Ifremer Info-card

Alternative feeds for fish aquaculture

Aquaculture fact sheet - May 2008

http://en.aquaculture.ifremer.fr/Info.-Card

Replacing fishmeal and fish oil with other sources of protein and fatty acids

With the growing demand from aquaculture and foreseeable levelling off in fishmeal and fish oil production from fisheries, it appeared necessary to reduce the proportion of fishmeal in feeds for aquaculture. Research has therefore developed on other sources of protein to replace fishmeal and fish oil, in particular using plant raw materials, while seeking to conserve the nutritional and organoleptic qualities of aquacultured fish.

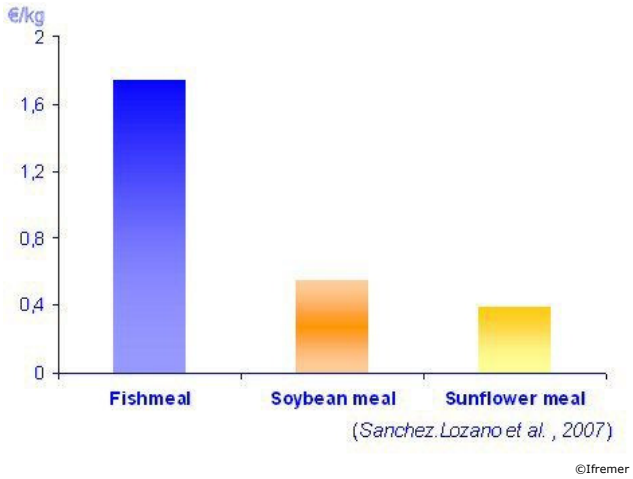
Plant Raw Materials

There are many different plant-based raw materials. They are less well adapted to the requirements of fish as they do not have the same nutritional value nor the same palatability as fishmeal. Also, though they have binding properties that improve the way a pellet sticks together, their integration into compound foods is completely different.

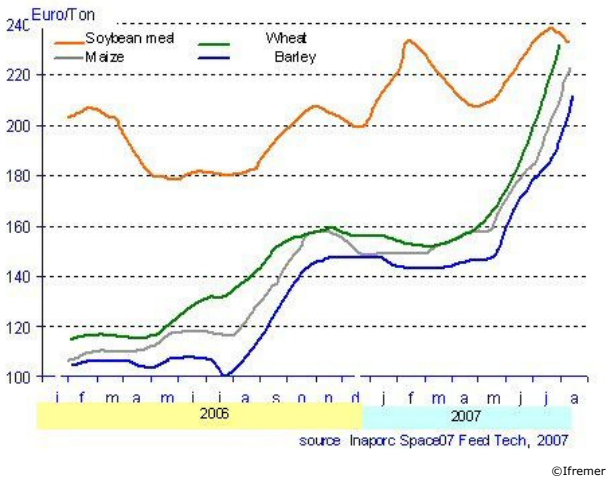
The manufacture of plant meals follows regulations in order to:

- Protect from risks of microbial contamination, chemical and toxicological origin
- Allow traceability of the different constituents and ensure that there is a control over GMO risk in the foods.

The use of vegetable ingredients in aquaculture feeds takes into account environmental consequences of the discharge of non-assimilated matter (phosphoric or nitrogenous). Phosphorous, related to phytate in the plant material, is made available by phytases, which increase its absorption and utilisation by fish though enzymatic hydrolysis, thereby decreasing phosphoric excretion. Research has tended to recommend adding phytases to feed formulations or choosing plant matter that is rich in phytase.



Comparative prices of proteins sources (€ /kg)



Worlwide price increase for soybean meal, wheat, maize and barley (2006-07)

Aquaculture feeds are growing in importance among animal feeds as a whole, but depend on a globalized market for ingredients.

Protein Sources

A large range of plant ingredients has already been examined to find substitutes for fishmeal. Feeds presently on the market contain 30 to 40 % plant products.

In Europe, the plant products concerned are: oilcrops, like canola/rapeseed, sunflower and soybean (meals, cakes or concentrates); pulses, like peas, beans and lupins; or cereal co-products like gluten. The potential of dehydrated forage crops (alfalfa) is also being explored.

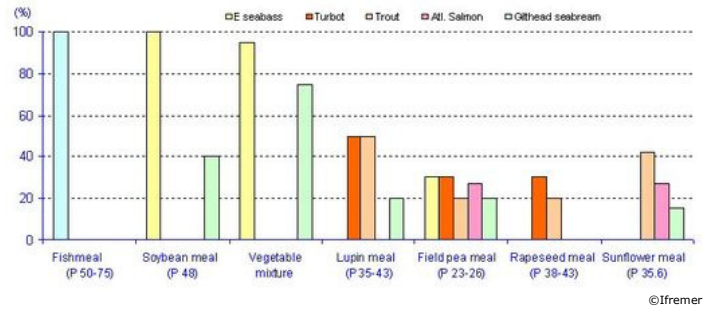
Apart from gluten, the protein content of these plants is lower than that of fishmeal (60-70 %): 60 % for gluten, 45 % for soybean and 26-30 % for pea and lupin. Vegetable proteins are also slightly less digestible, and certain amino acids may only be present in low quantities (lysine, methionine). Plant protein sources are rich in vitamins however.

To increase the digestibility of plant meal and limit the effects of certain poorly digestible constituents or compounds that reduce the food value of the ingredient, these may need to be heat or pressure treated (extrusion) or have the outer layers of the grains removed (dehulled seeds).

These negative properties can, nevertheless, be compensated for by making a mixture of several ingredients in the feed formulation, adapted according to the targeted fish species.

In salmonids, the best results for replacement of fishmeal have been obtained with soya.

For the trout and gilthead seabream, progress has been made by combining proteins from different plant sources. It is possible to replace 75 % of fishmeal with a mixture of cereals, pulses and oilcrops (wheat or maize gluten, extruded pea, lupin and rapeseed) without changing the growth, metabolism or immune system of the fish, or the taste or nutritional qualities of their muscle.



Ingredients to replace fishmeal

In certain species of herbivorous and omnivorous fish (carp, tilapia, catfish, etc.) and crustaceans (Pacific shrimp) unconventional protein sources with low production costs produced close to rearing sites have already given good growth and digestibility results; these products include cotton, sesame, linseed, or pulses such as beans.

The use of algae or bacteria as sources of protein is also being explored but has met with little success as yet.

Algal products are used as binders (alginate, carragheen or agar) appetising agents, sources of essential minerals - notably for shrimp - for their potential immuno stimulatory properties and as a source of pigments (Spirulina). Algal meals and their extracts are relatively new on the market of feed ingredients and need more research to establish their true potential.

The co-products of bioethanol production are also rich in proteins

In Europe, bio ethanol is produced from cereals (wheat, maize) or beet. The co-products can be concentrated to obtain distiller's spent grain, which is rich in protein and can therefore help to reduce the importation of soybean meal on which French terrestrial animal rearing industries are dependant.

New natural sources

New natural sources of ingredients, marine or terrestrial, to replace fishmeal are being explored in Scandinavia:

- Antarctic krill (Euphausia superba) is an excellent natural ingredient (56 to 76 % proteins, according to whether it is whole or has had the exoskeleton removed). Incorporating krill up to a level of 30 % improves feed intake and growth in salmon, trout, cod and halibut.

  Krill have great potential, as their biomass was estimated at 44 million tonnes in 2003/2004 (CCAMLR 2005), and less than 120 000 tonnes are presently exploited (Albrektsen, 2007).

- Another natural source of protein comes from insects. This is a high quality protein known as "ento-protein" that could become an important commodity for certified 'organic' rearing businesses.

Sources of fatty acids

Besides protein, fish require vitamins, minerals and essential fatty acids for growth and development. Long-chain polyunsaturated fatty acids are necessary, particularly those of the n-3 series known as omega 3, which form part of cellular membranes. Fish have a very poor ability to synthesise these fatty acids from other lipid precursors such as linolenic acid, which is plentiful in vegetable oils.

The feed must therefore contain essential fatty acids, at 1 % of the total dietary ration. This requirement could be covered either by adding fish oil to the diet at the end of the rearing cycle, or by adding a sufficient quantity of fish meal to the overall diet, in which case the fish oil could perhaps be totally replaced by a mixture of vegetable oils.

Table: Replacement of fish oil with different kinds of successfully tested vegetable oil

Reared species	Control fish oil	Maximum possible substitution rate for fish oil	Vegetable oil sources (proportion of each ingredient)
Salmon	Caplin	100%	Rapeseed or rapeseed-olive (50/50) (*Bell, et al., 2003 ; Torstensen, et al., 2004)*
Trout	Caplin	100%	Mixture rapeseed, palm, linseed (55 / 30 / 15) *(Richard, et al., 2006)*
Cat fish	Menhaden	100%	Palm *(Ng , et al., 2004)*
Turbot	Caplin	100%	Soya or linseed *(Regost, et al., 2003)*

European Seabass	Anchovy	60%	Soya or linseed or olive *(Mourente, et al, 2003)* ; mixture of oilseed, palm, linseed *(Montero, et al., 2005 ; Richard, et al., 2006)*
Gilthead Seabream	Anchovy	60%	Soya or linseed or oilseed or a mixture of the three ones *(Cabellero, et al., 2004 ;)*

For a number of reared species, it has recently become possible to completely replace fish oil with a mixture of vegetable oils, formulated to obtain a proportion of fatty acids similar to that of fish oil. This can be done without altering growth rate and minimising variation in flesh fatty acid composition (the level of cholesterol is also reduced with diets based on vegetable oils).

In addition, it is important to maintain fish muscle rich in long-chain polyunsaturated fatty acids for the benefit of human consumers, as these lipid compounds contribute to the prevention of cardiovascular diseases.

Conclusion

The diets of fish and crustaceans must take into account the requirements of each species to obtain a healthy, high quality, tasty and nutritional product reared in optimal conditions for livestock well-being.

It must also take into account the availability of the raw materials and their permanence when using substitute ingredients so as to ensure the sustainability of fishery and aquacultural activities.

Last modified : Friday 09 December 2011

Know more

- *The research on foods to replace fishmeal was conducted by the INRA-Ifremer mixed research unit (UMR 1067) INRA-Ifremer, as part of a thematic European research network. PEPPA (Perspectives of Plant Protein Use in Aquaculture); RAFOA (Researching Alternatives to Fish Oils in Aquaculture), Thematic network FORM (Fish Oil and Meal Replacement) and since 2006 AQUAMAX (Sustainable Aquafeeds to Maximise the Health Benefits of Farmed Fish for Consumers).*
  http://www.ifremer.fr/drvraarn/fr/presentation_nutrition.htm
- FAO, FAO Fisheries Department, 2006. State of world aquaculture 2006. FAO Fisheries Technical Paper No. 500. Rome, FAO, 134p.
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- Kaushik S. J., Covès D., Dutto G. and D. Blanc (2004). Almost total replacement of fish meal by plant protein sources in the diet of a marine teleost, the European seabass, *Dicentrarchus labrax*. Aquaculture 230 391-404. Available online doi:10.1016/S0044-8486(03)00422-8