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Fish feed nutrition and its management in aquaculture

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Abstract
Aquaculture production has increased considerably nowadays due to intensive culture and deploying biological techniques. Seafood is expected to be the future trustworthy food source that is going to serve the poor. Sustainability can be achieved by providing the nutritious and completely balanced feed. Aquaculture has many issues like efficiency in feeding, prevention of overfeeding for fish, avoiding wastage of food, maintaining good health conditions in fish, using advanced biotechnological methods, and fish consumption connected with human health. Prevention of nutrient deficiency and the occurrence of disease in fish can be achieved only by providing adequate nutrients. This study shows the effect of balanced feed on fish health, well-being, and prevention of disease in fishes.

Keywords: Feed nutrition, protein requirement, amino acid requirement, lipid requirement, vitamin requirement, formulation

Introduction
Fish or any animal needs an adequate balanced diet that contains all the required necessary essential nutrients to have optimal growth. These nutrient requirements vary from species to species, sex, age, the environment where it lives, different stages of larval development, and the health status of the species. A minimum of 35 to 45 nutrients is required for marine fish. To have the best optimal growth and reduce pollution in the environment a thorough knowledge of the feeding behavior and amount of nutrients required by the species is very essential (NRC, 2011) [7]. Fishes and other animals derive their energy from dietary lipids, protein, and carbohydrates. The amount of energy required also differs with different life stages of fish. Bowen (1987) [1] reported that the energy required by fish is much low when compared with warm-blooded organisms and hence it needs a high level of protein to energy ratio in the diet. Compared to the life stages of fish juvenile fishes require low energy high protein and mature adult fish requires high energy low protein diet.
Kaushik & Cowey (1991) [5] observed the reduction in dietary protein and dietary energy ratio had proven to be enormously efficient in improving protein utilization and decreasing nitrogenous waste in fishes. If there is an excess of diet and an energy reduction it reduces the growth of a fish or any organism. Fish or any aquatic organism consumes only the required amount of feed and once the energy required gets saturated the fish restrains from feeding which affects the fish's growth. Excess feeding results in the excess deposit of fat in the body, which also affects the quality of flesh reducing the marketing value. Whenever the energy derived from the feed is insufficient there is the reabsorption of the stored fat from the body for the regular maintenance of activities.

Feed Classification
- Based on the life cycle of the fish the feed is classified into starter feed, larval diet, fry feed, fingerling feed, grow-out feed, and brood-stock feed.
- Based on the moisture content feed is divided into wet feed, moist feed, and dry feed.
- Based on nutrients feed is classified into high-energy feed, low-pollution feed medicated feed, and pigmented feed.
- Based on the nature of feed ingredients they are again divided into purified feed, semi-purified feed, and practical feed.

Aqua feed is mash, microencapsulated, wet balls, flakes, crumbles, and pellets (sinking, slow sinking, and floating pellets). Feeds are classified into artificial feed and live feed. The requirement of feed quantity-wise or quality-wise differs from species to species. An aqua culturist should well know how much feed the cultivable species. The requirement can be calculated from the total culture area, stocking density, expected yield, no of harvests per year, and the potential Feed Conversion Ratio of the feed. Feeding schedule or ration is also an important factor to be considered. To achieve maximum yield feeding schedule and feeding ratio are essential. The ratio to be fed is decided by the live body weight of the fish. Heavy bodyweight fishes consume less than light bodyweight ones. The recommended ratio is 5 to 10% of the total body weight. Culture organisms or fish need to be fed twice a day advisable at the same time and the same spot every day. The pellet or feed size should always be smaller than the mouth size of the animal and a suitable size of the feed should be selected before feeding the fish. When fish are reared directly in the pond or pens, floating feeding zones should be provided for the effective consumption of floating pellet feed to minimize wastage.

Another important feed is the live feed. These are small aquatic organisms that float in the water like plankton, mosquito larvae, blood worms, *Chironomous* larvae, etc. fishes prefer live feed to the formulated feed. Live feed increases the growth and survival rate of fish more than formulated or pelleted feed. Some of the crustacean larval forms are also used as live feed like *artemia salina*, nauplius, etc.

Feed relates to good nutrition which is very essential for every organism to derive energy. Feed nutrition plays a vital role in the production of viable species. In recent years feed is in the form of formulated feed, supplementary feed, and balanced feed. Feed production is updated in technology in producing species-specific food formulation. Every feed prepared for aquaculture is a scientifically designed feed to obtain optimum growth within a short period. Inadequate nutrition either less or overfeeding can also affect fish health. The feed should be prepared economically with limited resources at the same time it should enhance the productivity and health of the organisms. Feed preparation is the major expensive issue in the cultural practice of an organism. Balanced feed varies from species to species and depends on the biochemical constitution of the animal. It also depends on the energy requirement of an organism. In most countries, Aquaculture is a lucrative industry and they keep on advancing and growing since demand exceeds supply everywhere.

Any organism derives energy from the metabolism of Proteins, Carbohydrates, and lipids. Energy is needed to perform day-to-day activities like digestion, respiration; maturation, reproduction, etc. The energy required differs from individual to individual species to species depending on the food availability and the food they consume. The energy requirement is different for herbivores, carnivores, and omnivores. There is interdependence between the food consumed and the nutrient requirement. Plant-based eaters and plant and animal-based food eaters have less energy requirement than carnivores.

Protein Requirement

Leu *et al.*, (2009) [6] reported that dietary protein is the vital factor that affects the growth, behavior, and feed cost of fish. Among the three biochemical constituents protein comprises 55 to 70% of the body tissues and thus protein becomes the vital nutrient in fish nutrition. Fish requires more protein because they can derive maximum energy from protein metabolism. The heat generated by the ingestion of protein is very less and less energy is required for nitrogenous waste excretion. The requirement of protein in the diet depends on various factors like species, size of the fish, availability of protein source, quality of protein available, and also the non-protein energy in the feed prepared. Protein is a combination of amino acid chains and each protein exhibits its unique character. Enzymes, hormones, and immunoglobulins are also proteins required by the animal body to perform normal functions of the body. But animals like fish absorb the protein supplied in their supplementary feed as well as they can manufacture their protein. Amino acids supplied through the food are the essential amino acids and some amino acids that are synthesized by the body are non-essential amino acids. Without protein or amino acids, a properly balanced diet cannot be formulated in aquaculture. Hossain *et al.*, (1998) [3] reported that an excess dietary protein than non-protein energy curtails the growth of the fish. Anything beyond a certain limit is detrimental likewise protein or amino acid beyond the optimal limit becomes very expensive and detrimental to the environment since it excretes excessive nitrogenous waste in the medium. When the fishes are fed more with dietary protein it leads to an excess energy cost and also increases nitrogenous excretion. Wilson (2000) [10] observed that herbivores and omnivores require 25 to 35% crude protein and carnivores need 40 to 50%. In general, larger fishes need less protein and small fishes need more protein. Formulated feed for commercial use is prepared with the required amount of protein and amino acid. Therefore there should be a balance in non-protein energy sources like carbohydrates and lipids. If the protein availability is at optimum or suboptimum level there is the necessity to balance with an amino acid to achieve optimal growth in fish. Similarly, when the fish consumes fewer amounts of protein from the diet it reduces growth, there is a decrease in the body weight, and protein is removed from the important body organs to maintain the functions of the organs.

Amino Acid Requirement

Mere proteins are not required for the fish's growth; they also need a balanced amount of amino acids to produce new proteins and also to preserve the already present protein in the body. Amino acids play as the building blocks in the manufacturing of proteins. Dietary excess of amino acids leads to the preferential destruction of amino acids (Jobling, 2012) [4]. Most juvenile fish suffer from skeletal deformity which affects growth due to a lack of amino acids and finally leads to death.

Carbohydrate Requirement

Carbohydrate is the cheapest source of energy. Unlike proteins fish never depends on carbohydrates for energy. Carbohydrate utilization also differs with the species and source of carbohydrates. Wilson (1994) [9] observed that herbivores and omnivores depend more on carbohydrates than carnivores. Utilized carbohydrate is absorbed by the liver and stored in the form of glycogen. Carnivorous fishes present in the marine environment have less ability to ingest, digest and absorb carbohydrates. Carbohydrate ingested more than required leads to poor FCR and reduces growth. Some amount of energy is derived from the carbohydrate absorbed by the

body which is deposited in the form of lipids. The amount of crude fiber added to the formulated feed is less than 10%. Starch is the most important carbohydrate and also the main energy source which is accumulated in the seeds, legumes, and tubers. The muscle and liver also contain some amount of soluble stored carbohydrate as glycogen. Formulated feed prepared for carnivores has less than 20% of carbohydrates and omnivores have more than 30 to 40% carbohydrates. Carbohydrates missed with formulated feed make it more stable and shape. Carbohydrate added to the formulated feed acts as a binder, reduces the cost of feed preparation, and also provides dietary starch for the fish.

Lipid Requirement

Dietary lipid also plays a vital role as the energy source for the fish. To have no physiological functions and maintain the cell tissues membranes fishes require essential fatty acids, phospholipids, sterols, fat-soluble vitamins, steroid hormones, and prostaglandins. Aquatic forms especially fishes derive energy also from triglycerides. An essential fatty acid that cannot be manufactured by the body is given as a dietary supplement. De Silva & Anderson (1995) [2] mentioned that lipid is mixed with formulated feed to take advantage of the protein-sparing effect and thereby reduce the cost of feed. Carnivorous fishes that live in the temperate region need more lipids in their diet than tropical ones. Like protein and carbohydrates, more ingestion of fat leads to a reduction in hunger, a decrease in growth rate, and more deposition of fat in the carcass of fish. Al the younger fishes like hatchlings, fingerlings, juveniles, and immature fishes since they need to grow faster they require more lipids than the mature adult ones whose growth rate is much less. Lipid is always needed by the fish to consume the formulated feed or feed as well as to utilize the feed consumed. When the fish consumes excess lipids the fish tissue gets accumulated with fat and becomes fatty fish which is not accepted for human consumption.

Fatty Acid Requirement

When the fish consumes the lipid it gets broken down into essential and non-essential fatty acids. Essential fatty acids cannot be synthesized by the body like α-linolenic acid, linolenic acid, Eicosapentaenoic acid, and docosahexaenoic acid. Hence they have been added to the diet fed. Marine fishes need 1 to 2% of Eicosapentaenoic acid and docosahexaenoic acid. Tocher (2010) [8] reported that young and juvenile fishes need more amount of essential fatty acids than mature adult ones. Arachidonic acid is the precursor of eicosanoids and they play a vital role in ovulation in aquatic animals.

Vitamins Requirement

Vitamins are essential organic compounds that are needed in very little quantity to perform basic body functions like growth, reproduction, and general health. But lack of these vitamins or a lesser amount than required can reduce hunger, retard growth and cause deformities in tissues and organ systems. In marine fishes, these vitamins have to be supplemented in the diet, but the micro gut flora replaces the vitamin requirement in some fishes. Fishes can easily absorb the water-soluble vitamins through their intestine and store them in the body tissues and the excess gets excreted out. If there is more absorption it leads to hyper vitaminosis. Hence the addition of more amounts of vitamins than needed by the fish affects the health of the same.

Minerals Requirement

Minerals are inorganic materials or compounds that are essential for the day-to-day life functions of fish. Even though fish can absorb some of the minerals present in the water through their gills and digestive tract, the rest of the minerals are supplemented through the diet. Minerals are essential for fish and other aquatic animals especially to strengthen bones, the balance of acid-base, enzyme function, and osmotic and ionic regulations.

Factors to be considered before diet formulation

- The way of feeding, mode of feeding of the fish.
- The size and age of the species to be fed.
- Size of the mouth of the feeding fish and feeding behavior.
- Amount of feed to be provided and the number of times to be fed for the culture species.
- Quality of the dietary ingredients used for the manufacture of formulated feed.
- The number of ingredients used in the formulation of feed to obtain optimal growth.

Characteristics of Formulated Feed to Be Taken Care

- The moisture of the feed
- The soaking capability of feed–expansion.
- Solubility of the feed dispersed in the medium.
- Absorption by the culture species.
- The texture of the feed prepared.
- The flavor of the feed attracts culture species.
- The bulk density required for supplying the demand.
- Palatability of the feed by the Culturable species.
- Floating tendency and ability of the feed in the medium.

Factors to be considered before feeding the species

- Feeding habitat of the Culturable species.
- Feeding niche of the species.
- Time taken by the fish to consume the feed given.
- Type of feed to be supplied for the species.

Fish feed formulation

Feeding is one of the most important functions of an organism since every activity arises from the energy consumed by it. A person interested in aquaculture should be well aware of the food and feeding habits of that organism. Naturally available food in the system plays a vital role in any culture. The quality and quantity of feed should be always inadequate. To have good management practices it is necessary to assess the energy requirements of the species and food conversion efficiency into the flesh. To achieve this proper and enough amount of food should be available in the system. If the culture system is extensive available food in the culture system is sufficient. This will be because the fish farmer will be stocking the fish at a lesser density. If there is less secondary productivity it can be maintained by fertilizing the pond. Thus the food biomass can be increased, which in turn will be readily available to the fish.

Artificial feed is a human-made feed that can be a single ingredient or a combination of many like groundnut oil cake or rice bran or silkworm pupae etc. or as different mixtures of different ingredients like trash fish, slaughterhouse wastes, or as simple mixtures of powdered ingredients or ingredients mixed with dough or pellet forms. A formulated feed should provide a maximum FCR Feed conversion ratio, completely

balanced nutrients, feed stable in the medium for a long period, should have attractants, stimulants, etc., size and shape of the feed should be easily consumed by the cultivable fish, ingredients used should not pollute the environment and should provide optimum growth. The formulated feed should be prepared from locally available minimal-cost ingredients. Apart from the fishmeal, soya bean meal, blood meal, leguminous seed kernels, etc. vitamin premix and traces of mineral salts should be added. A deficiency of one or more components will lead to nutritional deficiency. While formulating feed for the shrimps if the amount of calcium and phosphorus is less, it will lead to soft shell syndrome disease. They lose the exoskeleton and will not have market value.

Supplementary feeds are often prepared with low-cost byproducts or agricultural residues like groundnut oil cake, rice bran, fish offal, poultry waste, silkworm pupae, slaughterhouse wastes, etc. These feeds are fed individually as well as in combination. These supplementary feeds are suitable for extensive fish or prawn culture. Complete or compound or formulated feeds are prepared giving more importance to the conversion ratio. Formulated feed is a wholesome food for cultivable fishes which is a well-balanced nutritious, readily acceptable feed and also ensures maximum survival and optimal growth. These formulated feeds never disintegrate easily nor pollute the waters. They are economically viable and have a longer shelf life.

Addition of additives

Apart from ingredients certain additives have to be added while preparing the formulated feed. They are pellet binders, antioxidants, preservatives, chemo-attractants, feeding stimulants, probiotics, immune stimulants, growth promoters, hormones, exogenous enzymes, acidifiers, and organic acids. Addition of additives or binders makes the feed very stable and palatable. Preservatives used in the preservation increase the shelf life of the feed. It also prevents microbial attack. Chemo-attractants add flavor and taste to the product. These additives are required to have a high survival rate, more weight gain, alternative Antimicrobial Growth Promoters, and a better feed conversion ratio.

Conclusion

In recent years because of the technological knowledge and sharing the findings of aquaculture research, more and more farmers are involved in aquaculture. Advancement in technology has made it easily possible for farmers. Even though India has vast resources still yet to be utilized fully. Prawn culture is a well-recognized activity in the coastal regions. The area of prawn culture has been steadily increasing in all the maritime states of India. This is because of the thrust given by the government, providing increased credit facilities to farmers from banks, improved extension services, and also the entry of non-traditional entrepreneurs. Like the freshwater ponds, composite fish culture also occupies a major part of the area. To increase the fish crop yield, an intensive and semi-intensive system is practiced, since the stocking density is high the available food may not be sufficient. In this situation, adequate food can be managed by providing formulated supplementary feed and balanced feed. If this is followed the yield will increases and the fish crop production will be more.

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