Proceedings of the Summer Institute in Recent Advances in Finfish and Shellfish Nutrition

11 TO 30 MAY 1987

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE
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Technical Paper - 3

SUMMER INSTITUTE IN

RECENT ADVANCES IN FINFISH AND SHELLFISH NUTRITION

11-30 May, 1987

NUTRITION IN AQUACULTURE - AN OVERVIEW

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Aquaculture is gaining more and more importance as a means to augment finfish and shellfish production in both the developed and developing countries of the World, to partially meet the growing demand for fish and shellfish protein. It has been predicted by TAC (1973) that by the year 2000, aquaculture could produce at least 50 million tons of animal protein, if certain research and development measures are undertaken, as against the production of 6 million tons of fish and shellfish through culture in 1975 (Pillay, 1976).

In India, traditionally an extensive type of aquaculture was practiced by the farmers in the states of Kerala, West Bengal, Orissa and some of the North-Eastern States. Production realised from this system of aquaculture was extremely low, being less than 1 ton/ha/yr. These traditional practices being largely governed by local conditions and needs, the farmers seldom felt the need to intensify operations. Low-density culture with minimum inputs and low production per unit area has often been more economical than intensive farming, involving the rearing of dense populations and heavy inputs (Pillay, 1976).

Recent researches have amply proved that by adopting scientific culture procedures and efficient management practices substantial increase in production could be obtained especially from finfish and prawn culture systems. Production rate as high as 10 tons/ha has been achieved in static earthen freshwater carp culture ponds in India through optimum stocking, fertilization and supplementary feeding.

Feed is often considered as the major operational input in semi-intensive and intensive finfish and prawn culture systems. Feed costs often exceed 50% of the operational costs in intensive culture operations. In view of this practical feeds both supplemental and complete should be carefully formulated, and judiciously supplied considering the specific nutritional needs of cultivated species and the intensity of culture operation. In Semi-intensive systems, the supply of supplementary feeds can be regulated judiciously keeping in view the quality and quantity of the natural food produced in the pond. Natural food production can be increased through systematic and judicious administration of organic and inorganic fertilizers. Thus in this system, the exogenous food supply need to provide only nutrients which may be deficient in the natural food, so that the feeds are effectively utilized.

Among the three major groups of cultivable aquatic organisms, the bivalve molluscs are mainly cultured in open water bodies. Thus the production of most species of molluscs mainly depend upon the availability of plenty of preferred natural food in the system. In contrast to bivalve molluscs, finfish and crustaceans are cultured in ponds, raceways, cages, pens and recirculated systems. In these systems, in order to achieve optimum production, provision of compounded feeds, either supplementary or complete, forms are essential requisite.

Besides the need for feeds for grow-out systems, feeds are also required for hatcheries and nurseries to produce healthy stocking material. The larvae of most of the finfish, crustaceans and bivalve molluscs require microparticulate diets during the early larval phase. In most cases live-food particularly phytoplankton are being fed. While the bivalve molluscs continue to have preference for microparticulate diets, the advanced larvae of crustaceans and the fry of finfish efficiently ingest zooplankton and formulated feeds. In Table 1 the important basic food types ingested by the larvae are presented. Live-food production necessitates additional infrastructure, manpower and operational inputs, thereby the cost of production of stocking material is greatly enhanced.

Table 1: Potential sources of diets for larvae

Viable	Non-viable
a) bacteria	a) detritus
b) motile gametes, spores	b) organic aggregates
c) yeast	c) artificial formulations - microparticulate diets - microencapsulated diets
d) phytoplankton - - diatoms - unicellular algae	d) tissue suspensions
e) zooplankton	

Recent developments in feed technology reveal that microencapsulated diets can be fed to larvae in hatcheries.

Encapsulation is a process by which liquid or particulate materials are enclosed within a specially designed artificial membrane or wall made of natural polymers, as gelatin, gums, waxes or the synthetic polymers of ethyl cellulose or polyvinyl alcohol. The type of capsule required depends on the mode of feeding; for instance, molluscs ingests the food whole and must be provided with a capsule whose walls are stable to sea water but readily soluble in the digestive tract of the animal by the action of digestive juices. Thus for the larvae, development of nutritionally adequate microparticulate or microencapsulated diets with appropriate size, texture, taste etc. is most important.

Formulated feeds should contain adequate levels of nutrients to meet the physiological needs of the organisms, such as to supply energy, to build and maintain the cells and tissues, and regulate body processes. According to Halver (1976) any balanced formula for fish diets must include an energy source plus sufficient indispensable amino acids, essential fatty acids, specific vitamins and minerals to sustain life and promote growth. Studies with crustaceans show that in addition to the nutrients listed above, a dietary source of sterol and phospholipids are essential for normal growth and metamorphosis (Kanazawa, 1984). All the essential nutrients (Table 2) should be incorporated in adequate levels and in optimum proportions in compounded diets. Any imbalance of these nutrients would affect the efficacy of conversion of food by the animals. Quantitative requirements of specific nutrients vary with species, size, physiological condition, temperature, stress, nutrient balance of the diet and environmental factors, thus economical rations must be programmed accordingly.

After determining the nutritional requirements of the species, it is essential to identify feed ingredients which would provide the essential nutrients for formulating practical diets. Thus nutritional and ingredient standards are defined. Finally the diets are prepared as dry pellets, moist-pellets, flakes, pastes, microparticulates, microcapsules etc. keeping in view the specific preferences of various size groups and physiological stages of the species. Binders, antioxidants, mold inhibitors, anabolic agents, colouring and flavouring agents can be added as additives depending upon specific needs.

In the process of feeding aquatic animals, a general understanding of the type of digestive system found in the animal is essential (Mac Grath, 1975). Information about the ability of the animal to chew or break feed particles into smaller units, thus increasing the surface area of feed particles for greater ease of ingestion and digestion, and about type of digestive tract the animal has and its histology are required. In addition, digestion and absorption efficiency are required. These informations would help in evolving suitable diet forms for the species and stage concerned.

Based on the informations on nutritional requirements of the species and availability of nutrients in various feedstuffs and nutritional environmental interactions diets can be formulate keeping the cost of the finished product in view.

For achieving maximum production the feeding strategies employed are very important. Feeding strategies are evolved based on the size and physiological stages of animals, water quality, water temperature, feeding habits of the animal, dietary form, behaviour of the animals etc. Thus nutrition and feed formulation research involves a number of stages, which are summarized in Fig. 1.

Table 2: Essential dietary nutrients for finfish and Shellfish Energy nutrients: Proteins, lipids, carbohydrates
Non-energy nutrients: Vitamins, minerals

Essential amino acids

1. Valine
2. Isoleueine
3. Threonine
4. Tryptophan
5. Arginine
6. Lysine
7. Leucine
8. Phenylalanine — Tyrosine
9. Methionine — Cystine
10. Histidine

Vitamins

18. Thiamine
19. Riboflavin
20. Pyridoxine
21. Choline
22. Niacin
23. Pantothenic acid
24. Inosital
25. Biotin
26. Folic acid
27. Cyanocobalamin
28. Ascorbic acid
29. Vitamin A
30. Vitamin D
31. Vitamin E
32. Vitamin K

Essential fatty acids

11. Linolenic acid (18:2w6)
12. Linolenic acid (18:3w3)
13. Eicosapentaenoic acid (20:5w3)
14. Docosahexaenoic acid (22:6w3)

Sterol

15. Cholesterol

Phospholipids

16. Phosphotidyl choline
17. Phosphotidyl ethanolamie

Minerals

33. Calcium
34. Phosphorous
35. Copper
36. Magnesium
37. Zinc
38. Cobalt
39. Iron
40. Iodine
41. Manganese
42. Selenium
43. Molybdenum

Fig. 1. NUTRITIONAL RESEARCH

BASIC	APPLIED
Nutritional requirements (size, stage, physiological condition)	Ingredients - potential nutritive value composition-antinutritional factors biological value
Digestive system and digestion	
Metabolism of nutrients	
Nitrogen and energy balance	Digestibility of nutrients in diets
Excretion	
Metabolic rates	Feeding rates and factors influencing it
Nutrition and Environment interaction	Diet growth
Inter-relationships between nutrients	Diet form
Influence of nutrients on body composition	Additives: determining safe levels of antioxidants, mold inhibitors, anabolic agents, binding agents etc.

Nutritional standard

Ingredient standard

Least-cost formulation

Process standards

Process

Finishes feeds

Microparticulate	Pellets
Microcapsules	- hard
Flakes	- soft
Meals	

Storage - Shell-life

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