments

There have been several attempts at improving nutrient availability by reducing the encapsulating effect of the cell wall through the use of enzymes, including proteases, xylanases and phytases.

Addition of processing by-products

By-products of rapeseed processing are sometimes added back into the meal, notably in Canada. Adding gums, which mostly consist of phospholipids, and soapstocks, which are oil-rich components, increases the energy content of the meal and reduces dustiness. Screenings and foreign materials decrease meal quality.

Rapeseed meal from genetically-modified (GM) seeds

GM rapeseed cultivars have been developed and are widely used in Canada (95% of the crops) and in the USA (82%). In the European Union, the cultivation of GM rapeseed crops is banned but the seeds, oil and oil meal resulting from the cultivation of certain cultivars can be imported and used as feed and food. The harmonisation of GM rapeseed labelling has been recommended so that livestock farmers can make an informed choice, but no compulsory labelling is required for animal products from livestock fed GM oilseed rape products.

Nutritional attributes

Rapeseed meal is often included in the diets of several species of livestock because of its high protein content (35-44% of DM). It is often fed as a substitute for soybean meal. Rapeseed protein is poorer in lysine than soybean (5.5% *vs*. 6.3% of the crude protein) but is richer in sulphur-containing amino acids (sum of methionine + cysteine: 4.3% *vs*. 3% of the crude protein). Rapeseeds are small and contain about 18-21% hulls, and the oil meal contains about 30% hulls. Thus rapeseed meal has a relatively high fibre content, crude fibre being between 10-18% of DM, which is higher than the crude fibre content of all types of soybean meals, but lower than that of other oil meals such as sunflower meal. Its lignin content is also high (about 10% of DM), whereas the lignin content of soybean meal is usually lower than 1%. The low lysine and high fibre content tends to limit the use of rapeseed meal in monogastric and fish species. Feeding pigs and poultry with rapeseed meal as their only source of supplementary protein often results in lower animal performance. Solvent-extracted rapeseed meal contains small amounts of residual oil (about 3% DM). Canadian solvent-extracted canola meal may have higher oil content due to the reintroduction of gums and soap stocks into the meal during processing.

Expeller and cold-pressed rapeseed meals

Rapeseed meal obtained by mechanical pressure only has extremely variable quantities of oil, usually between 7-15% but sometimes as high as 20% of DM, resulting in a higher energy value than solvent-extracted meal. Cold-pressed rapeseed meal usually has a higher oil content than expeller rapeseed meal. Lysine availability was found to be higher in cold-pressed rapeseed meal than in expeller meal, indicating less heat damage. Glucosinolates tended to be higher in expeller and cold-pressed rapeseed meal as myrosinase was not, or less, deactivated than in solvent-extracted meal. However, another study found cold-pressed meal to have a much lower glucosinolate content, below the maximum level tolerated for optimal pig growth.

Dehulling

Dehulling has been shown to improve the nutritional value of rapeseed meal. Dehulling reduced fibre content and increased amino acid and nutrient digestibility in pigs, but did not affect the rumen disappearance of amino acids in ruminants.

Potential constraints

1. **Glucosinolates and erucic acid**

Rapeseeds used to contain erucic acid, an unpalatable and toxic fatty acid, and glucosinolates, which affect feed intake in ruminants and result in physiological disorders in the liver, kidneys or thyroid glands of monogastrics. In poultry, adverse effects of glucosinolates are pungency, bitterness, anti-thyroid activity and, as a consequence, a reduction in growth and laying performance. Mortality can be increased, especially in laying hens, due to hemorrhagic liver syndrome.

Modern 00 rapeseed/canola cultivars have very low levels of erucic acid and glucosinolates. The glucosinolate content of rapeseeds has been declining steadily, and is now often below 10 µmol/g *vs*. 120 µmol/g for former non-00 cultivars. Surveys conducted since 2010 reported averages of 3.9 µmol/g (Canadian canola meal), and 10 µmol/g (French rapeseed meal). The use of rapeseed meal in monogastrics (pigs and poultry) diets can now be increased without affecting feed intake or the physiological functions of livestock. In poultry the limitation is not due to glucosinolates but to the high fibre content. Some rapeseed cultivars are cultivated for the production of erucic acid and the meal resulting from their extraction should not be fed to animals.

2. **Tannins**

Tannins are phenolic compounds that bind with various compounds, including proteins, making them less available to the animal. In rapeseeds, most tannins are contained in the seed coat. With pigs it was found that dark hulled seeds were nearly indigestible whereas yellow hulled seeds were reasonably well digested. This was attributed to a lower tannin and lignin content in the brighter seeds. Lighter varieties of rapeseeds were reported to contain less tannins ("000" varieties). Some breeding programmes aim at reducing the thickness of the seed coat, and thus the level of tannins. Dehulled rapeseed meal and rapeseed meal from light-coloured varieties may thus have a lower tannin content.

3. **Phytic acid**

The phosphorus of rapeseed meal is mostly in the form of phytic acid, with a phytic P:total P ratio comprised in the range of 67-95%. Phytic acid binds to cations such as Zn, Ca, and Fe, thus reducing their bioavailability.

4. **Sinapine**

Rapeseed meal contains about 1% sinapine, an alkaloidal amine found in the seeds of *Brassica* species including rape. Sinapine is a choline ester converted into trimethylamine by the micro-organisms in the gastrointestinal tract of birds. Trimethylamine is then converted by an enzyme into an odourless form later excreted through urine. Hens with brown-shelled eggs lack that enzyme and, in these breeds, trimethylamine accumulates in the egg, causing them to have a fishy taste. All sources of choline (choline chloride and sinapine from canola meal) can be transformed in trimethylamine, but the tainting effect of rapeseed meal seemed to override the one with choline chloride. Sinapine also reduces palatability and has a depressing effect on feed consumption.

Use of Rapeseed Meal in Ruminants

Rapeseed meal is a common feed ingredient for all classes of ruminant livestock, as a source of protein and energy. Due to its lower protein content, higher fibre and higher protein degradability, rapeseed meal is often considered of significantly lower value than soybean meal. However, several meta-analysis of dairy cattle studies concluded that both the energy and the protein value of rapeseed meal were higher than previously thought. Rapeseed meal is a highly palatable source of protein for ruminant animals.

Rapeseed meal is a good source of energy for ruminants. For solvent-extracted rapeseed meal, the net energy values for lactation cited in feed tables range from 6.8 to 7.45 MJ/kg DM (NRC, 2001). These correspond roughly to 80% of the net energy value for soybean meal. OM digestibility is about 74-77%. However, it has been suggested that the fibre digestibility of rapeseed meal may be undervalued. Some experiments have shown than rapeseed meal can result in dairy performance similar to that obtained with soybean meal. Further research is needed to determine the correct energy value of rapeseed meal. Expeller and cold-pressed rapeseed meals have a higher energy value than solvent-extracted meal because of the higher amount of residual oil.

Rapeseed meal is a common source of protein for ruminants. Its protein has long been considered as more degradable than that of soybean, but estimates of rumen-undegraded protein (RUP), made using newer methods taking into account the contribution of the soluble-protein fraction to the RUP available to the animal, suggest that the RUP (expressed as a % of protein) of rapeseed meal is in the 40-56% range, compared to 27-45% for soybean meal.

Rapeseed meal has a good amino acid profile for ruminants, and contributes a significant amount of methionine, which is often the first limiting amino acid in production. In addition, the amino acid profile of the RUP fraction more closely matches requirements for maintenance and milk than other vegetable proteins.

Rapeseed meal is an excellent protein supplement for lactating dairy cows and can be included in relatively large amounts to their diet. Inclusion rates as high as 20% have been reported with no negative effect on intake and production. A meta-analysis of 122 studies comparing rapeseed meal to soybean meal found that for each additional kg of protein supplied in the diet, milk production increased by 3.4 kg with rapeseed meal, and 2.4 kg with soybean meal, showing a 1 kg advantage to the rapeseed meal. Another meta-analysis of 49 studies comparing rapeseed meal with other protein sources found that at the average level of inclusion, rapeseed meal increased milk yield by 1.4 kg when all the other ingredients were considered, but only by 0.7 kg when rapeseed meal was substituted for soybean meal. A follow-up of the latter study focused on plasma amino acids suggested that feeding rapeseed meal increased the absorption of essential amino acids, resulting in higher milk protein secretion and, thus, higher protein efficiency. Rapeseed meal was effectively used in combination with maize distillers grains to restore amino acid balance and maximise animal performance.

Expeller or cold-pressed rapeseed meal is a suitable ingredient for dairy cattle. When compared to solvent-extracted rapeseed meal, expeller rapeseed meal resulted in similar or higher milk yields. Cold-pressed rapeseed meal is a valuable energy and protein source in organic diets (where solvent-extracted meals are forbidden). Due to its high oil content, the feeding of expeller rapeseed meal tends to modify the fatty acid profile of milk by reducing saturated fat, increasing the level of oleic acid (C18:1) and decreasing the level of palmitic acid (C16:0).

Use of Rapeseed Meal in Poultry

Rapeseed meal is used as a protein source in poultry diets as an alternative to soybean meal. However, its nutritional quality for poultry is usually lower than soybean meal, due to lower protein and amino acid contents, lower amino acid digestibilities (particularly when the meal is overheated and undergoes a Maillard reaction) and a higher fibre content, which is inversely related to the metabolizable energy value of rapeseed meal, which is 10 to 15% lower than that of soybean meal. Products resulting from a Maillard reaction during processing are responsible for these low values. Tannins might also reduce amino acid digestibility. Rapeseed meal compares favourably with soybean meal for sulphur-containing amino acids and these two meals tend to complement each other. The use of dietary enzymes in poultry feeds containing rapeseed meal may improve digestion, but results are not completely conclusive.

Dietary inclusion of rapeseed meal from modern 00 and canola varieties in poultry diets should not exceed 20% in broilers and 15% in layers, so that the total glucosinolate content is lower than 1.5 µmol/g.

Rapeseed meal fed to sensitive layers was reported to cause a fishy taint when the inclusion rate was higher than 12% of the diet, which is above the levels recommended for layers

Generally, recommended levels of rapeseed meal in broilers diets do not go beyond 20%. However, in Australia, rapeseed meal from very low glucosinolate varieties could be included in starting chicks diets at levels ranging from 20 to 30%, and up to 30% for finishing chicks. The recommended inclusion rate of rapeseed meal in the diet also reduced bird abdominal fat percentage and intestinal viscosity, without affecting liver and pancreas weight. In Pakistan, up to 25% rapeseed meal was incorporated in broiler diets without any adverse effect on production parameters. In India, rapeseed meal was included at up to 30% in broiler diets without any adverse effects on health and performance (Ramesh et al., 2006).

Recommended levels of inclusion in laying hens used to be restricted in the range of 4-10% of the diet. However, recent results reported that higher inclusion levels are possible without hampering health and performance. In Canada, both solvent-extracted and expeller canola meal were well tolerated by laying hens at high (20%) dietary inclusions. In Romania, commercial layers were fed up to 15% canola meal without problems. In Iran, with local breeds of laying hens, it was reported that including rapeseed meal at up to 15-20% had no adverse effects on egg weight, yolk weight and yolk weight ratio. Diets containing 24% rapeseed meal were fed to a commercial line of brown-shell laying hens (Hy-Line) without impairing egg quality (no fishy taint). These findings suggest that brown-shell laying hens could be fed at conventional rates applied to white-shell laying hens, *i.e.* 8-10% of the diet.

Use of Rapeseed Meal in Fish

Rapeseed meal is used as a source of protein for many fish species. The main issue of rapeseed meal for fish feeding is its high fibre content, which limits its nutritional value for carnivorous fish species. However, as rapeseed meal is included at rates much lower than 50%, the fibre content is unlikely to exceed 8% of the diet and to impair growth performance (Hilton et al., 1986). Glucosinolates appear to be better tolerated by fish species, such as carp, than by swine and poultry. The combination of rapeseed meal and soybean meal is often a good solution to replace fish meal. The use of plant protein to replace fish meal in fish diets reduces the price of the diet and does not introduce dioxins and PCBs, which is reassuring for consumers.

For these reasons, it has been suggested that rapeseed meal can be included at levels between 10 and 20% in fish diets, but rapeseed meal high in erucic acid should not be over 5%.

Rapeseed meal is commonly included in carp diets, which are normally based on plant protein. However, recent studies with juvenile grass carp (*Ctenopharyngodon idellus*) and juvenile crucian carp (*Carassius auratus x Cyprinus carpio*) found that high levels of rapeseed meal (45% or 50% of the diet) had deleterious effects on fish liver and subsequently impaired performance (growth, feed intake, feed conversion ratio) and health (blood parameters) It was suggested to either limit rapeseed meal inclusion in grass carp diet at 16% or to supplement it with glutathione (400 mg/kg), as glutathione has a protective effect on fish liver. In fry, it was suggested that rapeseed meal inclusion could be as high as 15% for grass carp (*Ctenopharyngodon idellus*) and 22% for common carp (*Cyprinus carpio*). In 2-year-old common carp, cold-pressed rapeseed meal inclusion rates up to 33% had no effect on growth or feed utilization.

Apparent digestibilities of DM, energy and protein in Nile tilapia were higher than in catfish at 67%, 74% and 91%, respectively. In China, it was possible to use up to 19% rapeseed meal to replace 30% soybean meal in diets for juvenile hybrid tilapia without compromising growth, feed conversion and protein utilization. In Brazil, up to 24% rapeseed meal was fed to juvenile Nile tilapia with no health or performance issues. Earlier inclusion levels recommended have been in the 10-25% range. In China, genetically modified Nile tilapia were fed diets where 75% of the fish meal was replaced by rapeseed meal (thus representing 55% of the tilapia diet) without impairing growth performance.

A series of experiments on kuruma shrimp (*Marsupenaeus japonicus*) showed that rapeseed meal could be included in the diets of shrimps in order to replace part of the fish meal. While it was not possible for rapeseed meal to replace more than 20% fish meal protein as a sole protein source, it could be used in a blend with soybean meal (ratio 4:6), supplemented with amino acids, phytase and fish solubles, when 85% of the fish meal protein could be replaced. These results are in accordance with earlier results obtained on whiteleg shrimp (*Penaeus vannamei*) where rapeseed meal was recommended at no more than 15% in the diet to replace menhaden fish meal. A non-nutritional concern about using rapeseed meal in shrimp feeds is the negative effect that the fibre has on feed pellet water stability.

Conclusion

Indian poultry, dairy and aqua industry will continue to grow for next decade mainly due to increase in domestic demand for milk, egg, meat and aqua products. Therefore, future of compound feed industry is bright. Compound feed industry will produce around 54 million tons of all types of feeds, excluding 10.4 million tons of layer feeds prepared at farm level. The oil meal requirements for producing this feed will be around 15 million tons. There will be also requirement of oilmeals for direct feeding of dairy animals (30 million tons).