British Journal of Pharmacology and Toxicology 2(4): 179-191, 2011
ISSN: 2044-2467

Submitted: May 17, 2011 Accepted: July 02, 2011 Published: October 25, 2011

A Review of Conventional and Unconventional Feeds in Fish Nutrition

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Abstract: A review of conventional and unconventional feeds in fish nutrition *was carried out to provide* information on supplemental feed and its formulation for effective culture fisheries management. Foods for fry and fingerlings frequently exceed 50% crude protein. As growth rate decreases and fish age, protein levels in diets are decreased accordingly. Technology associated with rearing of live foods is improving rapidly. This is having a positive impact on larval rearing, a frequent bottleneck for commercialization of "new" species. This article reviews live feed for fish larvae, fish foods, fish feed ingredients, some common conventional feed stuff, animal and plant sources of unconventional feeds for culture fish, fish feed formulation and feeding methods to provide more information for the effective management of fish farming.

Key words: Conventional and unconventional feed stuffs, feed formulation, feeding methods, live fish feed

INTRODUCTION

Essential or indispensable amino acids (EAAs) cannot be synthesized by fish and often remain inadequate but are needed for growth and tissue development (Wilson *et al*., 1989). Fishmeal is known to contain complete EAA profile that is needed to meet the protein requirement of most fish species. Since fishmeal is expensive as a feed ingredient, the use of nonconventional feedstuffs has been reported with good growth and better cost benefit values. The utilization of nonconventional feedstuffs of plant origin had been limited as a result of the presence of alkaloids, glycosides, oxalic acids, phytates, protease inhibitors, haematoglutinin, saponegin, momosine, cyanoglycosides, linamarin to mention a few despite their nutrient values and low cost implications (Sogbesan *et al*., 2006).

These antinutritional factors negate growth and other physiological activities at higher inclusion levels (Oresegun and Alegbeleye, 2001). Nonconventional feed resources (NCFRs) are feeds that are not usually common in the markets and are not the traditional ingredients used for commercial fish feed production (Devendra, 1988; Madu *et al*., 2003). NCFRs are credited for being non competitive in terms of human consumption, very cheap to purchase, byproducts or waste products from agriculture, farm made feeds and processing industries and are able to serve as a form of waste management in enhancing good sanitation.

These include all types of feedstuffs from animal (silkworm, maggot, termite, grub, earthworm, snail, tadpoles etc.), plant wastes (jack bean, cottonseed meal, soybean meal, cajanus, chaya, duckweed, maize bran, rice bran, palm kernel cake, groundnut cake, brewers waste etc.) and wastes from animal sources and processing of food for human consumption such as animal dung, offal, visceral, feathers, fish silage, bone, blood) (Devendra, 1988).

All these can be recycled to improve their value if there are economically justifiable and technological means for converting them into useable products. The nutrient quality of feed ingredient is one of the major prerequisite apart from availability (which sometimes is a function of cost and season) for production of good quality feeds. The basic nutrient that cannot be compromised in the choice of ingredients for feed formulation and preparation is protein (Zeitler *et al.*, 1984). Hence it becomes imperative to research into the nutrient composition of some of the easily culturable animal protein sources. The aim of this experiment is to analyse chemical composition of earthworm, garden snail, termite and tadpole meals so as to provide information which will help in incorporating any of these nonconventional animals into fish feed ingredients during the feed formulation by fish nutritionist and fish farmers who may want to use them as onfeed ingredients.

For many years water quality has been the most important limitation to fish production. Advances in life support technology have been substantial in recent years, and nutrition is increasingly regarded a key limitation to increased production efficiency as well as the growth and propagation of "new" species. Commercially prepared diets for channel catfish and salmonids have been developed using a great deal of research data on specific

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nutritional requirements of these species, their production systems and their life stages. Some nutritional studies have also been carried out for tilapia production. For all other species, including freshwater and marine ornamentals, nutritional management is based on a combination of application of knowledge generated for the species mentioned above and the experience of successful aquarists (CAN, 1993).

Most successfully reared ornamental fish are omnivores, and these are the species that have adapted best to captive conditions, including available nutrition. Successful maintenance of "difficult" species is often influenced by the aquarist's success in obtaining or rearing specialized food items. For example, members of the highly popular sygnathid family, sea horses and sea dragons, have long, tubular mouth parts. These animals are not physically capable of ingesting typical commercial fish foods. Instead, successful husbandry typically involves significant investment in the rearing of brine or mycid shrimp. The popularity of these animals has made the extra investment worthwhile for many commercial exhibits, but makes it unrealistic for the typical home aquarist (Helfrich and Smith, 2001).

Generally, fish diets tend to be very high in protein. Foods for fry and fingerlings frequently exceed 50% crude protein. As growth rate decreases and fish age, protein levels in diets are decreased accordingly. Protein levels on growout diets often approach or exceed 40% crude protein, while maintenance diets may contain as little as 2535%. In addition to decreasing the protein content of the food as fish grow, the particle size must also be changed. Many fish require live food when they are hatched because their mouth parts are so small. Some fish, such as the channel catfish, are large enough to place on a fry diet immediately without having to bother with the expense and labor needed for live foods (Houlihan *et al*., 2001).

Fish meal should be a major protein source in fish diets. There are essential amino and fatty acids that are present in fish meal but not present in tissue from terrestrial plants or animals. Low cost formulations in which fish meal has been eliminated and replaced by less expensive proteins from terrestrial sources (soybeans) are not recommended for fish. Fish meal and fishery byproducts have high lipid content and therefore rancidity can be a problem if foods are not properly stored. Feed storage is discussed briefly below (Lovell, 1988).

In addition to the concern for essential amino acids that may be present in fish meal, fish require long chain fatty acids (C_{20} and C_{22}) that are not found in tissue from terrestrial organisms. Fish meal, shrimp meal and various types of fishery byproducts are the source for these essential fatty acids. In addition, crustacean byproducts serve as a source of carotenoid pigments that are excellent for color enhancement. There is a high oil content associated with carotenoid pigments, so vitamin E supplementation is recommended when these are used (Robert, 1979).

Vitamin and mineral requirements of most fish species are not well understood. It is known that fish absorb minerals from the water. Calcium deficiency of channel catfish fry has been associated with calcium concentrations less than 10 mg/L in rearing systems. Calcium chloride has been used to raise the calcium concentration of water used for fry rearing. Conversely, too much calcium in the water has been associated with reproductive problems in some Amazon fish. Water hardness > 100 mg/L has been attributed to formation of hard shells for eggs of some tetra species, and fry were not able to hatch (Roberts, 1989).

Most fish require dietary ascorbic acid (vitamin C). This becomes very important if fish are reared in a poorly lit area where algae cannot grow, or if they are so crowded that they cannot consume any natural food items that might be in the water. Ascorbic acid added to fish foods should be phoshorylated to stabilize the vitamin and increase storage time. In addition, vitamins A, D, E and B complex should be added to fish foods. The concentration of vitamin E is often inadequate, especially in diets that are high in fat. If fish are housed in natural systems with algae and phytoplankton, and stocking rates are not too great, then vitamin supplementation seems to be less important, presumably because of the availability of natural food items (Robinson *et al*., 1998).

Because fish feeds usually contain relatively high amounts of fish meal and/or fish oil, they are very susceptible to rancidity. In addition, ascorbic acid is highly volatile, but critical to normal growth and development of most species of fish. For these reasons, fish feeds should be purchased frequently, ideally at least once a month and more frequently if possible. Feeds should be stored in a cool, dry place and should never be kept on hand for more than three months. Refrigeration of dry feeds is not recommended because of the high moisture content of that environment. Freezing is an acceptable way of extending the shelf life, however (Tom and Van-Nostrand, 1989).

Vitamin C is an essential vitamin for fish, and most species tested are not capable of synthesizing their own. Stabilized (phosphorylated) forms of ascorbic acid are available and are used in many, but not all, fish feeds. Feeds that do not contain stabilized ascorbic acid are not recommended for fish. If assays for ascorbic acid content are to be run it is imperative to know which form the vitamin is in before sending the feed sample to a laboratory (Winfree, 1992).

Commercially milled fish foods are usually sold as dry or semimoist pellets or as flakes. Pellets are typically the most complete diets. They are cooked, and, if marketed as a complete ration, the nutrition in each particle should be uniform. Disadvantages include the potential for rapid sinking unless the pellet is extruded. In addition, the pellet size is very important. It may be impossible to manufacture a particle small enough for some fish, especially juveniles of many species. For larger animals, a very small pellet may be unacceptable.

Semimoist diets are soft and compact. Many of these are expensive, but they tend to be high quality diets and may be an excellent choice for some species (Winfree, 1992).

Flakes have been used extensively in the ornamental fish industry for many years and have the advantage of being soft enough for very small fish to consume. They also sink very slowly. Unfortunately, the volume required to meet the nutritional needs of the animals may be deceptively high. The author recommends weighing the diet to approximate the amount required and avoid accidental underfeeding Tom and Van-Nostrand, 1989).

Technology associated with rearing of live foods is improving rapidly. This is having a positive impact on larval rearing, a frequent bottleneck for commercialization of "new" species. Rotifers are the smallest live food that is routinely used for larval rearing. Newly hatched brine shrimp are larger, but still quite small, and are commonly used in fish hatcheries. Cultured live foods can provide a source of high quality nutrition, but care must be taken to avoid perpetuation of infectious disease. Use of wild caught food items is also risky because of the potential for disease introduction (Robinson *et al*., 1998).

Fish should be fed based on a percentage of body weight. For maintenance, 0.51.0% body weight per day is adequate. Fish should probably be fed at least 5 days per week. The most common mistake made by pet owners is overfeeding their fish, often with resulting degradation of water quality. Occasionally however, owners dramatically underfeed their fish. This is alluded to above. One feeding per day is plenty for most pet animals. Rearing of young stock does require small meals fed more frequently. This is often accomplished using automatic feeders on commercial farms (Robert, 1989).

Nutritional disease is often a diagnosis of exclusion. Other explanations for the problem are ruled out and then the feeding program is critically evaluated. Several examples of nutritional disease merit mention. These include starvation, scoliosis, nutritional anemia, and gill disease. Each is discussed briefly below (Robert, 1979).

Starvation is usually the result of poor husbandry and, in many cases, is a sequel to environmental problems. A poorly designed or maintained system is likely to develop water quality problems with related morbidity or mortality among the fish. In an effort to correct the water quality problems aquarists may cut back on feed to the point where the animals are in a negative caloric balance and begin to lose weight, if the problem becomes chronic, starvation can result (Lovell, 1988).

The classical cause of scoliosis or "broken back disease" in fish is ascorbic acid deficiency. Improvements in feed manufacture, including phosphorylation of vitamin C, and feed storage, have decreased the incidence of nutritionally derived scoliosis. Still, ascorbic acid deficiency must be considered as a possible cause of scoliosis and a thorough review of feeding practices is warranted when evaluating such cases (Houlihan *et al*., 2001).

Nutritional anemia is caused by folic acid deficiency and has been reported in channel catfish. The diagnosis is often based initially on history, with multiple units developingsimilarsigns at the same time. When suspected, a sample of feed should be frozen for later analysis, but all affected pondsshouldhavethefeed changed immediately to a fresh lot. The problem is caused by bacterial contamination of feed, so it is not related to particular brands or formulations (Helfrich and Smith, 2001).

Nutritional gill disease has been described in channel catfish and is caused by pantothenic acid deficiency. The primary lamellae at the tips of affected gills are fused, resulting in a very characteristic histologic lesion. Clinically the condition is rare, probably because of improvements in feed formulations (CAN, 1993).

Advances in the diagnosis and correction of nutritional disease should be significant over the next few years as there seems to be a great deal of research activity in this area. In the interim, practitioners are encouraged to include questions about diet and feeding practices in their histories and to keep the potential for a nutritional etiology in mind when working through perplexing cases (CAN, 1993). Live feed for fish larvae, fish foods, fish feed ingredients, some common conventional feed stuff, animal and plant sources of unconventional feeds for culture fish, fish feed formulation and feeding methods are reviewed to provide more information for the effective management of fish farming.

FISH FOOD AND LIVE FEED FOR FISH LARVAE

The transition from endogenous to exogenous feeding is a critical event in the life of a fish. It is generally acknowledged that live feed during the first few days of hatching is necessary to ensure adequate lava survival Dry artificial feeds are inadequate to nourish small larvae during the first stages of feeding. Such feeds can be used successfully after feeding the larva with live feed for some time. Fish larvae fed with live feed in the wild or cultured have higher survival rate than those fed with artificial feeds (Helfrich and Smith, 2001).

Live feed organisms include zooplanktons. These are the rotifers, copepods, cladoceras and other larval and adult forms of some invertebrates (Fig. 1).The type of fish feed determines fish production. The use of live feed in fish culture, have received tremendous attention in countries where fish culture is well developed. For example, in Malaysia, feeding with fusoria and rotifer, start from the second day of post hatch and lasts for one week (Houlihan *et al*., 2001).

Feeding of larvae with Daphnia, a cladocera was also successful in Hong Kong. *Cultured moina* (cladocera) in combination with rotifer are used effectively in Singapore. The Nagasaki prefectoral institute of fisheries in Japan designed a production technique for the culture of rotifers on suitable phytoplankton substrate (*Chlorella* sp.) and

Fig. 1: Some zooplankton species

baker's yeast for larvae rearing. The mass production of marine fish fry in Japan depended on the continuous supply of rotifer (*Branchionus plicatilis*) (Lovell, 1988).

These Japanese required 30 billion rotifers to raise one million pagrus major to 10 mm long. Successful rearing of milkfish (*Chanos chanos*) larvae also depends almost entirely on the use of the live feed, rotifer (*Branchinous plicatilus*). The African Regional Aquaculture center, Port Harcourt, reared the larvae of *Clarias gariepinus*, *Heterobranchus bidorsalis* and Heteroclarias with the live feed, Moina sp cultured in earthen ponds. The most widely cultured feed are rotifers because of their abundance in any water body. Monia and Daphnia species are also widely cultured (Robert, 1979).

Live feeds can be cultured using both organic and inorganic fertilizers. These fertilize the medium to produce a phytoplankton bloom. The desired species of zooplankton for the culture are later introduced into the medium. The use of inorganic fertilizer (NPK and urea mixture) can be effective for the culture of *Moina* sp. A shed of 3 m × 4 m constructed and plastic bowels of 40 L capacity is preferable for the culture. Different mixtures can be used. Moina species seem to grow best in 0.5 g urea and 0.5 g NPK and increases in growth rate within few days of inoculation (Roberts, 1989).

Live feeds can also be cultured using concrete tanks covered with transparent nylon sheets. The nylon sheet allows light to pass through the concrete tank.The water can be fertilized with chicken manure or cow dung mixture. The ratio of 31:7 of chicken manure and cow dung is recommended. Algal bloom appears after fertilization, followed by zooplankton, in most cases, the rotifer; *Asplanchna priodonta* appears after the inoculation. An abundance of 100,000 organisms per liter can be observed at the peak of the bloom (Robinson *et al*., 1998).

The best method of culturing live feed is the use of earthen ponds fertilized with chicken manure. The reason is that, it saves cost. Fertilize the earthen pond with chicken manure. Spread manure on dry grass (hay) and immediately fertilize with chicken manure. Pump water into the pond. Zooplanktons such as *Moina species* and the Rotifer, *Branchiones* species will appear after a few days of fertilization. This method of culture multiplies zooplankton quickly, because earthen ponds are natural habitats of zooplanktons. The water that is pumped may contain live organisms with eggs in sale. Fertilization of the pond also adds enough nutrient requirements. This enhances plankton growth within the shortest possible time. In earthen ponds, dykes of the pond create lacustine conditions and these conditions favor zooplankton growth (Tom and Van-Nostrand, 1989).

FISH FEED INGREDIENTS

Most fish farmers and ornamental fish hobbyists buy the bulk of their feed from commercial manufacturers. However, small quantities of specialized feeds are often needed for experimental purposes, feeding difficulttomaintain aquarium fishes, larval or small juvenile fishes, brood fish conditioning, or administering medication to sick fish. In particular, small ornamental fish farms with an assortment of fish require small amounts of various diets with particular ingredients.

It is not cost effective for commercial manufacturers to produce very small quantities of specialized feeds. Most feed mills will only produce custom formulations in quantities of more than one ton and medicated feeds are usually sold in 50pound bags. Small fish farmers, hobbyists, and laboratory technicians are, therefore, left with the option of buying large quantities of expensive feed, which often goes to waste. Small quantities of fish feed can be made quite easily in the laboratory, classroom or at home, with common ingredients and simple kitchen or laboratory equipment. This paper presents examples of:

- Experimental and practical fish feed blends or formulas which are nutrient balanced and adaptable to particular conditions
- The formulation and preparation of a semipurified ornamental African cichlid fish diet that can be used in the laboratory or when small quantities of feed are needed
- The preparation of a gelatinbased diet that is often used to administer medicines or other chemicals. Background information on nutrition, feedstuffs and feed formulations are presented with emphasis primarily on the feeding of ornamental "aquarium" fishes.

Nutrients essential to fish are the same as those required by most other animals. These include water, proteins (amino acids), lipids (fats, oils, fatty acids), carbohydrates (sugars, starch), vitamins and minerals. In addition, pigments (carotenoids) are commonly added to the diet of salmonid and ornamental "aquarium" fishes to enhance their flesh and skin coloration, respectively.

In their natural environment fish have developed a wide variety of feeding specializations (behavioral, morphological, and physiological) to acquire essential nutrients and utilize varied food sources. Based on their primary diet fish are classified as carnivorous (consuming largely animal material), herbivorous (consuming primarily plant and algae), or omnivorous (having a diet based on both plant and animal materials). However, regardless of their feeding classification, in captivity fish can be taught to readily accept various prepared foods which contain the necessary nutrients .

Increased understanding of the nutritional requirements for various fish species and technological advances in feed manufacturing, have allowed the development and use of manufactured or artificial diets (formulated feeds) to supplement or to replace natural feeds in the aquaculture industry. An abundant supply of feedstuffs are available, and farmers and hobbyists are now able to prepare their own fish feeds from locally available ingredients.

Proteins and amino acids: Fish meal, soybean meal, fish hydrosylate, skim milk powder, legumes, and wheat gluten are excellent sources of protein. Additionally, the building blocks of proteins (free amino acids) such as lysine and methionine are commercially available to supplement the diet.

Utilizing raw fish as a main ingredient in fish feeds has long been recognized to be harmful to the health and growth of fish due primarily to the presence of the antinutrient, thiaminase. Thiaminase, an enzyme that destroys thiamine (vitamin B1), one of the essential watersoluble vitamins, is mostly found in freshwater fish and is destroyed by heat (i.e., cooking). Other concerns related to using raw fish in diets include the spread of infectious diseases such as mycobacterium and botulism. In preparing diets, preferential use of marine fish is suggested to minimize thiaminase activity, and raw fish could be steamed or poached.

Lipids: Oils from marine fish, such as menhaden, and vegetable oils from canola, sunflower and linseed, are common sources of lipids in fish feeds.

Carbohydrates: Cooked carbohydrates, from flours of corn, wheat or other "breakfast" cereals, are relatively inexpensive sources of energy that may spare protein (which is more expensive) from being used as an energy source.

Vitamins and minerals: The variety and amount of vitamins and minerals are so complex that they are usually prepared synthetically and are available commercially as a balanced and premeasured mixture known as a vitamin or mineral premix. This premix is added to the diet in generous amounts to ensure that adequate levels of vitamins and minerals are supplied to meet dietary requirements.

Pigments: A variety of natural and synthetic pigments or carotenoids are available to enhance coloration in the flesh of salmonid fish and the skin of freshwater and marine ornamental fish. The pigments most frequently used supply the colors red and yellow. The synthetically produced pigment, astaxanthin (obtained from companies such as Cyanotech and F. HoffmannLa Roche Ltd.), is the most commonly used additive (100400 mg/kg). Cyanobacteria (bluegreen algae such as Spirulina), dried shrimp meal, shrimp and palm oils, and extracts from marigold, red peppers and Phaffia yeast are excellent natural sources of pigments.

Binding agents: Another important ingredient in fish diets is a binding agent to provide stability to the pellet and reduce leaching of nutrients into the water. Beef heart has traditionally been used both as a source of protein and as an effective binder in farmmade feeds. Carbohydrates (starch, cellulose, pectin) and various other polysaccharides, such as extracts or derivatives from animals (gelatin), plants (gum arabic, locust bean), and seaweeds (agar, carageenin, and other alginates) are also popular binding agents.

Preservatives: Preservatives, such as antimicrobials and antioxidants, are often added to extend the shelflife of fish diets and reduce the rancidity of the fats. Vitamin E is an effective, but expensive, antioxidant that can be used in laboratory prepared formulations. Commonly available commercial antioxidants are butylated hydroxyanisole (BHA), or butylated hydroxytoluene (BHT), and ethoxyquin. BHA and BHT are added at 0.005% of dry weight of the diet or no more than 0.02% of the fat content in the diet, while ethoxyquin is added at 150 mg/kg of the diet. Sodium and potassium salts of propionic, benzoic or sorbic acids, are commonly available antimicrobials added at less than 0.1% in the manufacture of fish feeds.

Attractants: Other common additives incorporated into fish feeds are chemoattractants and flavorings, such as fish hydrosylates and condensed fish solubles (typically added at 5% of the diet). The amino acids glycine and alanine, and the chemical betaine are also known to stimulate strong feeding behavior in fish. Basically, attractants enhance feed palatability and its intake.

Other feedstuffs: Fiber and ash (minerals) are a group of mixed materials found in most feedstuffs. In experimental diets, fiber is used as a filler, and ash as a source of calcium and phosphorus. In practical diets, both should be no higher than 812% of the formulation. A high fiber and ash content reduces the digestibility of other ingredients in the diet resulting in poor growth of the fish.

Other common feedstuffs used in ornamental fish diets include live, frozen or dried algae, brine shrimp, rotifers or other zooplankton. The addition of fish or squid meal will enhance the nutritional value of the diet and increase its acceptance by the fish. Fresh leafy or cooked green vegetables are often used. Although vegetables are composed mainly of water, they contain some ash, carbohydrates and certain vitamins. Kale, dandelion greens, parsley and turnip greens are examples of relatively nutritious vegetables.

The quality and form of feed required depends on the nutritional needs, feeding habit and age of fish. Many domestic and agricultural wastes such as corn bran, guinea corn bran, rice bran, wheat bran, brewery wastes, blood meal, fish meal, palm kernel cake, groundnut cake, cotton seed cake, soybean, vegetable oil, palm oil etc; are some main ingredients required for compounding artificial fish diet to reduce the cost of producing a fish (Tom and Van-Nostrand, 1989).

Fish feeds are the fine particles of ground feedstuffs given to fish in small compact, cylindrical and head like forms called pellets. The pellets could be moist, dry or extruded dry with natural material such as spleen, ground liver, heart and raw fish. The nutritional value of pellets is considered in terms of their percentage crude protein and energy levels, which are estimated at the initial stage of choosing feed ingredients based on conventional crude protein and energy values of the available feedstuffs. Therefore, the amount of estimated crude protein and energy of pellet feeds are determined by the crude protein and energy requirements of the fish cultured (Tom and Van-Nostrand, 1989).

Moist pellet, contaminate the water causing pollution and contains 2535% water. Except the diet is pasteurized, there is the possibility of introducing pathogens into the fish. Inadequate transport and storage destroy certain vitamins and lipids. The handling of this type of feed can be difficult and expensive. However, moist fish feed are readily digestible by fry and fingerlings. They also have the desirable floating qualities, water stability; and, the feed can easily be observed on introduction. Dry fish feeds are more popular because they are easier to manufacture, transport and store. Their nature reduces leeching of nutrients. However, dry fish feeds are not easily observed on introduction. Overheating can occur during manufacture (Tom and Van-Nostrand, 1989).

Some common conventional feed stuff: The feed industry is, currently maintained by conventional ingredients earlier mentioned. This is in spite of the attendant vagaries in high cost and scarcity, creating the existing problems that are apparent in high cost of feed (Robinson *et al*., 1998). Examples of such feedstuff include:

Groundnut cake: This contains about 45% crude protein but lacks the essential amino acid, lysine. When moldy, it becomes poisonous due to the presence of the mycotoxin called aflatoxin.

Soybean meal: This feedstuff is fast gaining increasing acceptability and use in the feed industry. It has a balanced amino acid profile and can replace a substantial part of fishmeal. The use of this feed stuff is however limited due to its high fat content and presence of trypsin inhibitor.

Palm kernel meal: This contains a fairly high quantity of crude fiber. The crude protein is 17%. Palm kernel meals are only useful when its crude fiber content is high.

Brewers dried yeast: This is a byproduct of the brewery industry. It contains sufficient quantity of crude protein but limited in amino acids, methionine and cystine.

Brewers dried grain: This is readily available and contains similar protein levels as palm kernel cake. The crude fiber content is high and therefore in limited use.

Maize: Maize is palatable and free from antinutritional factors. The energy content is high. This limits use in fish feed.

Table 1: Maximum and minimum levels of some conventional feedstuff

Type of meal	Maximum level (%)	Minimum level (%)
Fish meal (Tuna waste) 56% protein	50	10
Fish meal (miscellaneous) 60% protein	50	10
Poultry by product meal 58% protein	10	-
Fish protein concentrate (soluble) 70% protein	5	2
Blood meal (80% protein)	3	-
Soya bean meal (38% protein)	30	-
Soya bean meal (solvent extract) 48% protein	45	-
Groundnut cake meat (45% protein)	5	-
Brewers dried yeast (30% protein)	5	2
Brewers dried grains (18% protein)	5	-
Palm kernel cake meal (18% protein)	5	-
Wheat middling (17% protein)	5	-
Rice brans (12% protein)	3	-
Maize (10% protein)	20	5
Sorghum (Guinea corn) 10% protein	10	3

Roberts (1989)

Wheat offal: The nutritional property of wheat Offal is similar to palm kernel meals. The two can therefore be used interchangeably but scarcely together. Wheat Offal is very scarce due to adverse government policy.

Fish meal: Fish feed is hardly formulated without fish meal. Apart from its high protein content, fishmeal also acts as an attractant. Fishmeal is produced either from the trash obtained from trawling or fish waste from the canning industry. The percentage protein depends on the source of fish product and method used in producing the fishmeal.

Poultry byproduct meal: Poultry processing generates a lot of wastes such as offal, blood and heads of birds. These wastes can be processed to form poultry byproduct meal. The protein content is high with a balanced amino acid profile. It can replace fishmeal without any adverse effect on the fish.

The quantity and proportion in which these conventional feedstuffs are used depend on its nutrient composition, presence of antinutritional substances, palatability and cost (Robinson *et al*., 1998). Table 1 shows some conventional feedstuffs having similar nutrient composition. The maximum and minimum levels are also recommended.

The maximum and minimum levels are not fixed: These levels are adjustable upwards or downwards. The inclusion of mineral vitamin mixture is important due to its nutritional implication. Mineral vitamin mixture is added to the final feed, because fish oil and other unsaturated oils used in feed formulation soon becomes unpalatable. When eaten, this can result in pathological symptoms in the fish (Robinson *et al*., 1998).

UNCONVENTIONAL FEEDS FOR CULTURE FISH

Unconventional fish feeds are potential feed ingredients, which have hitherto not been used in fish feed production for the reasons that:

- They are not well known or understood
- No effective study of the method of production with a view to commercializing them
- They are not readily available
- They can be toxic or poisonous

These feeds are generally referred to as unconventional feed ingredients. They contain high quality feed ingredients that can compare favorably with conventional feed types. They are expected to be cheaper by virtue of the fact that there is no competition for human consumption. Unconventional fish feed can be of animal or plant source (Roberts, 1989).

Animal source: These are feed from any living thing, other than human being, that can feel and move. Examples include tadpole meal; fly larvae, earthworm meal, toad meal, shrimp waste, crab meal and animal wastes such as pig and poultry droppings and blood meal.

Tadpole meal: Frogs and toads breed at the onset of the rainy season with the first rains acting as stimulus for reproduction. Eggs are laid in stagnant pools or any body of water and later hatch into tadpoles. Tadpoles are seen swimming and feeding from food obtained in the pool of water. There is no parental care for these tadpoles. They however survive until the pool either dries up or they metamorphose into adult frogs or toads in 23 months.

Because of the period of life cycle spent in water, tadpoles can be cultured like fish and harvested before they can metamorphose. The harvested tadpoles can be processed by oven drying or smoking over a kiln. For immediate use, they can be feed whole to adult fish or pulverized and added to other feed ingredients at 4050% depending on availability.

Proximate analysis showed that the meal contained 50% crude protein. A direct comparison with fishmeal in a replacement trial on the catfish *Heterobranchus bidorsalis* showed that it was more cost effective, though fishmeal was nutritionally superior. It can however be used in place of fishmeal.

Table 2: Comparison of the essential amino acid profile in the proteins of fishmeal and fly larvae

Amino acids	Fish meal	Fly larvae
Arginine	5.82	5.42
Histidine	2.22	3.50
Isoleucine	4.05	4.13
Leucine	7.35	6.95
Lysine	7.85	7.37
Methionine and lysine	3.54	3.06
Phenyl lalanine and Thyroxin	7.80	15.05
Theonin	4.55	4.53
Tryptophan	1.33	1.45
Valine	5.65	5.60

Houlihan *et al*. (2001)

House fly larvae (Musia domestica): When there is a supply of damp decaying organic matter, houseflies thrive. It serves both as food and breeding ground for the adults and sustenance for the resultant larvae. In fact, within a short period of the existence of such matter, large number of fly eggs became apparent. A simulation of such condition is achieved by creating a decaying organic matter with an attractant such as a combination of fish on trays or shrimp waste with finely ground maize or soybeans, groundnut cake or palm kernel cake.

The mixture is turned into a slummy watery waste with water in a drum one quarter or half filled and left open in the field. Harvesting of maggots can commence from the third day. A continuous check can be made to see the fly larvae, which metamorphose from the laid eggs. When the quantity of wriggling larvae (maggots) is satisfactorily high, the paste is diluted and larvae harvested with a fine mesh sieve, washed thoroughly to remove the substrate and allowed to dripdry.

Processing follows by:

- Oven drying
- Smoking over a kiln
- Pulversing with a pepper grinder and mixing with other fresh ingredients
- They can be fed whole to fish
- They can be processed with the substrate in the mixed form instead of separate harvesting

The nutrient quality analysis of processed larvae is Moisture 8%, protein 45%, fat 15%, Ash 8% and chitin 25% (Houlihan *et al*., 2001). Table 2 is a comparison of the essential Amino acid profile of fishmeal and fly larvae.

Animal wastes: Faeces from animals, particularly piggery and poultry droppings can be used as pond organic fertilizers for the stimulation of plankton growth. However, both animal droppings are used as a direct source of food to fish.

As direct food for fish; pig wastes collected early in the morning without contamination by pig urine, are dropped into a marked area of the pond as food for the fish. The same thing goes for poultry droppings. In fact some fish culturist use poultry droppings without further use of any artificial feed with good results. However, care must be taken to avoid pond contamination.

Table 3: Protein and essential amino acid content of earthworm.

Crude protein	Essential amnion acid content		
56.1%	Arginine	Cystine	Methionine
	3.17	0.32	1.11
	Threonine	Isoleucine	Leucine
	2.48	2.20	4.11
	Lysine	Valine	Phenylalanine
	2.52	2.30	2.02
	Tyrosine	Tryptophem	Istidine
	1.76	0.44	1.38

Helfrich and Smith (2001)

As after fermentation and build up of fly larvae; the droppings can be left in open containers for a few days to allow fermentation and build up of larvae. The larvae and droppings are let into the ponds.

As oven drying and incorporation into feeds; the dropping can be oven dried or sun dried during the harmattan period and added to other ingredients in fish feed. Such droppings are known to contain nearly 30% crude protein content. Animal wastes are particularly useful in the poly culture of the local catfishes and tilapias.

Earthworm meal (Lumbricus terrestris and Allobophora long): These are detritivorous terrestrial oligocheate worms. They live in the soil and feed on decaying leaves and other organic matter, which they later pass out as worm caste. In other words, they convert organic matter to soil. In this regard they are used in the breakdown and utilization of human and animal waste. These worms are hermaphrodites and reproduce while being used to break down detritus increasing their number at the same time.

They are commercially produced by, heaping animal, human wastes or refuge in a land with enough moisture in the soil or swamps. Suitable pairs of earthworms are introduced. These would breed with the detritus serving as source of nutrients to them. Harvesting can be done after six months. This is by digging up lumps of earth and gently breaking them up to release the worms. Processing is either by oven drying, smoking over a kiln or pulversing with a pepper grinder. The bestknown use of earthworm today, is as fish bait in artisan fisheries. Proteins and essential amino acid content of earthworm is shownas reportedby Helfrich and Smith(2001) in Table 3.

Toad meal (Bufo regularis): Toads in the tropics are seen in moist or damp areas in the forests, house surroundings etc. In the dry season, they move under stones. They breed by laying large number of eggs in pools of water during the rains, which hatch into tadpoles. The tadpoles metamorphose into toads. Therefore, it is possible to breed toads on a commercial scale and processed by oven drying. Toads are however, viewed with revulsion and people seldom touch it because of its

moist rough skin. Some fish culturist, kill toads and put into the fishpond. When the toads go putrid, the catfishes feed on it. Putrefaction or fermentation removes the poison in the toad skin. Nutritionally, toads contain 99% protein and compares favorably with fish meal.

Blood meal: Cow blood is available in slaughterhouses on daily basis. This can be obtained freely. Processing is, by boiling the blood followed by

- Dry in an oven or smoke over a kiln
- Sundry, particularly, during the harmattan. The bulk of commercial blood meal is processed during the dry season.
- Add straight into the mixture of well ground ingredients. Dry cassava powder can be used as a binder and boiling water to gelatinize it. Mix thoroughly and spread out to dry. The result is a feed with crumble consistency ideal for adult fish and fingerlings.

Blood meal is high in protein content (85%). It is a supplemental source of lysine but low in methione. Antagonism exists between leucine and isoleucine which renders the latter unavailable if combined with soybean meal, the result is ideal for fish growth.

Plant sources: Plants are nonmotile multicellular organisms whose cells have cellulose cell walls and chloroplasts. The chlorophyll in the chloroplasts enables plants to make their own food by photosynthesis. Plants include *Thallophyta*, *Bryophyta* and Tracheophyta. Thallophytes and bryophytes do not have any stem for conducting food and water from one part of the plant to another. This restricts their size. Tracheophytes have conducting systems, so they are much larger.

The plant sources of fish diets however include, leaf protein, leaf meal, aquatic macrophytes, cultivable pulses such as mucuna bean, yam beans, bread beans, winged beans or any legume ornamental that can yield pods with seeds.

Leaf protein: Leaves are abounding in the tropics growing freely without cultivation. All contain diverse levels of protein, which can produce an inexhaustible and inexpensive source of nutrient for fish. Examples of plants with nutritionally valued leaves are cassava (*Manihot. esculenta*), pawpaw (*Carica. papaya*), pineapple (*Ananas. comosus*), Groundnut (*Arachis. hypogea*), soya bean (*Glycine max)* and plantain (*Musa paradisica*).

A number of techniques have been evolved for extracting protein from leaves. The crushing of leaves into a solution with trichloroacetic acid is a useful method. The mixture is allowed to settle in separating flax for a period of 12 h. The bottom slurry is protein obtained by decanting and drying. Any leave is suitable for this method. The resulting powder is leaf protein concentrate containing up to 1550% crude protein.

Aquatic macrophytes: These are common aquatic plants found growing on water surface. These include:

- Rooted flowering plants like grasses and sedges that are commonly seen along the rim of fresh water bodies
- Rotted flowering plants with submerged leaves like ceratophyllum, and with floating leaves like the water lilies (nymphaea)
- Free floating plants such as duckweed, water lettuce, water hyacinth and salvinia, a water fern

Water hyacinth are so wide spread that they constitute a menace to shipping and fishing activities but can be used as feed component for fish. A review of studies carried out on *Azolla piñnata* and *Eichhornia crassipes* are as follows:

Azolla piñnata (fresh water fern): *Azolla piñata* is a potential fish feed component in the diet of *Oreochromis niloticus*. Its oven dried state is equated with palm kernel cake. Forty percent of *Azolla piñnata* can be used in Tilapia diets. The plant grows fast, so can readily meet commercial needs. The ovendried sample contains 27% crude protein (CAN, 1993).

Eichhornia crassipes (Water hyacinth): Water hyacinth can be used in the diet of *C. nigrodigitatus* and other cultivable fish species e.g., *C. niloticus*, *Heterotis niloticus* etc. The plant grows very fast and abounds for commercial usage. Processing can be by oven drying and protein extraction as in leaf protein (CAN, 1993).

The unconventional pulses: A rang of legumes are used as cover crops or ornamentals. They are not eaten by reasons of suspected content of toxic substances. Examples include: Mucuna beans, broad beans, sword beans, winged beans, yam beans etc. Their protein content range from 1820%, fat 310%, carbohydrate 5060%, making them easily gelatinisable.

The toxic substances in them are hydrogen cyanide and trypsin inhibitors. These can be removed by applying heat during processing. Processing is by:

- Toasting (groundnut fashion)
- Boiling
- Steam cooking (moi moi fashion)
- Drying

Table 4: Nutrients in commonly available feed stuffs

Nutrients	Local feedstuff
1. Proteins	Fishmeal (crab meals, dried shrimps) Offal. Blood meal (cow blood, ox blood) groundnut cakes, beer wastes, cassava leaves, palm kernel cakes
2 Carbohydrates	Maize, corn, cassava flour/tuber cowpeas, beer wastes, palm kernel cakes, sugar cane fiber, banana
3. Lipids (fats)	Palm oil, vegetable oil, coconut oil, palm kernel oil
4. Vitamins	Most feed stuff, pawpaw (green) vitamin premix
5. Mineral	Most food stuff, fish meal, calcium phosphate-bone meal
6. Salt	Common salt (NaCl)
7. Binder	Cassava starch, cornstarch and garri.

CAN (1993)

Table 5: Percentage composition of nutrient in feed stuff commonly available locally

Feed stuff	Carbohydrate	Protein	Fat	Fiber
Cowpea (Beans)	40.0	16.6	19.0	4.3
Maize (yellow)	60.0	7.0	4.5	2.1
Cassava flor	83.3	1.6	0.5	1.7
Cassava leaves	14.3	7.0	1.0	4.0
Cassava tuber	34.6	1.2	0.2	1.1
Yam	25.6	1.5	0.1	0.9
Corn (cooked)	79.2	8.0	4.8	1.9
Groundnut cake	27.3	53.5	7.6	6.2
Palm kernel cake	53.0	19.9	8.9	14.0
Sugar cane fiber	55.4	1.3	0.64	0.0
Banana (whole)	79.2	6.5	1.8	5.3
Paw paw leaves	18.38	32.6	0.8	17.2
Paw paw fruits	24.6	4.1	0.6	11.5
Cocoyam	33.18	9.4	0.75	8.8
Cocoyam peels	9.43	20.62	11.7	12.2
Plantain	27.43	4.59	1.6	8.0
Plantain peels	18.4	9.2	5.6	17.2
Banana peels	14.1	7.9	11.6	13.4
Sweet potato	28.1	5.4	0.5	1.0
Sweet potatoe peel	11.7	6.3	0.2	4.6
Sweet potatoe leaves	12.5	24.7	3.6	11.5
Rice (unpolished)	79.9	7.5	0.5	0.2
Rice (polished)	37.0	13.7	11.9	6.8
Potato	30	1.6	0.1	6.8
Spinach	4.5	2.1	0.2	0.8
Groundnut shells	46.3	4.0	1.0	46.7
Blood fresh	36.2	11.7	1.0	0.0
Blood meal	1.5	81.0	3.5	0.0
Fresh fish	0.0	14.2	1.5	0.0
Fish meal	1.5	61.0	3.5	0.0
Shrimps (dried)	4.4	55.5	5.5	0.0
Locust	1.4	25.5	2.0	0.0
Mussels (fw)	0.0	18.4	0.8	0.0
Chironomids (aquatic used)	0.0	9.1	13.1	0.0
Silkworm pupae	6.6	55.9	24.5	0.0
River snails (fresh)	4.3	12.2	1.4	0.0

Lovell (1988)

They commonly available feedstuff nutrients and percentage composition of nutrients in locally available feedstuff are presented in Table 4 and 5.

FISH FEED FORMULATION

Feeds are formulated to be dry, with a final moisture content of 610%, semimoist with 3540% water or wet with 5070% water content. Most feeds used in intensive production systems or in home aquaria are commercially produced as dry feeds. Dry feeds may consist of simple loose mixtures of dry ingredients, such as “mash or meals”, to more complex compressed pellets or granules. Pellets are often broken into smaller sizes known as crumbles. The pellets or granules can be made by cooking with steam or by extrusion. Depending on the feeding requirements of the fish, pellets can be made to sink or float.

Flakes are another form of dry food and a popular dietfor aquarium fishes.Flakes consist of a complex mixture of ingredients, including pigments. These are made into slurry which is cooked and rolled over drums heated by steam. Semimoist and wet feeds are made from single or mixed ingredients, such as trash fish or cooked legumes, and can be shaped into cakes or balls.

Feed formulation is an act and its knowledge allows the formulator to take advantage of substituting one feedstuff for another and compound feed at the lowest cost. The fish however, is the subject to evaluate the nutritional adequacy of the feed in terms of increase in weight gain, higher reproductive capacity or reduced mortality and morbidity (CAN, 1993).

There is no single way for the preparation of formulated fish feeds, however, most methods begin with the formation of a doughlike mixture of ingredients. Ingredients can be obtained from feed stores, grocery stores, pharmacies, and specialty stores such as natural food stores, as well as from various companies that may be found through the internet.

The dough is started with blends of dry ingredients which are finely ground and mixed. The dough is then kneaded and water is added to produce the desired consistency for whatever fish is going to be fed. The same dough may be used to feed several types of fish, such as eels and small aquarium fish. Pelleting or rolling converts the dough into pellets or flakes, respectively. The amount of water, pressure, friction, and heat greatly affects pellet and flake quality. For example, excess water in the mixture results in a soft pellet. Too little moisture and the pellet will crumble.

Proteins and especiall vitamins are seriously affected by high temperatures. Therefore, avoid storing diet ingredients at temperatures at or above 70ºC (158ºF) and do not prepare dry feeds with water at temperature higher than 92ºC (198ºF).

Making your own fish feed requires few specialized tools. The tools are used primarily for chopping, weighing, measuring ingredients, and for blending, forming and drying the feed.

Most of the utensils needed will already be in the laboratory or kitchen. Multipurpose kitchen shears, hand graters, a paring knife, a 5 inch serrated knife, a 6 to 8 inch narrowblade utility knife, and a 10 inch chef knife for cutting, slicing, and peeling can be used. A couple of plastic cutting boards protect the counter and facilitate handling the raw ingredients. Heat resistant rubber spatulas, wooden and slotted spoons, longhandled forks, and tongs are very good for handling and mixing ingredients.

A basic mortar and pestle, electric blender, food processor or coffee grinder are very useful to chop or puree ingredients; use grinder sieves and mince die plates to produce the smallest particle size possible. A food mill and strainer such as a colander or flour sifter help discard coarse material and obtain fine food particles. For weighing and measuring ingredients, dry and liquid measuring cups and spoons, and a food or laboratory bench scale are required.

Other utensils include plastic bowls (1½, 3, 5, and 8 quarts) for weighing and mixing ingredients, a thermometer, and a timer. A 3-quart saucepan and 10inch stockpot are good for heating gelatins and cooking raw foods such as vegetables and starches. The ingredients and blends may be cooked in a small electric or gas burner. A few trivets to put under hot pans will protect counters and table tops.

Ingredients may be mixed by hand using a rotary beater or wire whisk, however, an electric mixer or food processor is more efficient. After mixing, a dough is formed which can be fashioned into different shapes.

A pasta maker, food or meat grinder will extrude the dough into noodles or "spaghetti" of different diameters. As the noodles emerge from the outside surface of the die, they can be cut off with a knife to the desired length or crumbled by hand, thus making pellets. A potato ricer also serves to extrude the dough into noodles of the same size. For making flakes, a traditional handcranked or electric pasta maker will press out the dough into thin sheets.

The pellets or thin sheets can be placed on a cookie sheet and dried in a household oven on low heat or in a forcedair oven. A small food dehydrator also performs the task quite well. To add extra oil and/or pigments to pellets, a handheld oil atomizer or sprayer can is useful. To separate pellets into different sizes, a set of sieves (e.g., 0.5, 0.8, 1.0, 2.0 and 3.0 mm) is required.

Freezer bags serve to store the prepared feeds, and using a bag vacuum sealer will greatly extend the shelflife of both ingredients and the feed. The feed can be stored double bagged in the freezer but should be discarded after 6 months. Ideally, dried larval feeds are not frozen but stored in the refrigerator for no longer than 3 months.

A finished diet, especially used for experimental purposes, should be analyzed for nutrient content (proximate analysis: crude protein, energy, moisture, etc.). In addition, anyone intending to make his/her own fish feeds with unfamiliar ingredients should have them analyzed prior to their use.

Purified and semipurified diets are used primarily in experimental formulations to study the effects a nutrient, such as the amount or type of protein, may have on the health and growth of fish. One simple formulation, which is used traditionally to feed ornamental fish in ponds, consists of a mixture of 30% ground and processed oats or wheat and 50% of fish meal or pellets from a commercial manufacturer. By weight, approximately 23% of fish oil, and a 0.3% vitamin and a 1% mineral premix are added to the mixture. This mixture is blended with water and can be formed into dough balls of different sizes.

A semi purified diet, determines the optimum protein level required. This diet also can be used as a basis for feeding other types of ornamental fish in the laboratory. The cichlid feed recipe was derived principally from salmonid formulations and uses casein as the purified protein source. The ingredients in the recipe are listed under major nutrient categories such as proteins, carbohydrates, lipids, vitamins, and minerals. Pigments are added to enhance the coloration of ornamental fish

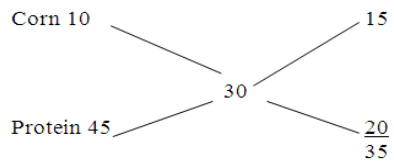
A gelatin-based diet developed for difficult to feed fishes by the National Aquarium in Baltimore. In this diet, gelatin is the primary binder. This recipe can be modified and supplemented with a variety of ingredients. Supplemental or replacement ingredients are presented. Gelatinbased diets are popular in the aquarium fish industry and useful for preparing medicated feeds at home.

Feeds are compounded by the use of the popular "Pearson square method". In this method:

- Put the ingredients on the left side
- Put the required protein level at the center
- Subtract each quantity from the required feed weight that would give protein level
- Substitute to get the answer

Example 1: Using two ingredients to achieve the required 30% protein level.

Method:
Corn = 10% protein
Shrimp = 45% protein
Required protein level = 30%

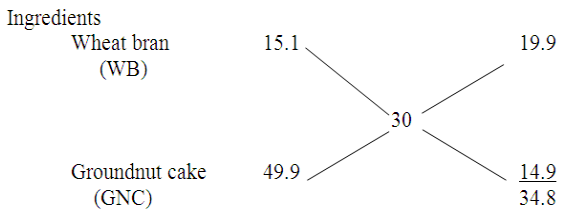


Therefore, 15/35×100 = 42-85 kg, 20/35×100 = 57.14 kg

Cross checking:

10/100×42.85 = 4.285
45/100×57.14 = 25.713
By adding, 4.285+25.713 = 29.998% = 30%.

Example 2: Adjustment of one requirement and two feedstuffs:



Prepare 100 kg of 30% protein diet using 15.1% wheat bran and groundnut cake (GNC) with 49.9% protein level

- Mixing 19.9 kg of wheat bran with 14.9 kg of groundnut cake gives 34.8 mixture 30% protein diet
- The basal mixture is composed of 49.9% protein and 19.9 kg of wheat bran containing 15.1%
- Individual contribution to the protein content of the basal diet is:

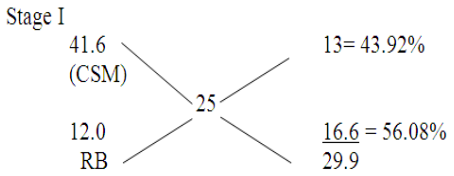
Wheat bran = 19.9% × 15.1 kg = 8.6348 kg
34.8%
Groundnut cake = 14.9% × 49.9% = 21.3652%
34.8%

\Wheat bran + Groundnut cake = 8.6348%
+ 21.3652% = 30%

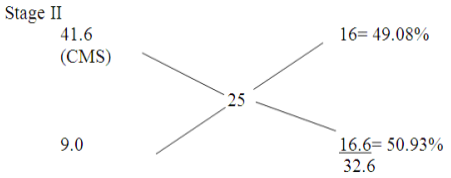
Example 3: Adjustment of one requirement and three feedstuffs. Cottonseed meal (CSM) mixed with rice bran (RB) and maize (M) with an adjusted protein level of 25%. The protein content of cottonseed is 41.6%, rice bran 12% and maize 9%. The requirement can be met in two stages.

During each stage, a highergrade feedstuff is mixed with a lower grade feed stuff:

Individual protein contribution would be:
Cotton seed meal = 0.4392×41.2707
Rice bran = 0.5608×12.0 = 6.7296



Individual protein contribution would be:
Cotton seed meal= 0.4908 x 41.6 = 20.4172



Rice bran= 0.5092 x 9.0 = 4.5828
Cotton seed meal + Rice bran = 20.4172 + 4.5828
= 24.98 = 25

Both stages are combined to calculate the requirement for a 25% diet using the available three feedstuffs:

Stage I CSM: 43.92 kg = 0.4392×41.6 = 18.2707
RB: 65.08 kg = 0.5608×12.0% = 6.7296
Stage II CSM: 49.08 kg = 0.4908×41.6% = 20.4173
RB: 50.92 kg = 0.5092×9% = 4.5828

An inspection of the calculations would reveal immediately that, in the first two stages of feedstuff containing 50% protein, a unit weight of 100kg feed stuff containing 25% can be prepared. In this way, multiple weights ranging up to tens and hundreds of tons of feed are manufactured. To obtain 100kg of mixture, each figure is, divided by two.

Feeding methods: The commonest method of providing food for the culture fish is to fertilize the culture media with organic and inorganic fertilizers to stimulate the growth of phytoplankton and zooplanktons. Other invertebrates such as water insects and their larva; benthic invertebrates and detritus materials are also utilized as food for fish (Winfree, 1992).

In a poly culture system where different species of fish are grown together, the fry and fingerlings of herbivorous fish are, preyed upon by carnivores. With increased growth rate of the stocked fish, the available natural food in the pond become inadequate to support the fish population, hence, the need to supplement the natural food with artificial feeds for enhanced fish growth (Winfree, 1992).

The selection of fish for culture with supplementary diet depends on the crude protein requirement of the fish and the unit cost of the feed ingredient available in a given locality. This consideration is important in view of the fact that fish feed account for between 4070% of the operating cost of a fish farm with an intensive management system (Winfree, 1992).

Feeding is one of the most important aspects of the fish culture. The basic activities of the fish include: Its growth, development and reproduction. All these take place at the expense of the energy, which enters the fish in the form of its food. All the other energy processes

within the fish also proceed at the expense of the food. The first stage in the life of a fish is completed at the expense of the food reserves, which it receives from the yolk in the egg. However, the fish can only live on its yolk for a comparatively short time, and after a short period of mixed feeding, it goes over completely to the consumption of external food. Fishes differ greatly in the character of the food they consume. Both the size and the systematic position of the food organisms are extremely variable. The range of type of food consumed by fishes is greater than for other groups of vertebrates. Different methods are used in administering feed to culture fish (Lovell, 1988).

Liming and fertilization produce fish food organisms. These are the phytoplankton and zooplanktons. The pond water turns green when planktons are many. Supplementary feed are given to fish in addition to the natural food organisms in the water body. Supplementary feed contains all the essential nutrients such as proteins, carbohydrates lipids, vitamins and minerals required for fish growth. Supplementary feeds are introduced into the pond by broadcasting and spot feeding (Lovell, 1988).

In broadcasting, the feed is spread over the pond. Spreading is enhanced by, drifting of the pond water. This method often contaminates the pond. Spot or spontaneous feeding involves placing the feed in a bag and tied on a spot. Alternatively the feed is introduced at a particular time (Lovell, 1988).

Fish is fed twice (2) daily, preferably morning and evening. Fish is fed 34% body weight. Fish fry is fed with paste made from boiled chicken egg. Ideally, 2530% protein level is required for feeding fish in the pond (Lovell, 1988).

CONCLUSION

Live feed for fish larvae, fish foods, and fish feed ingredients, some common conventional feed stuff, animal and plant sources of unconventional feeds for culture fish, fish feed formulation and feeding methods are important information for the effective management of fish farming.

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