Study of Mechanical Effects on the Quality of Fish Feed During Different Stages of Manufacturing

Y.A. Patwary, B.S. Surker, M. Belal Hossain, M.H. Minar and M. Shamsuddin
Faculty of Fisheries, Bangladesh Agriculture University, Mymensingh-2202, Bangladesh
Department of Fisheries and Marine Science, Noakhali Science and Technology University, Sonapur, Noakhali-3814, Bangladesh
Biology Group, Faculty of Science, Universiti Brunei Darussalam, BE1410, Brunei

Abstract: Successful aquaculture highly depends on ensuring the quality feed which mostly depends on the proper feedstuff's selection and the manufacturing process. This study was undertaken to monitor the deviation of protein level and the mechanical effects on different biofactors viz. protein, moisture, ash, crude lipid and fiber in feed during manufacture. Samples were collected at randomly and batch wise from the prominent feed industry during the production period. Samples were collected from two different production level viz. ‘Final Mixer’ and ‘Finished Feed’ and third other sample was prepared as ‘Control Mixer’ on the dry basis. All the samples were analyzed by using proper analytical procedure in the laboratory of fish nutrition. The percentage of protein content was 17.9 in control mixer and 18.46 in final mixer which finally decreased to 17.03% in finished feed. In control mixer ash content was 25.74 and 23.1% in final mixer which increased in finished feed to 24.68%. Lipid content increased in finished feed (6.1%) rather than the final mixer (5.95%) and the control mixer (3.75%). However, crude fiber content decreased from control mixer to finished feed throughly. Crude fiber content in control mixer was 7.4% which decreased to 6.86 and 6.56% in final mixer and finished feed respectively. Again a relation may be drawn between the moisture content and ash and lipid content with crude fiber. By this study it was observed quality of feed is highly influenced by quality machine.

Key words: Mechanical effects, quality feed, fish, aquatic organisms, manufacturing

INTRODUCTION

Bangladesh ranked the 6th aquaculture producing country with about 265 species of freshwater and 475 marine species, with a total production is about 2701, 370 metric tons (Mahfuj et al., 2012; Minar et al., 2012; Hossain et al., 2012). Based on fish farming practice, traditional food that are used as supplementary diets consist of a mixture of food ingredients which are available locally (Ahmed, 2007). Aquaculture of Bangladesh is heading towards intensification for increasing demand of fish as a food (Al Mahmud et al., 2012) and this is used as a protein source of Bangladesh people for many years (Hossain et al., 2012).

The aquatic organism can be subjected to poor growth and even death of the disease due to lack of nutrient content in the feed. Therefore, it is essential to establish an adequate amount of protein and amino acids, lipids, minerals and vitamins in the diet of aquatic animals that are known to influence growth and body composition of fish (Lovell, 1989). Fish production cost may increases and water quality may deteriorates due to improper protein and energy levels in feed. Daniels and Robinson, 1986 stated about the growth reduction and increased body lipid deposition for necessary nutrient for growth due to excessive energy spends.

Currently there are about 25 commercial food industries for fish in Bangladesh (Kader et al., 2005). Fish feeds and nutrition play a significant role in the sustainable aquaculture development. For increased production, even in the types of aquaculture where the main source of nutrition is the natural food produced by fertilization or other means, supplemental feeding with artificial food is necessary (Chow, 1980). Due to increased aquaculture practice, demand of good quality feed is increasing day by day. Maintain Feed Conversion Ratio (FCR) close to 1 is highly depends upon good feed. Feed should have adequate protein content which facilitates high growth (FAO/UNDP, 1985).

Sufficient amount of protein content in fish feed facilitates high growth of fish (Al Mahmud et al., 2012). For proper growth, net protein utilization by fish should be around 27 percent. Fish Feed should also contain suitable amounts of energy source, minerals and vitamins.
During the last decades, a large numbers of feed industries are developed in Bangladesh for increasing aquaculture production through applying adequate feed. But the feed industry cannot produce desired quality of fish feed in most cases due to the unavailability of quality food ingredients, the presence of adulterated ingredients, the presence of harmful antibiotics etc (Al Mahmud et al., 2012).

The optimal sources and amount of nutrients for fish must be known in order to make substitutions of ingredients. These values are variable in most cases between fish and feed. Theoretically warm water fish use carbohydrates for energy, while cold water species do not (Nose and Arai, 1976, Robinson et al., 1981). A significant number of research works conducted on the proximate composition of fish (Minar et al., 2012, Begum and Minar, 2012; Mahfuq et al., 2012, Begum et al., 2012; Azim et al., 2012; Ahamed et al., 2012) but a little about the proximate analysis of feed or feed ingredients (Al Mahmud et al., 2012).

The main ingredients used in fish diets should be tested regularly for proximate composition and selected nutrients, such as limiting amino acids. Animal by-products that may contain proteins of bone, feather or connective tissues should be subjected to in vitro enzyme assays for estimating protein digestibility. All feed ingredients should be tested for mycotoxins before purchase. Occasionally, the local power substances contain many types of chemicals which are the source of one of the fish’s disease (Hossain et al., 2012). Periodic screening for pesticides and other contaminants are recommended. The specific objectives of the study were to: (1) assess the deviation of quality of fish fed during manufacture, (2) know the effects of different ingredients during mixing, (3) know the relation of different biofactors of feed during manufacture.

MATERIALS AND METHODS

Sample collection: Samples were collected at randomly during two manufacturing stages (after final mixing and finish product) and named after ‘Final Mixer’ and ‘Finished Feed’ from a renowned feed manufacturing company named Globe Agro vet Ltd. Another sample was formulated by using the industrial proportion on the dry basis of selected feedstuffs and used as ‘Control Mixer’. Samples were collected from all three batches as batch 01, batch 02 and batch 03. The samples were collected from June to September 2011.

Analytical study: The samples were analyzed in the Laboratory of Fish Nutrition, Department of Aquaculture, Bangladesh Agricultural University (BAU).

Determination of moisture: Moisture contents in wet samples were estimated by following Oven method (Love, 1975). Materials needed for the experiment are analytical balance (METER AJ 100), drying oven, porcelain crucible and desiccators. Different stages include (1) weighing known sample in to a trade crucible, (2) drying in an oven at 105-110°C until the weight of the sample becomes constant, (3) cooling the dried sample in desiccators before interval weighing and (4) recording the final weight of the dried sample:

\[
\text{Moisture} \% = \frac{100 \times (B-A)-(C-A)}{B-A}
\]

Where:
A = Weight of clean dry crucible (g)
B = Weight of crucible with sample (g)
C = Weight of crucible with dried sample after heat (g)

Determination of ash: This method was used to determine ash content in feedstuffs by calcinations. Materials include (1) porcelain crucibles, (2) crucible furnace and (3) dryer. Determination is done by placing (2.5-5 g) sample in a crucible previously calcined and brought to constant weight and then placing the crucible in a furnace and heat at 550°C for 12 h and leaving to cool and transferring to a dryer. Finally, the weight of the crucible is taken again with the ash:

\[
\text{Ash content (\%)} = \frac{100 \times (A-B)}{C}
\]

Where:
A = Weight of crucible with sample (g)
B = Weight of crucible with ash (g)
C = Weight of sample (g)

Determination of protein: Protein was determined by Kjeldahl’s method. Reagents used were (1) mercuric oxide, (2) potassium sulphate or anhydrous sodium sulphate, (3) sulphuric acid (98%), (4) paraffin wax, (5) 40% solution of sodium hydroxide, (6) 4% sodium sulphate solution, (7) boric acid indicator solution, (8) standard solution of 0.1 N chlorohydric acid and equipments were (1) Kjeldahl digestion and distillation apparatus, (2) 500 mL Kjeldahl flasks, (3) 250 mL Erlenmeyer flasks, (4) glass beads. The method is done by weighing out 1 g of sample and placing in the Kjeldahl flask, adding 10 g of potassium sulphate, 07 g and 20 mL concentrated sulphuric acid. Then placing the flask tilted at an angle in the digester, bringing to the boiling point and retaining until the solution is clear; continuing to heat 30 min or more. Then leaving to cool, gradually adding approximately 90 mL distilled, deionizing water and when cold adding 25 mL sodium sulphate solution and stirring. Adding one glass bead and
80 mL of 40% sodium hydroxide solution, keeping the flask tilted where two layers will form. Then the flask quickly connect with the distillation unit, heating and collecting 50 mL of distillate containing ammonia in 50 mL of indicator solution. At the end of distillation, removing the receptor flask, rinsing the end of the condenser and titrating the solution with standard chlorohydrate acid solution:

\[
\text{Nitrogen in sample} = \frac{100(A-B)}{C} \cdot 0.014
\]

Crude protein% = nitrogen in sample% × 6.25.

Where:
A = Chlorhydric acid used in titration (mL)
B = Normality of standard acid
C = Weight of sample (g)

**Determination of fat:** Fat can be conveniently determined by extracting the material paste with light petroleum (petroleum spirit B.P. 40°C) in a soxhlet type extractor and the extract is weighted after careful recovered of the solvent. It is advisable to extract the sample first and then bound fat can freely extracted by the extracting solvent. Reagents include (1) 90% alcohol, (2) petroleum ether (B.P. 40°C-60°C), (3) Anhydrous sodium sulphate. Determination was done by weighing of the empty, cellulose thimble was taken. Then it was weighted the crushed and pasted sample. The soxhlet apparatus was set in a water bath and placed the thimble with sample in into the extractor. The whole extraction was accomplished by two phases:

**Alcohol extraction:** Fat were extracted with 99% alcohol. After alcohol extraction, alcohol was recovered from the flask by distillation. After completed recovery of alcohol the thimble and content was heated slowly to vaporize trace alcohol present in the thimble content. Then the petroleum ether was added in to it.

**Petroleum ether extraction:** The soxhlet apparatus was again setup in the water bath and petroleum ether (B.P. 40°C-60°C) was added and continued as in alcohol extraction. Alcoholic extract after recovery of alcohol was dissolved in ether extractive. Then the mixed extract was taken in a separating funnel was washed with hot water. When the oil ether solution was separated from water layer a quantity of anhydrous sodium sulphate was added to remove the bound water present in ether solution. After a while the clear oil ether solution was taken in previously round bottle flask. The ether was recovered by distillation. Then the fats were dried at 100°C in an oven and cooled in desiccators. Heating and cooling were continued until constant weight was as curtain.

Fat was calculated as in under:

\[
\text{Fat content (g)} = \frac{A - B}{100}
\]

Where:
A = Weight of fat after completed evaporation of the solvent (g)
B = Weight of taken sample

**Determination of lipid:** The lipid were extracted from the sample with petroleum ether and evaluated as a percentage of the weight before the solvent was evaporated. Reagents and materials include petroleum ether, soxhlet extraction apparatus, laboratory kiln set at 105°C, dryer, extraction thimbles. The determination is done by removing extraction flasks from the kiln without touching them with the fingers, cooling in a dryer and weighing. Weighted (3-5) g dry sample was taken, handled with tongs and placed in the extraction unit. Connect the flask containing petroleum ether at 2/3 of total volume of the extractor. Brought to boil and adjust heat to obtain about 10 refluxes per hour. The length of the extraction will depend on the quantity of lipid in the sample. Very fatty materials will be taken 6 hours. When finished, evaporate the ether by distillation or in a roto evaporator. Cool the flasks in a dryer and weighted them to within mg. the defatted sample can be used to determine crude fiber:

\[
\text{Crude lipid content} = \frac{100(B-A)}{C}
\]

Where:
A = Weight of clean dry flask (g)
B = Weight of flask with fat (g)
C = Weight of sample (g)

**Determination of crude fiber:** Reagents used are sulphuric acid solution 0.255N; sodium hydroxide solution 0.313N free of sodium carbonate; antifoam (octyl alcohol or silicene); ethyl alcohol at 95% (v/v; petroleum ether; chlorhydric acid solution at 1% (v/v). Materials include 600 mL flat bottomed balloon flask with roughened neck; condensation unit for flask; 11 Kitazato flask; buchner funnel; filtration; crucible; rubber cones; Whitman ash less filter paper; 500 mL retort; dryer; laboratory kiln; crucible furnace. Method was done by weighing out 2-3 g of defatted, dry sample within milligrams, placing in the flask and adding 200 mL boiling sulphuric acid solution, attaching the condenser and bringing to boiling point in one minute.
Nitrogen free extracts (NFE): It is calculated as:

\[
\text{Nitrogen free extract (\%) } = 100\times\frac{A+B+C+D+E}{G}
\]

Where,
- A = Moisture content %
- B = crude protein content %
- C = crude lipid content %
- D = crude fiber content %
- E = Ash content

RESULTS AND DISCUSSION

Control mixer: Samples were made by using only dry ingredients on the basis of industrial proportion as a control mixer sample. The proportion moisture, lipid, crude protein, ash, crude fiber and NFE content for the examine mixer are 15.82, 3.75, 17.9, 25.74, 7.4 and 29.39% respectively (Fig. 1).

Final mixer: Final mixer was collected after completion of the mixing stage during feed production. The percentage of moisture, lipid, crude protein, ash, crude fiber and NFE content for final mixer are 23.83; 5.95; 18.46; 23.1; 6.86 and 21.8%, respectively (Fig. 1).

Finished feed: The samples were collected from the final pelleted feed randomly, analyzed and the result was depicted. In the finished product feed contained 20.95% moisture, 6.1% lipid, 17.03% crude protein, 24.68% ash, 6.56% crude fiber and 24.68% NFE (Fig. 1).

Comparative proximate analysis: Different biofactors (moisture, lipid, crude protein, ash, crude fiber and NFE) for the three samples were plotted in the chart and made the comparative line diagram (Fig. 1).

![Comparative diagram of different biofactors of the three samples](image)

Fig. 1: Comparative diagram of different biofactors of the three samples

Protein is the first and foremost factor that has to be considered for formulating a fish feed. For control mixer protein content was 17.9%. In mixing stage that increased to 18.46% and finally decreased to 17.03% in finished feed.

Moisture content is the second important factor in fish feed. Moisture content in control mixer was 15.82% that increased to 23.83% in final mixer and to 20.95% in finished feed.

Ash is another important factor that also determines the quality of the feed. From the above fig. 1, it was noticed that in control mixer ash content was 25.74% that decreased in final mixer to 23.1% and then increased to 24.68% in finished feed.

Lipid and crude fiber are also important for determining quality of the feed. Lipid content increased in the finished feed (6.1%) rather than the final mixer (5.95%) and the control mixer (3.75%). However, crude fiber content decreased from control mixer to finished feed thoroughly. Crude fiber content in control mixer was 7.4% that decreased to 6.86 and 6.56% in final mixer and finished feed, respectively.

From the study it was observed that the protein and ash content were not in appropriate proportion in the feed. And also determines the unbalanced growth of fish. In the fish, the requirement is 35-40% but the protein content was 18.46% in mixing stage that again decreased to 17.03% in finished feed. The highest crude protein content (65.34%) was found in miscellaneous type fish meal of Lakshmipur city (Al Mahmud et al., 2012). Protein levels in aquaculture feeds generally average 18-20% for marine shrimp, 28-32% for catfish, 32-38% for tilapia, 38-42% for hybrid striped bass. Protein requirements usually are lower for herbivorous fish (plant eating) and omnivorous fish (plant-animal eaters) than they are for carnivorous (flesh-eating) fish and are higher for fish reared in high density (recirculating aquaculture) than low density (pond aquaculture) systems (Craig and Helfric, 2002).

During manufacturing, feed ingredients are converted into a physical form otherwise it is not possible to intake for fish. So fish feed can be manufactured as finely ground meals, crumbles or pellets of various size and density (Hardy and Barrows, 2002). Most diet forms are sold as dry products with 10 percent moisture or less so that they do not have to be stored refrigerated or frozen. Some semi-moist diets (20 to 35 percent moisture) are available primarily for feeding early life stages of carnivorous species but requires refrigerated or frozen for long-term storage.

Block and Mitchell (1947) concluded those food products whose unheated proteins rank lower by a
biological assay than by chemical score will probably improve in biological value on heating, however, those food proteins whose biological assays and chemical rating show reasonable agreement are likely to be damaged in biological value by heating. Of the proteins that are ordinarily fed to livestock, only the proteins of soybean products appear to be improved by heating. The others are more likely to be damaged, primarily by destruction of lysine. In my study it was observed that protein percentage was deviated in different stage of feed processing and in final finisher product it was lower than other.

The by-product feeds are likely to be more constant in chemical make-up than the unprocessed energy feeds. Heat may be either detrimental or beneficial, depending on the feed and on the amount of heat. Soaking the product and subsequent drying may also have an effect on the availability of some of the nutrients of the resulting products. The proteins of most feed decrease in nutritive value when subjected to heat. It was also indicated that when heat damages a protein, the damage is likely due to a destruction of lysine. Certain heated proteins are restored to their original value by additions of lysine.

There is a significant relationship between the moisture content with ash and lipid content with crude fiber. For consideration, in final mixer it was observed that moisture content increased in terms of control mixer but ash content was decreased. And in terms of final mixer, moisture content decreased in finished feed but ash content increased. That may presume an inverse relationship between moisture content and ash content. Again it was observed that lipid content increased in finished feed from control sample and final mixer step by step but crude fiber decreased step by step. It may also presume an inverse relationship between the lipid content and the crude fiber content.

Protein is the first nutrient that is considered as the main factor to support the growth, reproduction and health of fish. However, from the study it was observed that protein percentage was slightly unbalanced from the required value during feedstuff selection and again slightly deviated from the selected protein value.

**CONCLUSION**

Feed cost is one of the main costs for any successful aquaculture farm and for this reason feed cost should be considered besides ensuring quality feed. The quality of feed depends on the manufacturing process of the feed industries. The study was undertaken to monitor the probable deterioration of feed during different stages of manufacturing. It was observed that, steam pelleting process involves the use of steam, heat and pressure which tends to agglomerate ingredients into compact particles and affects quality during manufacture.

**REFERENCES**


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