

# Nutrition and Feeding: Knowledge acquisition and transfer of know-how in feed production and management strategies

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**ABSTRACT:** All animal production depends on a controlled management of feeding practices which should provide for the essential nutrients and energy in the most acceptable form and manner. Aquaculture has a major role in ensuring nutritional security of humans. Irrespective of the culture system, economic as well as biological viability are dependant on the provision of the most adequate feed supply. Although a large variety of species are involved in aquaculture, our knowledge on the nutrition and feeding is limited to a few major groups. But, it is generally accepted that, in the absence of definitive information with regard to a particular species, much can be learnt from other closely related biological models. From a practical point of view, it is necessary to evaluate how far the variety of practices already in use have proved themselves to be efficient in serving aquaculture in a sustainable manner. The aim of this session will be a) to stress the importance of sound nutrition and feeding on most issues facing the aquaculture such as productivity, environmental and product quality and food safety; b) to illustrate the functional role of nutrition in ensuring complete domestication including reproductive success and larval development and c) to discuss on how far existing know-how can be extended to other species and situations.

## 1. INTRODUCTION

Fish are in general low in calories but high in protein of very good biological value with an ideal amino acid balance, rich in  $\omega$ 3 polyunsaturated fatty acids and in several micronutrients. It has even been postulated that the evolution of the modern human brain depended very much on the dietary supply of docosahexanoic acid (DHA, a major polyunsaturated  $\omega$ 3 fatty acid) provided by marine sources (Broadhurst *et al.* 1998; Crawford *et al.* 1999). It is well recognised that fish and shellfish contribute significantly towards human nutrition and health. Besides being an excellent protein source, fish is also the unique supplier of long-chain  $\omega$ 3 polyunsaturated fatty acids involved in brain development and vision as well as in protection against cardiovascular diseases and some cancers (Nettleton, 1991; Sargent, 1997). It is also known that over the years, the fatty acid status of the human populations have undergone significant changes with a significant decline in  $\omega$ 3 fatty acid intake with a concurrent rise in  $\omega$ 6 and trans fatty acid intakes (Simopoulos, 2001), leading to a number of nutrition-related disorders.

It is evident that from a human nutrition perspective, a strong emphasis on fish intake is required, fish being the unique source of the long-chain  $\omega$ 3 polyunsaturated fatty acids. However, it should also be borne in mind that the flesh composition of fish is very much related to the dietary fatty acid profile. In this context, aquaculture has a major role, in as much as tailoring fish flesh composition is possible (Kaushik, 1997) paving the way for the supply of the essential nutrients to those in need in an efficient manner.

### Fatty Acid Status across Populations

| Population             | w6/w3 ratio |
|------------------------|-------------|
| Paleolithic            | 0.79        |
| Greece before 1960     | 1.00-2.00   |
| Current United States  | 16.74       |
| Current UK & N. Europe | 15.00       |
| Current Japan          | 4.00        |

From Simopoulos, 2001

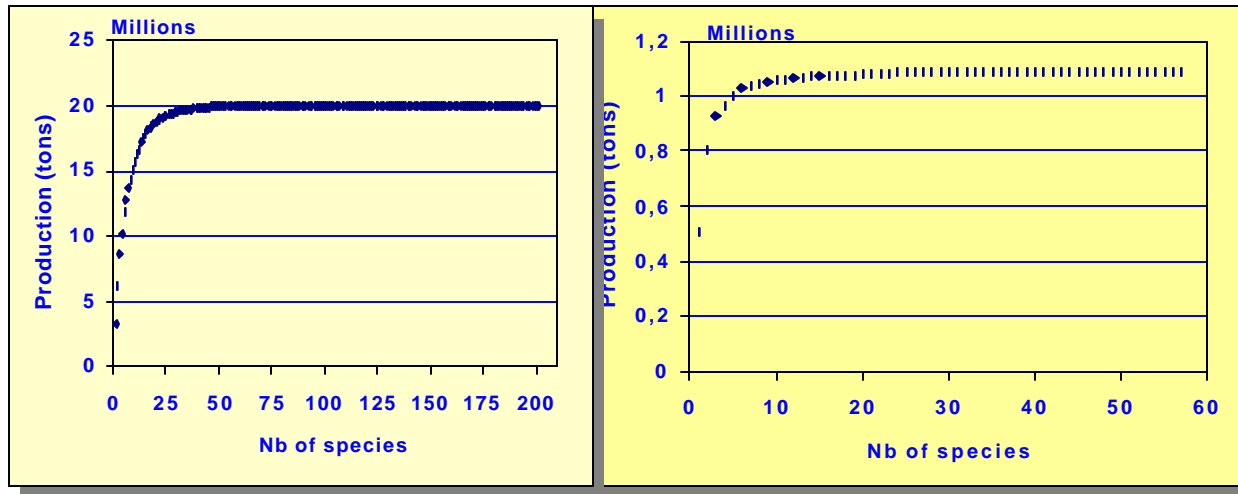
## 2. INCREASING ROLE OF AQUAFEEDS IN AQUACULTURE DEVELOPMENT

Indeed, aquaculture's contribution toward total world fisheries landings has more than doubled, increasing from 11.4% of total landings in 1984 to 26.3% of total landings by weight in 1996. Although as a continent, Asia is the primary producer as well as the consumer of fish and shellfish, differences do exist between countries and areas within countries. Aquaculture development currently witnessed in Asia is getting more and more towards intensification with the concurrent advantages and drawbacks.

Issues facing aquaculture are (i) to increase productivity, environmental and product quality and food safety, (ii) ensure complete domestication, reproductive success, larval development and (iii) strengthen our knowledge on the functional role of nutrition. Given the variety of species under culture, it is also of importance to know how existing knowledge and know-how from a limited number of species can be extended to other species and situations. Resource allocation management is another issue that we have to consider in the global context of provision of food for the human kind in the most efficient manner. In this context, it is worth considering the following facts. Compared to terrestrial animal production systems, aquaculture is (i) more efficient in terms of energy utilisation, (ii) more flexible in terms of production systems, but (iii) more demanding in protein and (iv) more sensitive to anthropogenic impacts affecting the aquatic environment

With an increasing demand for higher value species rather than for fish species that have traditionally been grown under semi-intensive pond based, polyculture systems and fed on natural food, formulated complete aquafeeds are being used more and more even in Asia (nearly 30 million metric tons). This increasing need for formulated feeds also leads to an increasing demand for good quality fish meal and fish oil, the production and availability of which has remained more or less stable over the last decade.

Since feed costs remain the major portion of the production cost, attempts towards reduction of such feed costs should not overlook the importance of the supply of essential nutrients and energy to the different species concerned. On a global scale, although the total number of species cultivated is high, quantitatively, less than thirty species represent more than 95% of production. Since precise quantitative data are not available even for these thirty odd species involved, the extension of data from one species to another has been a common practice. We need strengthened efforts to remedy this situation. In developing feeds, efforts should be made to develop formulae which depend on locally available ingredients rather than on relying on few major ingredients derived from marine fisheries.



Globally or on a regional basis, a very small number of finfish species represent more than 95% of production

### 3. NUTRITION AND FEEDING FOR SUSTAINABLE AQUACULTURE DEVELOPMENT

#### 3.1. Research for alternatives to fishmeal and fish oil in fish feed

Research for alternatives to fishmeal and fish oil in fish feed has been a major thrust area for more than thirty years and considerable advances have been made. Under practical conditions, our objective is to make the aquaculture sector a net contributor to the world fish supply rather than being a net consumer of food-grade fishery resources (Naylor *et al.*, 2000). While it has long been known that replacement of fish meal with plant protein sources is definitely possible (Kaushik, 1990; Kaushik *et al.* 1995), recent work towards the replacement of fish oil by terrestrial plant oils studies has also led to very convincing results (Regost *et al.* 2002). The true concern lies in the efficiency with which aquafeeds can incorporate a greater proportion of alternative ingredients supplying the essential nutrients while still maintaining the quality of fish products for human consumption.

#### 3.2. Fish Nutrition and Environmental Quality

Besides resource allocation management, aquaculture, like any other animal production system, has to bear in mind the environmental consequences of the food production activity. In feed-based aquaculture, from a nutritional point of view, the major objective is to reduce the release of nutrients at the source, by improved feed formulations and through appropriate feed management strategies. It is of interest to note that finfish nutrition research has taken up the challenge and responded much faster than other terrestrial animal production systems as witnessed by several major symposia held on the "Nutritional Strategies for Management of Aquaculture Wastes (NSMAW)" (Cowey and Cho, 1991, *J. Appl. Ichthyol.*, 1995, vol.11, (3-4); *Aquat. Living Resources*, 1998, vol. 11 (4)). It is clear that in this particular field, lessons learnt from some species can be extended to others, as evidenced by applicability of basic models developed for salmonids (Cho and Bureau, 1998) to other species (Kaushik, 1998).

#### 3.3. Fish Nutrition and Flesh Quality

As mentioned above, a major concern is that of the provision of nutritious and safe food from aquaculture. There is an ever-increasing amount of information available on the possibilities of tailoring flesh quality at least as regards fat-soluble components such as fatty acids, fat soluble vitamins and pigments mostly in species under intensive culture conditions. There is a definite lack of such information for those species cultivated

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under semi-intensive conditions with nutrients being supplied both from natural productivity of the water body and from external feeds.

While in some cases, there is precise definition of quality and efforts are made towards "labelled products", criteria for the definition of "quality" tend to vary depending upon socio-geographic considerations. But, while the major objective here is to continue to ensure the nutritional value of aquaculture products, one might also question as to whether all aquaculture systems are capable of meeting such demands.

### **3.4. Role of nutrition in the Domestication of Cultivated Species**

In the context of full domestication, nutrition has a major role not only in ensuring broodstock and quality of gametes, on which rely further development and growth over the full cycle. Proper understanding of the interaction between nutritional factors and endocrine regulation of growth and reproduction is an area which requires more attention. There is ample evidence today to show that dietary factors can modify broodstock quality and performance: while there are positive beneficial effects of essential fatty acids or vitamins on broodstock performance (Luquet and Watanabe, 1986), there are also situations where other feed derived phytoestrogens for instance can affect reproductive function (Bennetau *et al.* 2000). Thus there is a need for increased awareness of all possible effects of nutritional factors on reproductive function.

Too much dependence on live prey for larval culture should be reconsidered. Development of adequate larval diets can only permit us to determine the nutritional requirements of larval stages. Despite considerable success in this area with regard to cyprinids (Charlon and Bergot, 1984), and given the importance of cyprinid production in world aquaculture, it is surprising that they are still not under practice on a large scale. Recent work undertaken by Cahu *et al.* (1998) and subsequent development of complete feed for first-feeding European seabass larvae without any live prey supply is a considerable achievement which can remove a major bottleneck in the area of marine finfish rearing.

### **3.5. Feed technology and Management of Feeding Practices**

Aquafeed development involves specific technologies in order to meet all the physical quality standards required for growing fish from less than a few mg to those weighing more than 5 kgs. Diet processing technologies have to be adapted to produce diets with particle sizes ranging from 100  $\mu$  to more than 9 mm in diameter, while maintaining all the nutritional characteristics in tact. Several other aspects such as water stability, palatability, texture, friability, fines, density, floatability, gelatinisation, fat coating also require specific technological adjustments (Kaushik, 2001). On a nutritional scale, development of high nutrient dense diets have indeed allowed the salmon culture to develop a very efficient production system. Currently, attempts are also being made towards development of improving fecal decantation characteristics in order to facilitate the removal of suspended matter from aquaculture operations.

Feed management is an area where concerted efforts are needed not only to improve economic efficiency, but also to avoid damage to the aquatic environment. Efforts over the past decade have led to the proper consideration of endogenous rhythms of the fish and towards development of feeding systems that enable very little feed wastage. Application of bioenergetic principles can indeed be useful in drawing adequate feeding charts provided proper information on the biomass under culture is available. Under pond culture conditions, simple self feeders such as those used in some carp culture conditions is an important advance in reducing feed wastage and thus improving the economics. The major motto here is to feed the fish but not the pond.

#### 4. TRANSFER OF KNOW-HOW AND TECHNOLOGY

Besides knowledge acquisition in the field of fish nutrition by researchers, adequate feed development needs close interaction between the industry and farmers. Under the umbrella of the International Symposia on Fish & Shellfish Nutrition (IUNS), the committee on fish and shellfish nutrition and production has held a number of symposia almost every other year in different parts of the world. The charter of the committee is "Nutrition and Production of finfish and shellfish for better human health" in a better environment".

With regard to EU and Asia, there have also been cooperative research and training initiatives under the AADCP. Clear statements have been made at the Bangkok summit with regard to the importance of nutrition research and feeding for sustainable aquaculture development. Basic research should continue to exert its strength in terms of prospective research on scientific excellence rather than in response to demands. Cooperative research with the different stakeholders involved can comply with the demands of societal relevance.

To illustrate the efforts with regard to the questions on alternatives to fish meal and fish oil in fish feed, it is worth indicating here that under the V framework programme of the EU, several research projects are under way covering all aspects of biological significance as well as social issues involved.

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