Perspective on Fish Feed Production Technologies

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Feed is defined as the mixture or compound of various ingredients that accomplish the nutritional requirements of any organism. The intensification of aquaculture has necessitated a more substantial supply of food from external sources. In this context, artificial feeding is the only option available to satisfy the nutritional requirements of cultured aquatic species. As the fish become more dependent on prepared feeds, the need for nutritionally complete feeds becomes more critical. In cultured organisms, proper nutrition is one of the most critical factors affecting their ability to reach their genetic potential for growth, reproduction, maintenance, and longevity. Better feed management is essential to ensure the better performance of cultured organisms. Overall, feeds and their management are essential parts of any mariculture method, and there are different types of feeds are available for fish farming.

Feed is a crucial component of aquaculture production, and there has been a growing demand for high-quality feeds over the years. Ensuring the availability of affordable, species-specific formulated feeds is vital for the success of aquaculture operations. Presently, fish feed accounts for 40-60% of the total operational costs of a fish farm, making aquaculture a costly venture. Imported feeds are available in Indian markets, but their exorbitant prices make them unaffordable for small and medium-scale farmers.

Feed manufacturing techniques Fish feed manufacturing technology will differ based on the types of feeds produced. Aquafeed manufacturing is often a challenging task that involves the production of feed with good water stability, manufacturing difficulties due to high-fat content, good keeping quality due to high unsaturated fatty acids and protein content and protecting the water-soluble vitamins and minerals from leaching. Though several kinds of feeds are available in the market basically two methods are employed to produce most of the commercial feeds. They are steam pelleting and extrusion pelleting techniques. For both of the techniques, most of the preparatory procedures and equipment are common except the pelletizer and extruder, respectively in steam pelleting and extrusion pelleting. Equipment/ Machinery in a fish feed mill. The major essential equipment/ machinery required for a feed mill and their purpose are listed in the following Table:

Si no.	Equipment	Purpose
1.	Pulverizer/ hammer mill	To grind the ingredients and to reduce particle size
2.	Weighing balance	To weigh the ingredients and feeds
3.	Homogenizer/ bowl mixer	Uniform mixing of ingredients in a feed mix
4.	Extruder and/or pelletizer	To produce feed pellets. Different dies (1, 1.5, 2, 3 mm etc.) are used for producing pellets of desirable sizes. Extruder can produce floating pellets, while pelletizer produces sinking pellets
5.	Hot air oven	To dry the feeds and ingredients by blowing hot air
6.	Sieve assembly/ shaker	To sort the feed pellets of desirable particle sizes
7.	Packaging system-impulse sealer	For air tight packing of feed pouches
8.	Fat coater	To coat oil on feed pellets
9.	Spheronizer	For preparation of spherical feeds for larvae

10.	Steam Conditioner	For conditioning/ maturing of feed mix/ dough prior to extrusion. To adjust the moisture and temperature for cooking during extrusion
11.	Spray drier	To produce dry powder from liquid slurry by rapid drying, preferably in the case of thermally sensitive materials

Steps in feed manufacturing

The basic steps in feed manufacturing are:

1. Selection of ingredients; 2. Grinding/ particle size reduction; 3. Feed formulation; 4. Mixing/ homogenizing; 5. Pre-processing or preconditioning; 6. Pelleting; 7. Drying, cooling and sieving; 7. Packing; 8. Bagging and storage

Selection of ingredients: The first operation in the feed processing plant involves the selection of raw materials. The quality of feed ingredients both dry and liquid form has an important impact on the quality of final feed. It should be fresh and free from contaminants like sand, stones, and others earthen materials. The ingredients should be examined for quality check and also for nutrient analysis.

Grinding: Grinding or particle size reduction is a major step in feed manufacture. Prior to use, ingredients must be powdered, in order to get uniform particle size. The grinding of ingredients generally improves feed digestibility, acceptability, mixing properties, pelletability, and increases the bulk density of some ingredients. It is accomplished by many types of manual and mechanical operations involving impact, attrition, and cutting. The most commonly used grinding machines are hammer mill, pulverizers, flour mill etc. The powdered ingredients are then passed through a standard mesh sieve to obtain a uniform particle size. Sieving the ingredients helps in preparing feed pellets with uniform and attractive physical appearance.

Feed formulation: In this process appropriate dietary ingredients are selected on the basis of availability, chemical composition, nutritional value and, cost. The ingredients are selected in appropriate amount and blended to produce a compounded feed which is nutritionally balanced, palatable, pelletable, and easy for storage. The important points to be considered for feed formulation are:

- Nutritional requirements of the species to be cultivated
- Feeding habits of the species
- Expected feed consumption
- Type of feed processing required

Mixing: Feed mixing may include all possible combinations of solids and liquids. Sieved ingredients were weighed and mixed in desired proportion according to the formulation. Generally dried ingredients are mixed first followed by liquid materials. Liquid materials such as fish oil may be added at the end and further homogenized. Water is also added for increasing the moisture level may also be added. For proper mixing of different feed ingredients into a homogenous mass, the mixing may be 20 to 30 minutes. Mixing can be done in batches or in continuous mixers. Batch mixing can be done on an open flat surface with shovels or in any containers. Continuous mixers are such that the material moves through the mixers as it is being mixed. The types of mixers used are horizontal ribbon mixers, vertical mixers, and turbine mixers.

Pelleting: It is the process of compacting of feeds by extruding individual ingredients or mixtures of ingredients. Pelleting converts the homogenous mixture into a quality feed, having physical characteristics that make them suitable for feeding. Pelletisation is mainly done using two types of machines namely extruder pelleting and compressed pelleting.

(i) Extruder pelleting technology

Fish feed extrusion process refers to cook the mixture of feed ingredients under high temperature, pressure, and moisture by the means of an extruder within a short time. The basic components in an extruder are, a barrel fitted with a die plate and a screw shaft conveyor connected to a high speed motor. The most important operating parameters are the temperature, pressure, diameter of the die apertures and shear rate.

(ii) Compressed Pelleting technology

The pelletizer works on the principle that the finely ground feed mixture is pelleted by compression process. Compressed pelleting then involves exposing the mixture to steam for 5-20 seconds obtaining 85o C and 16% moisture followed by forcing the mix through holes in metal die by the action of a roller located inside the die. This process is also known as steam pelleting, due to the use of steam to precondition the mix prior to compression. The combination of heat, moisture, and pressure in which gelatinization of the starch occurs. As the pellets emerge to outside surface of the die, they are cut off by a stationary adjustable knife to the desired length. Pellet quality is influenced by the fat level, moisture, and humidity.

The fat level of the mixture should be not less than 2-3% to lubricate the holes in the die and to reduce the dustiness and not higher than 8-10% to avoid excessive lubrication causing insufficient compression of the feed mixture. The moisture level is also critical as the excessive moisture results in soft pellets and insufficient moisture results in crumbly pellets.

Drying: Immediately after pelleting the feed should be dried to reduce the moisture content below 10%. This is essential for good shelf life of the feed. Different type of dryers are used for drying feed pellets, like horizontal conveyer type, vertical hopper type, hot air

oven and fluid bed dryers. The ambient temperature used for drying feed is at 65-75oC. Higher temperature is not desirable.

Packing: The dried feed is cooled before packing. Good quality packing covers are used to prevent damage to the feed quality on transportation and storage.

Storage of aquafeeds

Appropriate storage of ingredients and feeds is an important aspect in feed manufacturing process. Good storage is essential because the value of the feed presented to fish depends on it. Feed spoils during storage and the extend of deterioration depends very largely on the storage conditions. Since fish feeds usually contain relatively high amounts of fish meal and/or fish oil, they are very much susceptible to rancidity. In addition, loss of certain nutrients occurs during prolonged periods of storage. For these reasons, fish feeds should not be stored for longer periods (not more than 3 months). Ingredients and feeds should be stored in a cool, dry place away from direct sunlight.

Classification of feeds based on moisture content

Feeds are broadly classified into 3 categories based on the moisture content as follows:

Wet / Moist feed: The feed contains 35-75 % moisture and is made by mixing well-ground dry ingredients with well-ground wet materials and then extruding/pelletizing the mixture through a food processor equipped with the optimum size holes. Many fish species find soft diets more palatable than dry, dense diets. In preparation of farm-made wet feeds, heating and drying are avoided, which may prevent nutrient loss. Feeding fresh or preserving wet feed against microbial spoilage is necessary. The cost of frozen or refrigerated wet diets is very high.

Semi-moist feed: This type of feed contains 12 – 35 % moisture level. The wet and dry ingredients should be combined in the correct proportions to achieve the desired moisture level and consistency. A semi-moist formulated feed uses natural/ wet ingredients as its main ingredient and other additives with graded lipid levels that can be accepted by culturing organisms like crabs and broodstock fish. For long-term storage, the feed can be refrigerated.

Dry feed: The moisture level in this type of feed is 6-12 %. A mix of more dry ingredients and wet ingredients is used for the preparation of feed and to achieve the desired moisture and nutrient levels. Dry pellets do not require refrigeration, and room-temperature storage is sufficient for at least 90 days with adequate preservatives, after manufacture.

Types of Dry feed

Dry feeds are further classified into different types such as:

(i) Pellet feed: Feeds that are compressed into a defined shape, generally by mechanical means. Pelleting can be defined as the agglomeration of small particles into a larger solid with a given shape and texture. This is done using a mechanical process in combination with moisture, heat and pressure. Pellets can be classified into compressed pellets, expanded pellets and extruded pellets.

(ii) Compressed pellets: Steam pelleting is used to produce this kind of feed, which produces a dense pellet that sinks quite rapidly. The compressed pellets are called sinking pellet feeds. The amount of lipid included in the pellet mix does not exceed 10%. Additional lipid can be sprayed onto the feed after pelleting, and lipid levels of 16-20% can be obtained. The bulk density of compressed pellet feed will be 0.45 - 0.6 g/cc.

(iii) Expanded pellets: The feed is manufactured based on high pressure conditioning of feed mixtures within an angular expander and it will be slow sinking in nature. It is possible to increase the lipid content of expanded pellets up to 20-22 % via top dressing (coating) with oil. The amount of starch gelatinization obtained by expansion exceeds 60% and the microbial content of the mixture can be reduced significantly. In addition, it is possible to add additives such as oils and molasses. The bulk density of expanded pellet feed will be 0.3-0.4 g/cc.

(iv) Extruded pellets: Fish feeds may be pelleted by the "extrusion" process, thereby expanding rather than compressing the various ingredients. The extruded feed will be floating in nature. Due to the porosity of the extruded pellet there is the possibility of increasing lipid incorporation by top – dressing with oil up to 30%. The bulk density of extruded pellet feed will be 0.25 - 0.35 g/cc.

(v) Flake feeds: Flake feeds are the most common type of feed fed to aquarium fish. The most common method of manufacturing flake feed is the double-drum drier. The ingredients are ground to an extremely fine particle size with an attrition mill. They are blended with water to form a slurry that is spread over the surface of a heated rotating drum to turn into a thin dry sheet. The dried sheet is continuously scraped off the rotating drum and crumbled into flakes. By adjusting the distance between the drums, the thickness of the flake can be adjusted. Drying conditions may influence the nutritional value of the product.

(vi) Microencapsulated feeds: The process of microencapsulating involves surrounding and coating another substance (the payload) with a material (the wall). The process involves coating a small particle or granular feed with a thin layer of compound that will reduce dissolving and leaching of nutrients. Nylon (N-N bonds) cross–linked proteins, calcium alginate, and lipids have been used as

encapsulation materials. As a larval feed technology, this technology has been developed and adapted.

(vii) Microbound feeds: In microbound diets, nutrients (both particulate and dissolved) are bound within a matrix containing binding material such as agar, gelatine, alginate or carrageenan. Dietary ingredients are mixed with the binder to form a slurry, which is then dried, ground and sieved to produce food particles of the desired size. There is no barrier between dietary ingredients and culture water so there is a chance for nutrient leaching and they are susceptible to direct bacterial attack.

(viii) Micro-coated diet: A micro-coated diet refers to the miniature feed surrounding the microcoherent feed within a capsule. To improve its quality and water stability, these feeds are prepared by coating microbound diet with zein, cholesterol, and lecithin.

Fish feeds and technologies developed by ICAR-CMFRI

The Central Marine Fisheries Research Institute (CMFRI) is committed to research and development in marine fisheries and mariculture. In recent decades, focused efforts have been made to enhance the nutrition of marine ornamentals, lobsters, and food fishes.

(i) Cadalmin™ Varna- Marine ornamental fish feed

Scientifically evaluated, marine ornamental fish feed with 38% protein, 9% fat, 7% minerals and 39% carbohydrates. The slow sinking pellets are produced through twin screw extrusion technology which is the state of art in aquatic feed production. Capable of maintaining growth, health, colour and vigour of the fishes. Available in different pellet sizes (250, & 750 microns, and 1.0 mm), and coded as CMFRI OFF 25538, CMFRI OFF 7538, and CMFRI OFF 138.

(ii) Cadalmin™ Varsha- Freshwater ornamental fish feed

Scientifically developed Fresh Water Ornamental Fish Feed. Central Marine Fisheries Research Institute's Freshwater Ornamental Fish Feed (CMFRI FWOFF) with protein contents 25, 30, 35, 40 and 45% as 1mm & 2mm slow sinking feed pellets coded as CMFRI FWOFF 134, 234, 139, 239, 144, 244

(iii) Cadalmin™ Broodmax

Scientifically developed feed for brood fish. Contains protein- min. 42%, and fat- 8%. Adequately rich in essential nutrients to ensure high fecundity, good larval quality and survival. Enhances the health and condition of broodstock.

(iv) Cadalmin™ Silvergrow

Specially formulated, feed for silver pompano to ensure higher growth with a better feed conversion ratio. Contains protein- min. 38%, and fat- 8%. Adequately rich in essential nutrients, suitable for pompano grow- out in sea cages and pond culture.

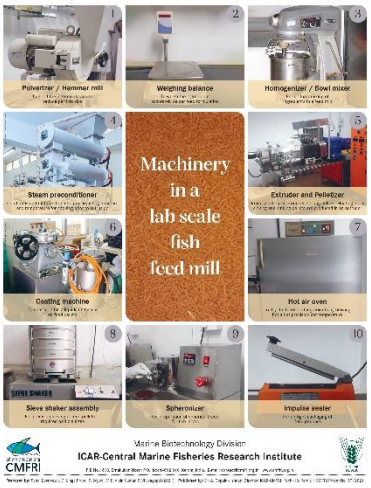
(v) Cadalmin™ Microfin

A cost-effective indigenous micro-feed for marine fish larvae (suitable for cobia, Rachycentron canadum and silver pompano, Trachinotus blochii) for sustainable mariculture. Prepared through extrusion, spheronization, fluidized bed processing (drying and spray coating), and precision sieving which delivers the highest quality feed for fish larvae. Tested and evaluated in the marine fish hatcheries of ICARCMFRI. Ensures better growth, survival and condition of larvae. Available in particle sizes of 100 to 700 microns according to life-stage/ mouth size of larvae.

(vi) Cadalmin™ BSF FFF

A fish meal free feed was developed using Black soldier fly larvae meal (BSFLM) for the juveniles of Indian pompano (Trachinotus mookalee) and Silver pompano (Trachinotus blochii). Feeding trials and evaluation using the standardized feed (having not less than 38%
protein & 6% fat) have proven that BSFLM can be used as a total replacer for fish meal in the diets of pompano juveniles without any adverse effects on the growth and condition.

CMFRI publications in fish feed technology



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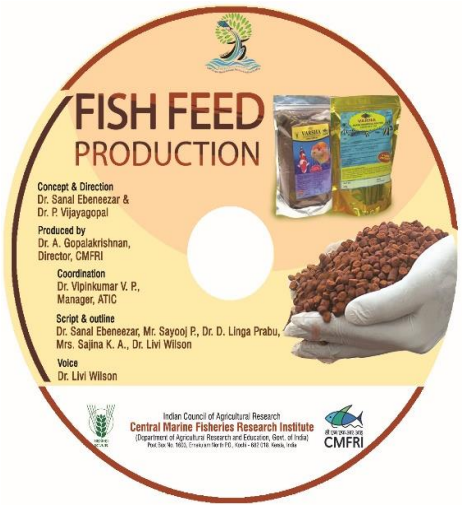

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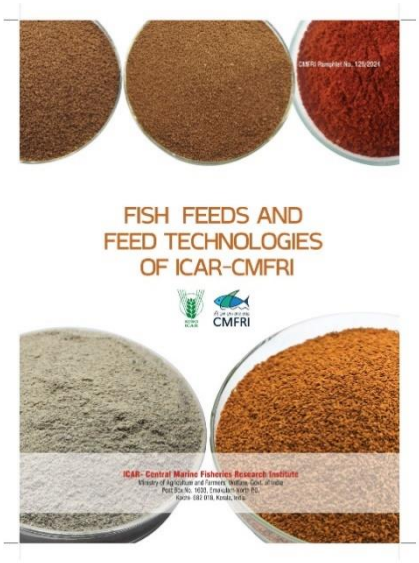
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