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Demand and supply of feed ingredients for farmed fish and crustaceans

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Abstract

The rise into global prominence and rapid growth of finfish and crustacean aquaculture has been due, in part, to the availability and on-farm provision of feed inputs within the major producing countries. More than 46 percent of the total global aquaculture production in 2008 was dependent upon the supply of external feed inputs. For the aquaculture sector to maintain its current average growth rate of 8 to 10 percent per year to 2025, the supply of nutrient and feed inputs will have to grow at a similar rate. This had been readily attainable when the industry was young. It may not be the case anymore as the sector has grown into a major consumer of and competitor for feed resources. This paper reviews the dietary feeding practices employed for the production of the major cultured fed species, the total global production and market availability of the major feed ingredient sources used and the major constraints to feed ingredient usage, and recommends approaches to feed ingredient selection and usage for the major species of cultivated fish and crustacean. Emphasis is placed on the need for major producing countries to maximize the use of locally available feed-grade ingredient sources, and, in particular, to select and use those nutritionally sound and safe feed ingredient sources whose production and growth can keep pace with the 8 to 10 percent annual average annual growth of the fed finfish and crustacean aquaculture sector.

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Abbreviations and acronyms

ABP	animal by-products
BM	blood meal
CGM	corn gluten meal
CP	crude protein
CPC	canola protein concentrate
CSM	cottonseed meal
DE	digestible energy
DHA	docosahexaenoic acid
DP	digestible protein
EFCR	economic feed conversion ratio
EPA	eicosapentaenoic acid
EU	European Union
FAQ	fair average quality
FBM	faba bean meal
FM	fishmeal
FO	fish oil
FOB	free on board
FPM	field pea meal
G/PM	groundnut/peanut meal
HFM	hydrolysed feather meal
IFFO	International Fishmeal and Fish Oil Organisation
KM	krill meal
LKM	lupin kernel meal
MA	maize/corn
MBM	meat and bone meal
MC	mustard seed cake
MM	meat meal
Mtoe	million tonnes of oil equivalent
nei	not elsewhere included
PBM	poultry by-product meal
PO	poultry oil
RB	rice bran
R/CM	rapeseed/canola meal
R/CO	rapeseed/canola oil
SBM	soybean meal
SCP	single cell protein
SL	soy lecithin
SM	squid meal
SO	soybean oil
SSM	sunflower seed meal
US$	US dollar
USDA	United States Department of Agriculture
WB	wheat bran
WF	wheat flour
WGM	wheat gluten meal
WH	wheat
WM	wheat middlings

Executive summary

The rapid rise and growth of finfish and crustacean aquaculture has been due, in part, to the availability and on-farm provision of feed inputs within the major producing countries. If the aquaculture sector is to maintain its current average growth rate of 8 to 10 percent per year to 2025, the supply of nutrient and feed inputs will need to grow at a comparable rate. While this may have been readily attainable when the industry was still in its infancy, this may not be the case in the future as the sector matures and grows into a major consumer and competitor for feed resources.

It is estimated that about 31.5 million tonnes of farmed fish and crustaceans (46.1 percent of the total global aquaculture production in 2008) is dependent upon the supply of external nutrient inputs provided in the form of fresh feed items, farm-made feeds or commercially manufactured feeds. Total industrial compound aquafeed production increased more than threefold, from 7.6 million tonnes in 1995 to 29.2 million tonnes in 2008, with production growing at an average rate of 11.0 percent per year. Aquafeed production is expected to continue growing at a similar rate to 71.0 million tonnes by 2020. Although current estimates for industrially produced aquafeed for the period 2007–2010 vary between 24.4 and 28.9 million tonnes, aquafeed volume represents only 4 percent of the total global animal feed production of the over 708 million tonnes in 2009. In contrast to compound aquaculture feeds, there is no comprehensive information on the global production of farm-made aquafeeds (estimated at between 18.7 and 30.7 million tonnes in 2006) and/or on the use of low-value fish/trash fish as feed, with 2008 estimates for China at 6 to 8 million tonnes.

Fed aquaculture production, in particular, of higher trophic level finfish and crustaceans (includes marine shrimps, salmonids, marine finfishes, eels) are largely dependent upon capture fisheries for the supply of their major dietary source of protein and lipids. For example, on a global basis, it is estimated that the aquaculture sector consumed 3.72 million tonnes of fishmeal (60.8 percent of global fishmeal production) and 0.78 million tonnes of fish oil (73.8 percent of global fish oil production) in 2008; it was 3.84 million tonnes of fishmeal (or 68.4 percent of global production) and 0.82 million tonnes of fish oil (or 81.3 percent of global production) in 2007. Despite this continued dependence of aquaculture production on fishmeal and fish oil, there remains a wide variation in fishmeal and fish oil usage between major producing countries for individual farmed species. This variation mainly reflects differences between countries concerning the selection and use of fishmeal and fish oil replacers from plant sources or by the use of land animal proteins and fats in feeds for high trophic-level fish and crustacean species.

The total use of fishmeal by the aquaculture sector is expected to decrease in the long term. It has gone down from 4.23 million tonnes in 2005 to 3.72 million tonnes in 2008 (or 12.8 percent of total aquafeeds by weight), and is expected to decrease to 3.49 million tonnes by 2020 (or 4.9 percent of total aquafeeds). The reasons for this are the diminishing amount of fishmeal and fish oil supplies owing to tighter quota setting and additional controls on unregulated fishing and the increased use of more cost-effective dietary fishmeal replacers. On the contrary, the use of fish oil by the aquaculture sector will probably increase in the long run albeit slowly; total usage will increase by more than 16 percent, from 782 000 tonnes (2.7 percent of total feeds by weight) in 2008 to the estimated 908 000 tonnes (1.3 percent of total aquafeeds for that year) by 2020. Increased usage will shift from salmonids to marine finfishes and crustaceans because of the current absence of cost-effective alternative lipid sources that are rich in long-chain polyunsaturated fatty acids. Increasing volumes of fishmeal and fish oil are likely to come from fisheries by-products, extracted from both wild capture and farmed fish. Estimates have been made that around 25 percent of fishmeal production in 2007 came from by-products. This will grow as it becomes increasingly viable to process this material.

It is estimated that the total usage of terrestrial animal by-product meals and oils within compound aquafeeds ranges between 0.15 and 0.30 million tonnes, or less than 1 percent of total global compound aquafeed production – clearly, there is considerable room for increased usage. In addition to meat meal, or, to a lesser extent meat and bone meal, ingredients such as blood meal, poultry by-product meal and poultry oil have all been very effective in feeds for a number of aquatic species.

Soybean meal is the most common source of plant proteins used in compound aquafeeds, with feeds for herbivorous and omnivorous fish species and crustaceans usually containing from 15 to 30 percent soybean meal, with a mean of 25 percent in 2008. In global usage terms, and based on a total compound aquafeed production of 27.1 million tonnes in 2007, it is estimated that the aquaculture feed sector consumed about 6.8 million tonnes of soybean meal (25.1 percent of total compound aquafeeds by weight). Other plant proteins being increasingly used include corn products, pulses, oilseed meals and protein from other cereals products.

Alternative lipid sources to fish oil are being used in greater amounts. Key alternatives include vegetable oils, preferably those with high omega-3 contents, and poultry oil. The use of oil from farmed fish offal is also a potential omega-3 source for other farmed fish. The production of marine microalgae or bacteria with very high contents of highly unsaturated fatty acids is currently expensive for use in most aquaculture feeds, but more cost efficient production methods will change this.

Prices for food and feed ingredients have been rising and are likely to continue to rise owing to the increasing demands from an increasing population, the diversion of some grains for use in biofuels, the increasing costs of production and transport, and the changes in global trade owing to the demand of food and raw materials from China and other emerging economies. The focus on carbohydrate-rich fractions for production of biofuels may indeed provide an opportunity to use protein fractions for feed ingredients.

Although current discussion on the use of marine products as aquafeed ingredients focuses on fishmeal and fish oil resources, the sustainability of the aquaculture sector is more likely to be linked with the sustained supply of terrestrial animal and plant proteins, oils and carbohydrate sources for aquafeeds. This is because a significant proportion of aquaculture production is of the non-carnivorous species. Therefore, aquaculture producing countries should place more emphasis to maximize the use of locally available feed-grade ingredient sources and use nutritionally sound and safe feed ingredients that can be sustainably produced and grow with the sector.

Cage culture of Atlantic salmon (Salmo salar) *in a fjord, Norway.*

Courtesy of FAO Fisheries and Aquaculture Department photo library

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1. Introduction

The dramatic rise and emergence of acquaculture onto the global marketplace as a major provider of much-needed farmed aquatic food produce were spurred by a combination of factors. Chief among them include:

- the in-country promotion of aquaculture as a viable economic activity and source of livelihood;
- the in-country provision of an enabling legislative framework for conducting the activity;
- the in-country availability of suitable land and water resources and technical know-how for conducting aquaculture farming operations; and
- the in-country availability and on-farm provision of nutrient inputs in terms of fertilizers and/or feed.

For finfish and crustacean aquaculture to maintain its current average annual growth rate of 8 to 10 percent per year to 2025, the external provision of nutrient and feed inputs will have to grow at a similar rate. This had been easily attainable when the industry was young. It will be more difficult as the sector grows into a major consumer and competitor for feed resources.

The aim of this paper is to:

- review the dietary feeding practices employed for the production of the major cultivated fish and crustacean species, including major feed ingredients used;
- review the total production and market availability of the major feed ingredient sources, including current usage by sector;
- review the major constraints to feed ingredient availability and use by the aquaculture sector on a regional and global basis; and
- recommend approaches to feed ingredient selection and usage within dietary feeding regimes for the major cultivated fish and crustacean species.

For the purposes of this paper, only dietary feeds and feeding regimes based on the external provision of fresh feed (usually fed singly, and including low-value/trash fish and cut green fodder), farm-made feed, and commercial feed composed of mixtures of different feed ingredient sources will be considered.

Hand feeding (broadcasting) of Indian major carps in a pond, Myanmar. Hand feeding in ponds for carp culture has been adopted recently in Myanmar and is not very common; each pond generally varies from 1 to 4 hectares.

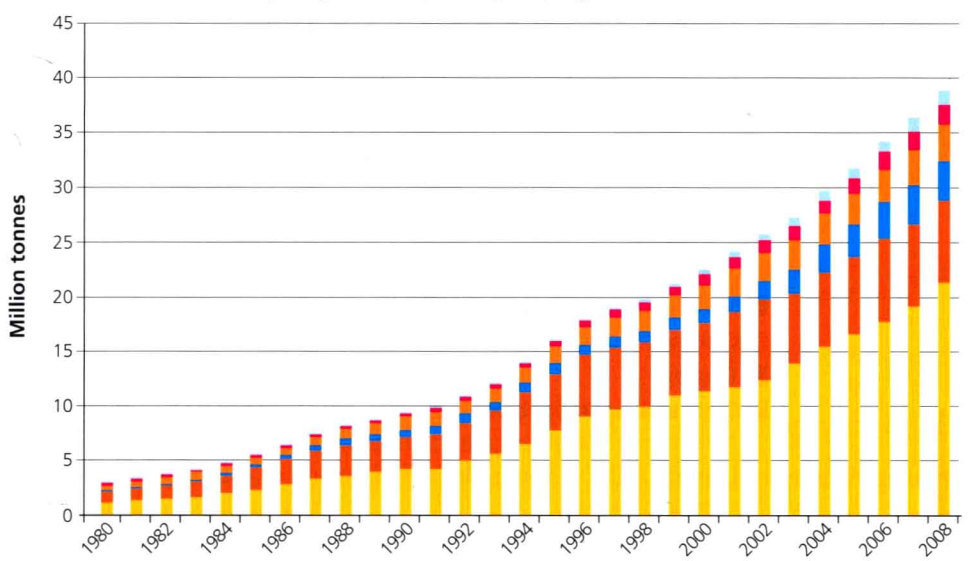
Courtesy of M.C. Nandeesha

2. Current feeds and feeding practices

2.1 MAJOR FED FISH AND CRUSTACEAN SPECIES

In 2008, about 31.5 million tonnes of farmed fish and crustaceans, or the equivalent of 46.1 percent of the total global production of farmed aquatic animals and plants, was dependent upon the supply of nutrient inputs in the form of externally provided fresh feed items, farm-made feeds or commercial pelleted feeds. The above estimate excludes filter-feeding fish species (silver carp and bighead carp: total production 6.10 million tonnes in 2008) and freshwater fish production not reported down to the species level (1.2 million tonnes in 2008; FAO, 2010a). Moreover, of the more than 200 species of fish and crustaceans currently believed to be fed on externally supplied feeds (Annex 1), nine species account for 62.2 percent of total global-fed species production, including grass carp (*Ctenopharyngodon idellus*), common carp (*Cyprinus carpio*), Nile tilapia (*Oreochromis niloticus*), catla (*Catla catla*), whiteleg shrimp (*Litopenaeus vannamei*),

FIGURE 1
Total global production of fed fish and crustacean species by major FAO species grouping, 1980–2008



GROWTH	APR (%/year)					Change (%)		
	80-85	85-90	90-95	95-00	00-05	05-06	06-07	07-08
Freshwater fishes: fed species	+14.9	+12.3	+13.5	+8.0	+7.9	+6.5	+8.5	+11.3
Freshwater fishes: non-fed species	+16.6	+8.2	+11.4	+3.7	+2.6	+7.5	-2.5	-1.0
Marine crustaceans: fed species	+24.4	+25.8	+7.3	+5.3	+17.8	+16.0	+5.9	+3.6
Diadromous fishes: fed species	+6.5	+12.4	+4.7	+8.2	+4.9	+4.7	+8.0	+2.2
Marine fishes: fed species	+4.0	+6.6	+11.5	+12.2	+8.1	+13.9	+5.8	+4.5
Freshwater crustaceans: fed species	+23.7	+12.2	+8.1	+32.7	+16.3	+4.5	+33.2	+7.7

Source: FAO (2010a).

crucian carp (*Carassius carassius*), Atlantic salmon (*Salmo solar*), pangasiid catfishes (striped/tra catfish [*Pangasianodon hypophthalmus*] and basa catfish [*Pangasius bocourti*]), and rohu (*Labeo rohita*; Table 1; FAO, 2010a). In this respect, aquaculture is no different from animal husbandry, in that global livestock production is concentrated in a few species; in agriculture, the top eight livestock species are pig, chicken, cattle, sheep, turkey, goat, duck and buffalo (FAO, 2010b).

Figure 1 shows the total global production of fed fish and crustaceans by major species grouping, together with their respective growth at five yearly intervals, from 1980 to 2008. In marked contrast to capture fisheries, freshwater fish species dominate finfish aquaculture production (Tacon, Metian and Hasan, 2009), with over 80.8 percent of fed finfish production being freshwater species in 2008 (FAO, 2010a; Annex 1).

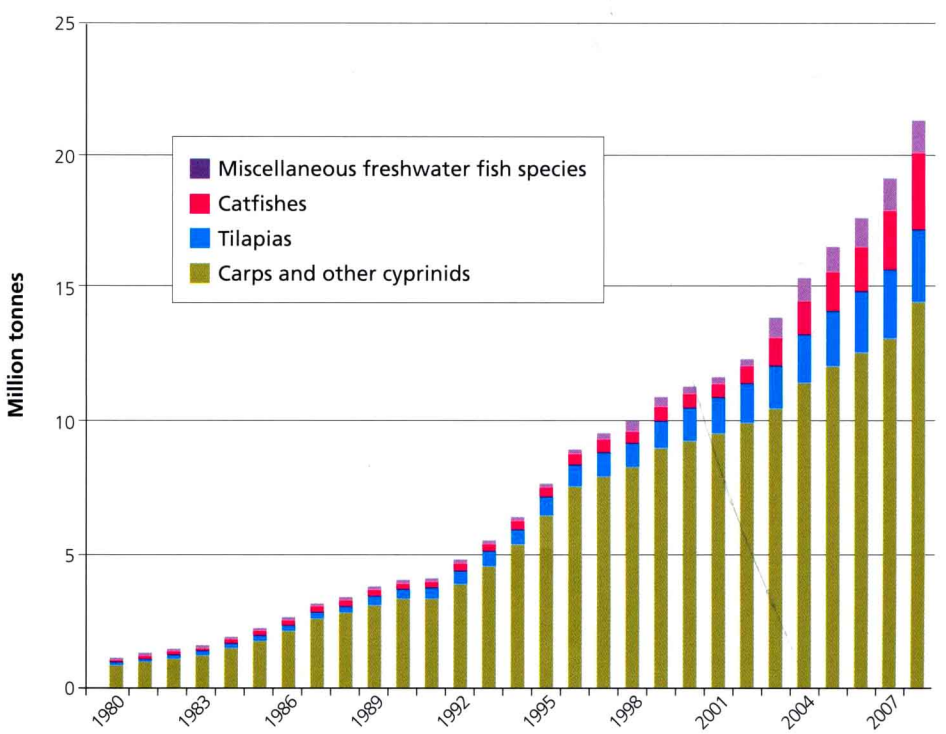
Of particular note is the double-digit growth rates of all major groupings during the 1980s and 1990s, with the overall growth of fed fish and crustacean aquaculture production stabilizing at an average of 10.5 percent per year by 2008. In contrast, livestock meat production and capture fisheries production have grown at an average rate of 2.5 percent and 1.3 percent per year, respectively, since 1980 (FAO, 2010b).

The major fed fish and crustacean species groups can be ranked in order of total global production by weight in 2008, as shown below.

Fed freshwater fishes: 21.34 million tonnes, valued at US$27.36 billion (Figure 2; Annex 1):

- carps and other cyprinids – 14.43 million tonnes, nine major species;
- tilapias – 2.80 million tonnes, two major species;
- catfishes – 2.78 million tonnes, six major species; and
- miscellaneous freshwater fishes – 1.33 million tonnes, six major species.

FIGURE 2
Growth of fed freshwater fish species, 1980–2008



Source: FAO (2010a).