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## Replacement of fish meal with canola/rapeseeds meal in aquaculture diets

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### Abstract

The aquaculture sector is the world's most important fish food provider for human consumption. Fishmeal, the most expensive protein source in aquafeed which leads low income and environment pollution. Therefore aquaculture is looking for alternative suitable protein sources, which could replace this limited resource. A useful protein source from the by-products of rapeseed oil production, cake or meal, has been suggested as an alternative to fishmeal for aquafeed. Unfortunately the rapeseed meal contains some antinutritional factors (ANFs) such as glucosinolates, phenolic compounds (tannins and phenolic acid), phytic acid and indigestible carbohydrates. These antinutritional substances can affect negatively on the fish growth performance and health status, but the level of ANFs are reduced by heat treatment. Due to wide availability, high protein content and a desirable amino acid profile have caused an interest in rapeseed products as fish meal alternative in aquafeeds.

**Keywords:** Fish meal, Environmental impact, canola/rapeseed meal and Fish growth,

### 1. Introduction

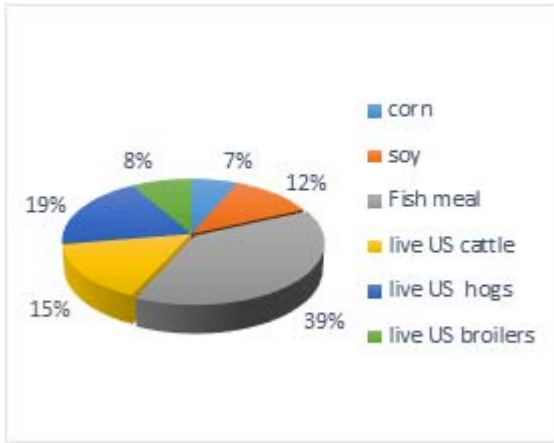
In many developing countries, the basic and affordable animal protein is provided by aquatic organisms, mainly fish from capture fisheries as protein from terrestrial animals is very expensive for ordinary or low income earners. The worldwide supply of fish meal (annual production volume 5–7 mt) will not be able to cover the needs of the expected future expansion of global aquaculture. Fish species adapt differently to the replacement of fishmeal by plant protein feed ingredients, in terms of growth performance, nutrient digestion and digestive system adaptations. Fish meal usage in aquaculture is estimated to reach well over 4 million metric tons by 2015 and total production of fishmeal is approximately 6 million tons per year. Fishmeal is the most expensive protein source in aquafeed whereas aquafeed cost contributes 50-70% of total production (Tacon, 1993). Canola meal is a suitable protein replacement for fish meal as it has relatively high protein content (38%) and the protein is highly digestibility for fish (Cheng, Z.J., and Hardy, R.W, 2002). Canola includes seed from *Brassica napus* and *B. rapa* with low levels of glucosinolates in the meal and a low concentration of erucic acid as described by the Canola Council of Canada. Canola meal, or flour, is the by-product of the seed after oil has been extracted either physically or by solvent extraction.

### 2. Fish Meal Production and Change in Price

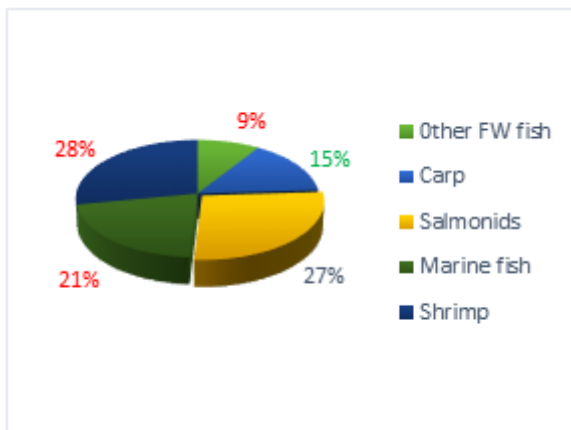
Fish meal production was recorded at 2.6 million ton in 2008 with a decrease of 100,000 ton compared to 2007 (FAO, 2009a). Overall, feeding costs generally represent the highest amount of total operating expenses of an aquaculture operation even up to 70% in some instance. In Mediterranean aquaculture between 1.5 and 2.5kg of feed are needed to produce 1kg of fish; this makes up around 45% of production expenses. This is true particularly for carnivorous species such as salmonids diets (Meyers, 1994), because protein is costliest component in aquaculture diets (Nguyen *et al.*, 2009). Investigation for fish meal replacement are often for a single alternative protein source and can result in a high percentage of substitution but seldom equivalent values for growth performance, survival rate and specific weight gain. Essential amino acid composition, particularly lysine and methionine are lower in plant and animal sources than in fish meal and often have to be supplemented to achieve growth rates and weight gain of equal values.

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**Fig 1:** July 1999 to August 2014, Change in price in different feed source



**Fig 2:** Fish meal use in Aquafeeds

### 3. Canola/ Rapeseed Meal

Traditional varieties of rapeseed contain high amounts of erucic acid whereas newer Canadian Varieties (known as canola) contain lower values that were achieved by generic modification. Therefore, canola and rapeseed are two different species (Shahidi, 1990). Canola is the name given to selected varieties of rapeseed that are low in glucosinolate and erucic acid (Bell, J.M., 1993). The amino acid profile of canola meal protein is similar to that of herring meal protein and superior to soybean meal protein. However, the cost of canola meal is generally lower than that of fish meal (Sajjadi, M., Carter, C.G., 2004). In aquaculture, feed accounts for over 50 percent of the production cost. Fishmeal is the single most important source of protein in fish feed. Canola meal (CM) is alternative protein source for FM similar to soybean meal (SBM) in diets for many aquaculture species. ANFs in rapeseed products are glucosinolates, phytic acid, phenolic constituents and indigestible carbohydrates (Francis *et al.*, 2001; Burel *et al.*, 2000). The inclusion of plant protein sources in aquafeeds is expanding due to the limited amount of fishmeal available for the production of animal feeds (Glencross *et al.*, 2005; Gatlin *et al.*, 2007). Canola meal and canola protein concentrate have been investigated in a variety of finfish (Burel and Kaushik, 2008). Protein apparent digestibility coefficients for rainbow trout fed rapeseed meal are similar to fishmeal whereas apparent digestibility coefficients for energy and dry matter are

significantly lower compared to a fishmeal reference diet (Mwachireya *et al.*, 1999; Burel *et al.*, 2000).

### 3.1 Characteristics Of Canola Meal

Canola is a mid-protein meal with a good amino acid profile and mid-range fibre content. Canola is a registered trademark of the Canadian canola Association and refers to cultivars containing <2% erucic acid (Raymer, 2002).

**Table 1:** Current Australia trading standard for Canola Meal.

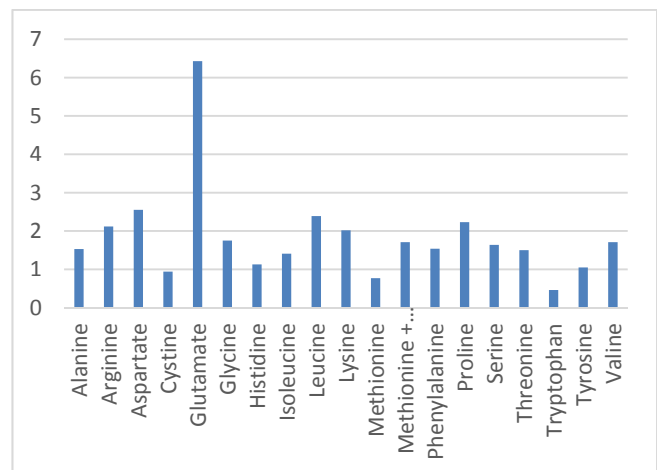
| Component                                    | limit   |         |
|--|---------|---------|
|  | Solvent | Pressed |
| Oil content (minimum %)                      | 0.5     | 4       |
| Moisture content (maximum %)                 | 12      | 11      |
| Glucosinolates (µmoles / g in oil-free meal) | <30     | <30     |
| Crude Protein content (minimum %)            | 34      | 32      |
| Crude Fibre (maximum %)                      | 15      | 14      |

(Source: AOF Trading Standards, 2003)

**Table 2:** Quality Characteristics of Canola Meal

| Component                      | Canola meal |
|--------------------------------|-------------|
| Moisture (%)                   | 10.0        |
| Crude protein (N x 6.25 ;%)    | 35.0        |
| Rumen bypass protein (%)       | 35.0        |
| Oil (%)                        | 3.5         |
| Linoleic acid (%)              | 0.6         |
| Ash (%)                        | 6.1         |
| Sugars (%)                     | 8.0         |
| Starch (%)                     | 5.2         |
| Cellulose (%)                  | 4.6         |
| Oligosaccharides               | 2.3         |
| Non-starch polysaccharides (%) | 16.1        |
| Soluble NSP's (%)              | 1.4         |
| Insoluble NSP's (%)            | 14.7        |
| Crude fibre (%)                | 12.0        |
| Acid detergent fibre (%)       | 17.2        |
| Neutral detergent fibre (%)    | 21.2        |
| Total dietary fibre (%)        | 33.0        |
| Tannins (%)                    | 1.5         |
| Sinapine (%)                   | 1.0         |
| Phytic acid (%)                | 4.0         |
| Glucosinolates (µmoles/g)      | 16.0        |

(Source: canola council of Canada)



**Fig 3:** Amino Acid profile of Canola Meal

Rapeseed meal is the major plant protein source which is alternative source for fish meal replacement in aquacultures. In comparison to fish meal, rapeseed meal is limiting in lysine and few other essential amino acids but have high level of methionine and cysteine. Due to anti-nutritional effects, canola or rapeseed meal has a limited use for carnivore fish diet (Drew *et al.*, 2007).

**3.2 Process of Canola Meal Production**

The process of separating oil from canola seed involves several steps. These include:

- Cold-pressed – where the oil and meal is physically separated without heat

- Expeller - where the oil and meal is physically extracted with added heat
- Solvent extracted - where the oil and meal is extracted with the combined physical “expeller” extraction followed by solvent washing

The solvent extraction method results in more efficient extraction of the oil and produces a meal with less than 1% oil residue. Cold-pressed and expeller meals can contain 8-12% oil and are processed generally at moderate temperatures of <60 °C although this can be considerably higher. Glucosinolates and their volatile by-products would normally be lower in heat treated and solvent extracted meal.

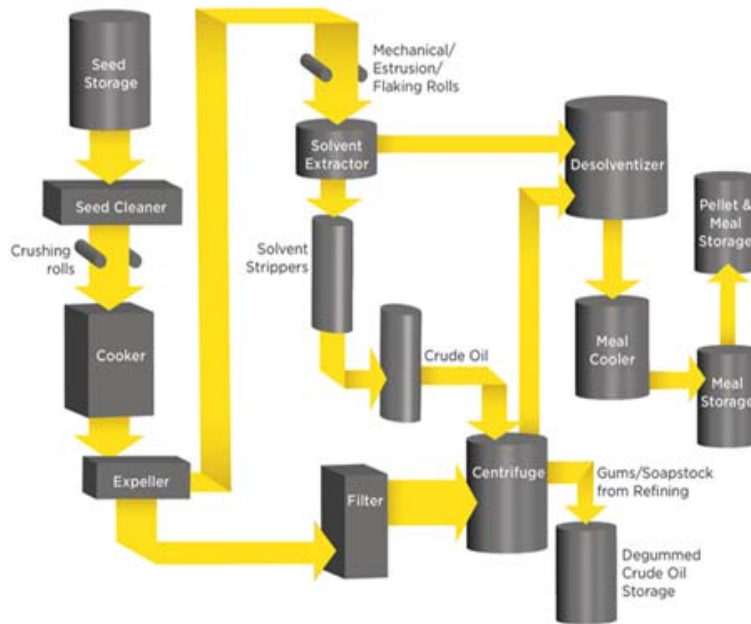


Fig 4: processing of canola meal from raw material (seeds).

**3.3 Canola Protein Concentrate**

Production of Rapeseed/Canola protein concentrate from whole Rapeseed/Canola seeds by means of special processing methods that have protein content comparable to that of fish meal with less amount of ANFs such as GLS,

sinapine and fibre. Hence, based upon their level of proximate constituents (>60% protein) and their digestibility about 90%, Rapeseed/Canola protein concentrates could be considered as potential fish meal replacement in fish diets.

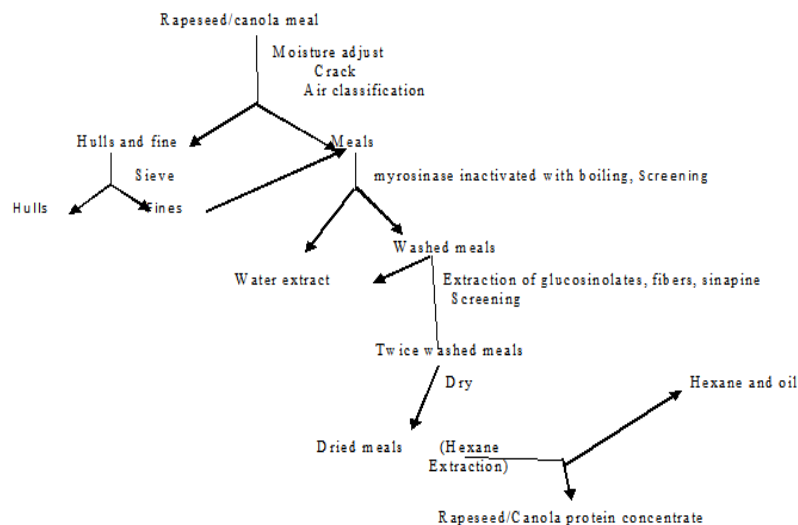


Fig 5: Schematic presentation of a process to produce protein concentrate from canola seed.

(Source: Chhorn Lim *et al.*, 2008.)

### 3.4 Canola Protein Isolates

The protein isolates are more expensive than protein concentrate because of their higher quality, more pure and their high biological value. They contain more protein less fat, carbohydrate and inorganic matters. The aim of this

process is to produce a high quality plant protein isolate in term of nutritional value.

### 4. Proximate Composition

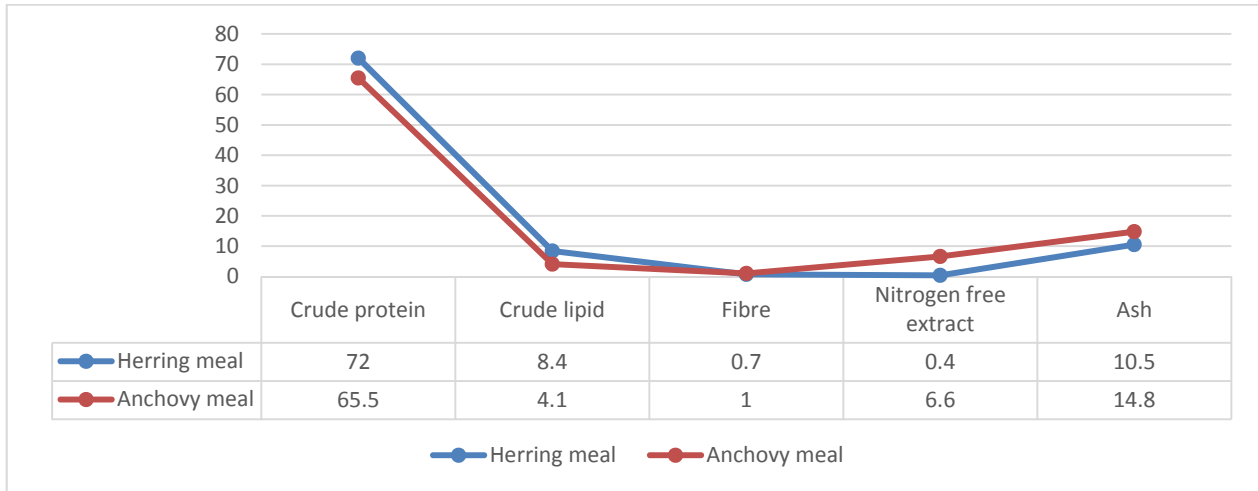


Fig 6: Fish meal

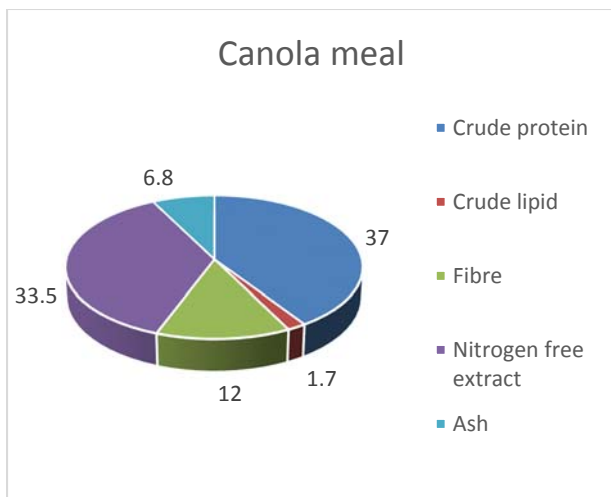


Fig 7: Canola Meal

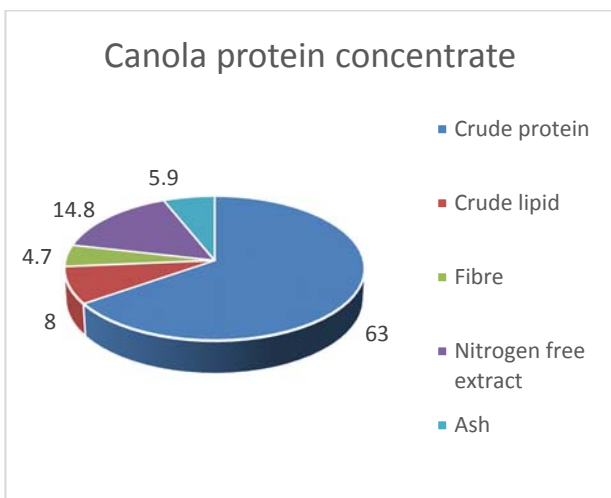


Fig 8: Canola Protein concentrate

(Source: Higgs *et al.*, 1995)

### 5. Canola/Rapeseed Meal Use In Aquadiets

Acceptable levels of CM in some species, such as 13 – 16% dietary protein for Chinook salmon, *Oncorhynchus tshawytscha* (Higgs *et al.*, 1982, Satoh *et al.*, 1998); 15% in diet for tilapia, *Oreochromis mossambicus* (Davies *et al.*, 1990); and 20% in diet for rainbow trout (Thiessen *et al.*, 2003). However, CM at a higher level in diets was accepted by other species, such as 31 - 36% in diet for channel catfish (Webster *et al.*, 1997, Lim *et al.*, 1998); 60% FM protein replacement in diet for red seabream, *Pagrus auratus* (Glencross *et al.*, 2004b). The RPC successfully replaced 33 % of fish meal protein from a control diet without retarding fish growth performance, feed intake or feed efficiencies for common carp.

Studies on the inclusion of 30% dehulled, solvent- extract and 30% dehulled, heat – treated RSM in combination with fish meal in practical diets for rainbow trout and turbot have shown that protein digestibility was similar to high quality fish meal whereas digestibility for turbot was significantly lower without thermal treatment for the 46% CP diet for rainbow trout, 28% of fish meal replacement was possible whereas for the 52% CP turbot diet, 30% fish meal substitution was shown to be possible (Burel *et al.*, 2000). on the other hand, both expeller- extracted and solvent – extracted canola meal could be included up to 60% in 30% CP diets for juvenile red sea bream (*Pagrus auratus*, Paulin) substituting for 50% fish meal without adverse effects on growth rate, feed performance or protein utilization (Glencross *et al.*, 2004b).

### 6. Impacts of Waste/Excess Feed on The Environment

In order to increase production with limited land resources, aquaculture systems have been highly intensified and high nutrient formulated feeds is the first requirement of the operations. These practices are causing negative impacts on surrounding ecosystems at different levels and also have

significant effects on the integrity of the ecosystems. Intensive aquaculture systems with a supply of high protein formulated feeds release more organic and inorganic nutrient waste to the surrounding environment (FAO, 2006).

The level of waste loading is influenced by many factors including feedstuff quality, diet formulation, feed production technology, and feeding practices. Feed waste will increase rapidly when the energy fed exceeds the maximum energy intake for the animal. The same principle is applied to nitrogen (N) and P in formulated feeds. Nutrients are also lost when dietary nutrients exceed the requirement for maintenance and growth of fish. These excess nutrients are excreted and become waste for the environment (Bergheim and Asgard, 1996). Phosphorus and nitrogen waste, the products of aquaculture's feeds and feedings, are often the cause of significant eutrophication and pollution of the surrounding aquatic and associated ecosystems (Cho and Bureau, 2001). Therefore, attempts to reduce environmental pollution should focus on improving feed formulation and management (Cho *et al.*, 1994) and the use of alternative feed ingredients has shown significant effects in reducing aquaculture waste.

### 7. Economic Price

CM is one of the promising alternative protein sources for aquafeed, primarily due to its availability and low price. Drew (2007), revealed that the protein cost of CM is only half of that of FM protein. The average world price for canola meal reached a value of \$195 ton<sup>-1</sup> in 2008/09, compared to \$131 ton<sup>-1</sup> in 2004/05 (FAS, 2010).

### 8. Limitation

Deficiencies of EAA often cause decreases in growth performance and feed efficiency ratios (Anderson *et al.*, 1995). Another limiting factor to using plant derived proteins is the presence of ANF (antinutritional factors) or toxicants that may be present as protease inhibitors, lectins, phytic acid, saponins, phytoestrogens, alkaloids, tannins, cyanogens and glucosinolates (Murray *et al.*, 2010). ANFs can adversely affect digestion, absorption and physiological utilization of protein and amino acids and can limit the palatability and the nutritive utilization of protein (Burel *et al.*, 1998; Murray *et al.*, 2010). Locations, seasonal changes, growth conditions, agricultural practices as well as variations between individual plants can affect the nutritional composition of plant materials.

Numerous ANF can be inactivated or reduced by heat treatment (Francis *et al.*, 2001), dehulling, germination and other processing steps (Bau *et al.*, 1997; El adawy, 2002; Kuo *et al.*, 2004).

### 9. Conclusion

Plant protein sources can include lower price, greater availability to fish meal, though they vary in their nutritional and biological values and generally have lower palatability. Commercial aquafeeds have been based on fish meal due to its many advantages, including high protein content, high digestibility, essential amino acid profile, fatty acid profile, minerals, vitamins and palatability. These characteristics make it very challenging to find less expensive alternatives

to fish meal without affecting fish performance and fillet quality. Depending on the location of an aquaculture facility a sustainable strategy would be to use locally available plant sources in combination with animal protein sources such as rendered products, depending on what is available can enhance sustainable aquaculture.

In contrast to canola /Rapeseed meal, canola /Rapeseed protein concentrate and isolates are well utilised by various fish species. Thus, these products seem to be accept the challenge for replacement of fishmeal from a nutritional point of view than meals.

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