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FISH FEED PROCESSING TECHNOLOGY FOR ENTREPRENEURSHIP DEVELOPMENT IN INDIA

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The objective of feeding fish is to provide the optimum nutritional requirements for good health, growth, yield while minimizing wastage to optimize profits. Though natural feed forms the main source of nutrition, supplemental feeding is necessary to obtain increased production in ponds. Therefore, a good artificial feed not only facilitate in meeting nutritional requirements but also help to maintain good water stability and acceptance by the fish. To produce supplementary feed with the desired physical characteristics, feed processing and technology has a major role to play for quality feed production. Commercial feed is mainly used by few advanced and progressive farmers while the high cost is prohibitive for the small and marginal farmers. Moreover, non-conventional ingredients are normally not used for fish feed production by aqua feed industry, resulting into increased cost of the feed in the market. Some of the limitations in using non-conventional ingredients are poor utilization by fish either due to presence of anti-nutritional factors or insufficient processing. Furthermore, the scientific information on fish feed technology of conventional and non-conventional feed ingredients are limited. Production of feed as per the requirements essentially involves industrial processing that needs to be marketed in the form highly preferred by the end-users. Hence, the entrepreneurs need to access and use technical information and technology available at the research institutes to produce the desired commercial demand. The combination of the technical knowledge, technological package and business skill would certainly ensure establishment of the successful venture of feed production to cater the demand.

INTRODUCTION

India is the second-largest aquaculture producer in the world dominated by carps. About 80% of India's aquaculture production is composed of carps of Indian and Chinese origin. Feed is a vital input which greatly influences the production cost and sustainability. Similarly, production of feed of desired characteristics like minimum feed wastage, lower handling cost, easier storage and improved feed efficiency have role in improving aquaculture production.

India produces enormous quantities of feed materials derived from crops. These include a wide variety of oil cakes, pulses, mill byproducts of seeds and grains. Smaller quantities of byproducts from the meat, fish and dairy processing industries are also available in the market. Amalgamation of these types of feed ingredients could form good quality supplemental feed to provide balance nutrition to the cultured fish.

Unlike natural foods which normally are present as discreet living forms and therefore are biologically stable until consumed, artificial feeds undergo rapid nutrient loss through normal deteriorative processes and leaching by water unless quickly consumed. Moreover, when feed aggregates tend to disintegrate and separate into their ingredients components, thus losing their original nutritional properties. So a successful artificial feed apart from meeting nutritional requirements should have good water stability and acceptance by the fish.

FISH FEED TECHNOLOGY IN INDIA

The concept of feed technology in India started about 30 years ago. In 1967, the compounded livestock Feed Manufacturers Association of India (CLFMAI) was set up to represent the interest of manufacturers in the government, cooperative and private sectors with an estimated designed capacity of 1.73 million tonnes/ annum. However, the production of compounded feed was for livestock and poultry. At that time, there was no commercial production of fish feed. Few mills gradually produced pelleted feed by using old pelleting technique suitable for producing large size pellets for livestock and Poultry; it was inadequate for making small sized pellets of sufficient hardness and compactness suitable for fish feeding. Small size pellets are required for fish feeding that not only possess hardness but also remain water stable when fed to fish. A laboratory size feed pelleting machine manufactured by California Pellet Mills Co. in USA was installed long back at ICAR-CIFA, Bhubaneswar, India for production of laboratory size feed pellets producing about 100 kg feed per hour. However, it was having number of limitations and feed manufacturers started producing fish feed on commercial scale. Now, many states have feed mills producing fish feed on commercial scale, both sinking and floating type. ICAR-CIFA installed the extrusion machine under the Division of Fish Nutrition and Physiology and started producing both sinking and floating pellets for carp and prawn feeding.

BASIC STEPS OF FEED MANUFACTURING AND TECHNOLOGY

Raw material collection

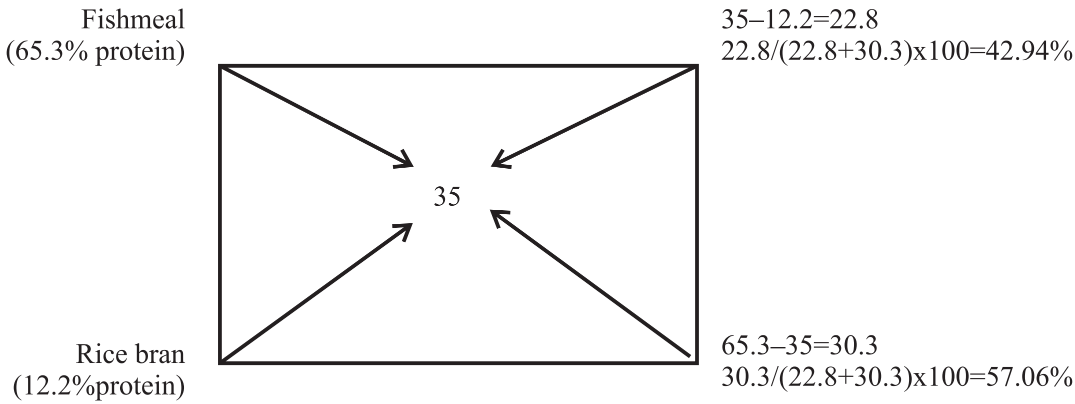
The 1st operation for feed manufacturing is the collection of raw materials. Initially the raw materials are checked by physical observation and chemical analysis to ascertain the quality. Good quality locally available feed ingredients like maize, soyabean meal, ground nut cake, till oil cake, rice bran, rice polish, fish meal and mustard oil cake are procured from the market that arrive in bags or small containers are stored in dry location preferably in specially designed feed store. Proper storage temperature and humidity are maintained during storage, so the nutrient losses are minimized. Liquid ingredients like oil and molasses are generally stored in bulk tanks.

FEED FORMULATION

It is a process which has to address two principal objectives. The first is nutrient requirement of fish based on which feed formulation is performed to achieve an optimal production. The second is the calculation to find the types and amounts of ingredients to be mixed to produce complete feeds.

a. Hand formulation

A simple method in hand formulation is 'Pearson square' which can be simply applied for mixing one, or two groups of ingredients considering the requirement (usually protein). Fig 1. shows a simple application of Pearson's square to fish meal (65.3% protein) and rice bran (12.2% protein) to formulate 35% protein supplementary feed. Application becomes more complex for more ingredients and requirement considerations for which worksheet are needed.



The solution is 42.94 % fish meal + 57.06% rice bran

Fig: Pearson Square model

Fig.1. Harvesting of freshwater IMC in ICAR-CIFA pond

b. *Linear programming computerized formulation*

Linear programming is a class of mathematical programming models concerned with the efficient allocation of limited resources to known activities with the objective of desired goals such as maximizing profit or minimizing cost when there are alternate uses for their sources. Basically linear programming works by solving of a number of linear equations. A series of equations which describe in mathematical terms the conditions of requirements of the formula is established. These requirements are to be measured in numerical terms. These are fairly easy to accomplish for some items like protein, fat, calcium etc., but difficult for other factor like palatability. Such a programme would allow a number of constraints, maximum or minimum levels of nutrient requirements and ingredient inclusion to be set based upon cost and nutritive values. The primary advantage of using linear programming (LP) in the formulation of feed is that it can rapidly and accurately determine combination of feedstuffs that will meet specific nutritional and physical requirements at lowest possible cost and not have any bias towards any ingredient. But there are limitations also.

c. *Quadratic programming formulation*

Nutrient requirements used in linear programming feed formulation are usually for fixed maximum rate of growth. This may not be the best decision from economic point of view. Nutrient constraints may be relaxed to bring down feed cost while still achieving acceptable lower growth. Quadratic programming takes into account the growth response within a range of nutrient constraint. A good understanding of biological response functions from actual feeding trials is therefore, essential in the use of quadratic programming.

Grinding

Grinding or particle size reduction is a major function of feed processing. Grinding generally improves feed digestibility, acceptability and increases the bulk density. Different types of grinders are used for grinding the feed ingredients like hammer mills, attrition mills, roller mills, cutters etc. Hammer mills are mostly impact grinders with swinging or stationary steel bars forcing ingredients against a circular screen or solid serrated section designed as a striking plate. The material is held in grinding chamber until it is reduced in size of the opening in the screen. Attrition mills use the hammer mill principle to a certain extent. Grinding is done between two discs equipped with replaceable wearing surfaces. One or both of these discs is rotated, if both they rotate in opposite directions. In roller mill, a combination of cutting, attrition and crushing occurs. These are smooth or corrugated rolls rotating at the same speed set at a predetermined distance apart with material passing between the two.

Mixing

This is a process in which each small unit of the whole is the same proportion as the original formula. Only when all ingredients as per the formula are thoroughly mixed, the feed will prove worthy. Various types of mixers are available in the market like vertical and horizontal type. Feed mixing include all possible combinations of solids and liquids.

Extrusion cooking

Extrusion processing has become the primary technique used for fish feed production, mainly because of the high physical and nutritional quality of the feed (Hilton *et al.,* 1981). Basically, an extruder is a long barrel with one or two rotating screws (single - or twin screw extruder) which is specially designed to subject feed mixtures to high heat and steam pressure. When feed exits the die at the end of the barrel, trapped steam blows off rapidly, the soft warm pellets expand, and a low density floating pellet is produced. The system is also equipped with a preconditioner as well as an accompanying machine control system. The preconditioner is a high speed mixing unit designed for the purpose of mixing water and steam into the blend of dry ingredients. The overall goal with preconditioning is to supply the extruder barrel with an evenly moistened and preheated mix. Preconditioning allows more efficient transfer of heat through friction in the extruder barrel, and also reduces the extruder barrel wear and energy. Most materials require milling prior to extrusion, especially large granular ingredients like maize or soya. After extrusion, cooling is required to remove excess moisture. A moisture content of 12-14% should be achieved to prevent fungal activity. Moreover, aquatic animals cannot digest starch effectively resulting in excessive excrement which causes physiological problems such as excessive gas, bloating diarrhoea and these apart from affecting the growth of the fish also lead to water pollution. So starch in the feed are effectively utilised by extrusion for preparation of floating feed. Extrusion processing has become the primary technique used for fish feed production, mainly because of the high physical and nutritional quality of the feed (Hilton *et al.,* 1981).

Extruded feed may be of sinking type or floating type. A part of the supplementary feed for fish in sinking form goes waste as it sinks to bottom and fish cannot consume it. This wastage is less in floating feed and farmer can directly observe the feeding requirements and adjust feeding rates accordingly. The advantages of feeding floating feed are less waste, higher feed intake, improved feed efficiency, lower handling costs, easier storage, and less bacterial contamination. Floating feed for fish has become very common for feeding of fish including fresh water fish. Extruded floating feed after incorporation of fish hydrolysate (Bind-Add+) increased growth rate and feed utilization in *Oreochromis niloticus* (Sahu *et al.*, 2017).

Benefits of extrusion

1. In extrusion, raw material is expanded, starch is gelatinized and oil cells are ruptured. So the digestibility of nutrients is increased. Denaturation exposes sites for enzyme to attack and may thus make the protein more digestible. So it increases the nutritional value of protein-containing ingredients.
2. Extrusion can destroy harmful organisms like salmonella. Heat labile proteinaceous anti-nutritive factors such as trypsin inhibitors and lectins may be destroyed.

3. The heat and pressure deactivate destructive enzymes such as those that cause rancidity.
4. Increase availability of carbohydrates.
5. It neutralizes growth inhibitors.
6. There is increase availability of sulphur containing amino acids.
7. There is also improvement of palatability.

Cooling and drying

The temperature imparted to pellets after extrusion cooking assists the removal of moisture by the air drying process. Generally, within ten minutes after extrusion, hard pellets are cooled to ambient temperatures and brought to moisture content slightly above that of the entering soft feed. This may be done by spreading pellets in a thin layer on the floor and blowing air over them. Commercially, it is done by passing the hot pellets through a vertical or horizontal chamber designed to bring air at ambient temperature into intimate contact with the outer surface of the pellets. The cooling and drying operation are of vertical type or horizontal type. Heated air may be used in the cooling and drying process. Pellets after preparation may also be dried by using dryer fitted with electrical heaters.

Packing, storage and distribution

Most feed are sacked. The sacking operation includes weighing, sacking, taping, coding and sewing. The sacked bags are then sent for distribution. The bulk products are stored in large bins.

Fig. 2. Carp feed in the feed mill of ICAR-CIFA before packaging