CHAPTER 07

Feed diversity in aquaculture

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Feeds and feeding in aquaculture when viewed from the angle of the diversity of the material in use; both live and dead is interesting. This compilation is an effort to sum up that under the headings, live feeds, wet feeds, dry feeds, formulated feeds and the variety of transformed products in use.

Live feeds

The uniqueness of the aquatic organisms is that their food is available to them in the medium they live. Scarcity occurs only when we culture them restricting their space which we technically refer to as increased stocking density. By imposing the space restriction we not only make the food available to them scarce, but also limit the diversity of the food available to them. Thus, in aquaculture, mainly in the hatchery by imposing the restriction of food diversity we make the food available nutritionally incomplete. Now, we develop techniques and technologies to overcome such deficiencies. The proceeding discussion will first list out the live feeds available to new born and young fish in nature and then move on to an account of live feeds used commercially, their fortification techniques etc.

Even though microbes play an important role in providing nutrition to all aquatic organisms in nature, in hatcheries, they are excluded through several disinfection methods so as to prevent pathogen entry through water. Here, what is forgotten is that almost all B vitamins are synthesized by microbes and becomes available to the animals in nature. In a hatchery when we have to meet all the nutritional requirements, B vitamins have to be supplemented through feeds.

Other live feeds in use are mainly, phytoplankton, zooplankton. Microalgae are the phytoplankton used as the first feed to fish which is less than 10 microns in size. Popularly known as' green water' microalgae has a dual role. They are good water conditioners as well as live feeds. Their nutritional composition varies widely between the marine and freshwater forms. They are also grouped based on fatty acid content as EPA rich and DHA rich. There are some algae which contain only DHA like *Schizochitrium* which is preferred in marine fish larviculture. Products are developed from such algae for commercial scale larviculture applications by blending it with defatted *Haematococcus pluvialis* meal, which is another fresh water green microalgal strain, rich in astaxanthin along with inactive yeast for proteins/carbohydrates (Eg. Algamac, http://www.aquafauna.com/Diets-AlgaMac-Enrich.htm). *Crypthecodinium cohnii* is another unique, heterotrophic, marine dinofl agellate in that DHA is almost exclusively the only PUFA present in its lipid and can be as high as 65% of the total fatty acids used for commercial scale extraction of DHA for nutraceutical applications.

In the case of zooplankton the most preferred are rotifers, artemia nauplii and copepodites. Rotifers, and artemia nauplii and naturally deficient in fatty acids, especially the polyunsaturated fatty acids (PUFA), docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA). Taking note of this, bioenrichment techniques have been used. Feeding both rotifers and artemia nauplii with the DHA rich phytoplankton is the first approach. When the level of enrichment with phytoplankton was found insufficient, oil emulsions were used, albeit problems of handling and contamination. Research and development lead to products easier to handle (Easy DRY Selco and S.presso from INVE) and identification of strains of artemia maintaining enrichment level for more than 24 hours. A strain of artemia from China designated as *Artemia sinica* is found to retain the levels of DHA up to 24 h post-enrichment. As far as rotifers were concerned, size was a constraint in feeding especially some of the marine fish larvae. Discovery of 'small (S) and 'super small' (SS) strains of rotifers from several geographical locations addressed that problem. From India, CMFRI identified *Colurella adriatica* as the small strain of rotifer and up scaled its culture (Madhu et al. 2016) is reported to have a size less than the S and SS strains.

Copepod larval stages known as copepodites with several stages and sizes are known to meet all the nutritional requirements of marine larval fish especially, in nature. With low fecundity compared to rotifers and artemia, maintenance of a steady supply of copepodites in a hatchery is still a challenge. The nutritional completeness in copepodites comes from the presence of phospholipids with PUFA in the ratio of DHA: EPA as 2:1, which otherwise occurs only in the milt and roe of marine fish. That is why, roe phopolipids is chosen as a major natural ingredient in development of live feed enrichment oil emulsions.

Biofloc technology has diffused worldwide ever since it was propounded by Avinimelech (1999). The heterotrophic food web is activated by manipulating the C/N ratio above 10. This is done by adding exogenous carbon sources like flours (tapioca, wheat, molasses etc.) resulting in the shift from an autotrophic system to a heterotrophic system. This results in an increase in microbial protein production due to the formation of biofloc which enhances nutrient utilization by the cultured animal by making available recycled protein which would have otherwise gone waste.

Mechanisms of nitrogen removal from aquaculture systems are (1) dilution (2) plant and algal uptake (3) nitrification by autotrophic bacteria and (4) assimilation by heterotrophic bacteria. Among all the aforementioned techniques and technologies associated in harnessing the potential of biofloc has several clear advantages than disadvantages compared to the other technologies listed. Microbial biodiversity with the involvement of physical, chemical and biological interactions leading to formation of bioflocs and the benefits that accrue in terms of reduction in cost of feeds, biosecurity and health is phenomenal.

Wet feeds

Use of low value fish as feed for cultivation of high value fish has been practiced mainly in Asian region. In a study by Bunlipatanon et al. (2012) it was demonstrated that both the feeding practices Low value fish abbreviated as (Lvf) and compounded pellet feed abbreviated (Cpf) are economically beneficial and environmentally sustainable. The pronounced advantage of Cpf is only in its storability compared to low value fish. Low value fish feeding will naturally indicate high FCR due to the water content in it. Moreover, they need to be prepared to be fed which involves preparatory procedures like degutting. Or, mincing and pelleting using a binder. Surprising the environmentalists advocating

Cpf, it was shown that management with Lvf is more economical than Cpf. Wet feeds in Indian context includes farm made wet pellet, dough ball etc. which has given way to extruded floating pellets in the freshwater aquaculture sector (Ramakrishna et al. 2013).

Dry feeds, formulated feeds and transformed products

All dry feed material and dry formulated feeds made both farm made and factory made come under this category. Evolution of feeds and feeding technology would be worth remembering here. It starts from a no-feeding scenario. Then, fertilization and supplementary feeding started, knowing that both will increase the productivity of the pond. Broadcasting of mash feed from the pond banks and through boats was the next stage of evolution of feeding in aquaculture. This activity gradually changed to feeding doughs, to increase its water stability and made into different shapes knowing the wastage involved in broadcasting dry mash feed. It was the ingenuity of the farmers who started feeding Indian major carps with feed mash in perforated bags which lasts even now as one of the handiest feed dispensing methods. Universal pellet cooker is the first line of technology in commercialization of pellet feed for shrimp. A sinking pellet is essential for crustaceans which are bottom dwelling slow feeders. This was produced using pellet mills with or without cooking. Cooking improved digestibility of feed and now shrimp pellets are mostly steam pelletized with pre-conditioning or post- conditioning.

Extrusion if the state-of-the-art technology in aquatic feed production. This technology came to aquaculture through food industry which borrowed it from plastic and rubber industry. The technology was adopted in aquatic feed production to increase the diversity of the products which can be produced. The product diversity primarily required in aquaculture is to have feed pellets which are fully sinking, slow sinking and floating. Diversity in the size of the feeds range from less than 10 microns to more than 10 mm in diameter. Feeds with the particle size or diameter of 10 microns to 1.5 mm are known as micro feeds. They are used in larviculture nutrition, ornamental fish nutrition and nursery rearing of food fishes. Twin-screw extruders are used to produce such feeds. Feeds used for grow-out culture are called macro feeds which are above 1.5 mm in diameter. Floating and slow sinking feeds of that size are produced using single-screw extruders.

With that account of the feed diversity in aquaculture, let us have a look at what are the feed products available in India. All major international players have their factories here for shrimp feed, because India is the largest aquacultures shrimp producer and exporter now. Recent reports say that Equador will soon over take India in production of farmed shrimp (tom.seaman@undercurrentnews.com Aug. 21, 2018). Extruded fish feed is produced by around 15 feed mills in India. The capacity utilization of these mills is currently below 50% and extruded feeds for carps, catfish and tilapia are available. Indigenously produced marine fish feed is yet to be available commercially, because mariculture of food fish has not reached such volumes. Technologies have been standardized by CMFRI and CIBA. With the increase in farmed fish production in the marine sector this will soon be a reality. With the available overcapacity in extruded fish feed production within the country, the add-on technology to produce marine fish feeds known as vacuum fat infusion technology needs to be brought in to infuse fat content of more than 6% in floating pellets.

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