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Research Article
Determination of the Proximate Composition of Available Fish Feed Ingredients in Bangladesh

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Abstract

Background and Objective: Proximate composition of most of the fish feed ingredients available in Bangladesh are unknown to fish feed producers and farmers. That prohibit them to utilize these ingredients in the formulation of low cost fish feed for aquaculture. The objective of the present study was to determine the proximate composition of fish feed ingredients from a wide range of area of Bangladesh. **Materials and Methods:** A total of 163 samples of 19 different available feed ingredients were collected and analyzed for proximate composition viz. moisture, crude protein, total ash, crude fiber, crude fat and nitrogen free extract (NFE) followed by standard methods. **Results:** Among the plant origin ingredients, the highest value of crude protein was found in soybean oil cake and thus it can easily replace fish meal and meat and bone meal to produce quality fish feed. Among the animal origin feed ingredients, higher crude protein content was found in protein concentrate and lower in dry trash fish. Crude fat content of plant origin feed ingredients ranged between 0.99±1.31 (rapeseed oil cake) to 18.93±1.07% (soybean full fat) and in animal origin feed ingredients the fat content ranged between 4.08±1.86 (meat and bone meal) and 10.33±2.02% (dry trash fish). Most of the samples of mustard oil cake (88.89%), soybean oil cake (55.56%) and wheat bran and rice bran (B-grade) (100%) were found in lower standard. **Conclusion:** Knowledge of proximate composition of feed ingredients acquainted in the present study will help to produce low cost quality fish feed from locally available feed ingredients.

Key words: Crude protein, crude fat, feed samples, proximate analysis, Bangladesh

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Now-a-days use of expensive protein rich ingredients make the aquaculture expensive and non-profitable all over the world[1]. Fish feed plays a major role in aquaculture viability and profitability, because it accounts for at least 40-60% of the total cost of fish production[2,3]. It is anticipated that the transformation of locally available low protein by-products into high quality fish protein can be a major contributor to improving the protein supply for the local human population. Therefore, the requirement of low cost nutrient rich feed in place of expensive feed, formulated using locally available feed ingredients are needed to be used to cut off the expenses of feed cost in aquaculture. Locally produced feed reduces the cost of production and hence, cheaper means of meeting the protein requirement, improving food security and reduce the level of poverty in developing countries. Thus inexpensive and locally available feedstuffs are to be identified as because the future development of small-scale aquaculture system depends on the use of available local ingredients which will reduce feed cost[4]. In Bangladesh, a number of by-products from agricultural processing are available, which are usually not utilized for human consumption but it have a high potential for small-scale and commercial aquaculture. The use of plants or plant-derived feedstuffs such as legume seeds, different types of oilseed cake, leaf meal, leaf protein concentrates and root tuber meals as fish feed ingredients is sometimes limited by the presence of a wide variety of anti-nutritional substances[5]. By-products of animal origin may also contain anti-nutritional compounds, especially if the products are not properly preserved or processed[6]. However, whilst some anti-nutritional factors are easy to eliminate by processing, others may be more difficult to eliminate. To date, nutritionists and feed manufacturers have focused their trials on determining which of the wide variety of foodstuffs available to the livestock and fish feed industry may be used to produce a low cost fish diet. But unfortunately, there is a scarcity of information on chemical composition of profit making fish feed ingredients in Bangladesh. It can also be stated that the information on nutritive value of local market feed and proximate composition of these feed is essential[7] but the information available in this aspect is unreliable. As development of a feed for fish production involves evaluation of proximate composition of feed components and cost implications, the current study was conducted to determine the proximate composition of locally available feed ingredients for development of commercial aquaculture feed for fish culture in Bangladesh.

MATERIALS AND METHODS

Collection of samples: The feed ingredients were collected from different feed value chain actors like feed mills, ingredient suppliers, retailers, producers etc., from Mymensingh, Gazipur, Comilla, Bogra, Noakhali, Chittagong, Dhaka, Barisal, Bhola, Khulna and Rajshahi areas of Bangladesh (Fig. 1). A total of 163 samples of 19 different feed

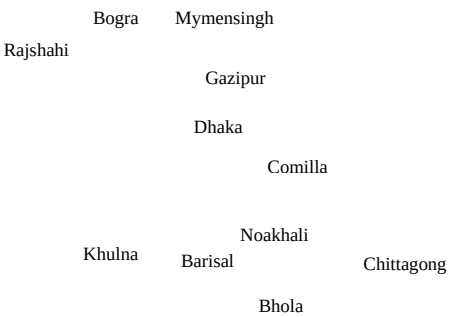

Fig. 1: Location of areas selected for collection of samples (Scratch map of Bangladesh)

ingredients (Appendix plate 1) were collected during the study period of 2013-2014.

Preparation of samples: The feed ingredients were collected as bulk quantity from different lots of supplied raw materials. Sampling of each feed ingredients from an entire lot was done following "Quartering" method followed by Jacobs[8] and Lovell[9]. The sample of each feed ingredient was grounded using an electrical grinder into small particle size and sieved the trash with a sieve of 60 µm mesh size. After

Plate 1: Graphical presentation of different plant (a) Mustard oil cake, (b) Soybean oil cake, (c) Sunflower oil cake, (d) Sesame oil cake, (e) Rapeseed oil cake, (f) Rice bran (A-Grade), (g) Rice bran (B-Grade), (h) De oil rice bran, (i) Maize, (j) Wheat bran, (k) Wheat flour, (l) Soybean full fat, (m) Corn meal and animal (n) Fish meal imported, (o) Mean and bone meal, (p) Dry shrimp meal, (q) Dry trash fish, (r) Dry fish (local fish meal) and (s) Protein concentrate, fish feed ingredients collected from different region of Bangladesh

sieving the samples were stored in dry and well covered containers until analysis.

Proximate analysis: The analysis of proximate composition was done in the laboratory of SMS feeds limited, Gazipur, Dhaka, Bangladesh. On each chemical analysis, triplicate determinations were carried out.

Determination of moisture: Moisture contents in the raw materials were determined by following Oven method[9]. The percentage of moisture was calculated using the following formula:

$$\text{Moisture (\%)} = \frac{\text{Original weight of sample} - \text{Dry weight of sample}}{\text{Original weight of sample}} \times 100$$

Determination of crude protein: Crude protein was determined followed by Kjeldhal method[8,10,11] according to the following formula:

$$\text{Nitrogen (\%)} = \frac{\text{Vol. of } H_2SO_4 \times \text{No. of } H_2SO_4 \times 14}{\text{Wt. of original sample (wet basis)}} \times 100$$

$$\text{Crude protein (\%)} = \text{Nitrogen (\%)} \times \text{Conversion factor}^*$$

*= Conversion factors for animal and plant origins ingredients[12] are 6.25.

Determination of total ash: Ash content of each feed ingredients was estimated by following incineration method[13]. The total ash content of the sample was determined by the following formula:

$$\text{Total ash} = \frac{\text{Wt. of crucible with original sample} - \text{Wt. of crucible with ashed sample}}{\text{Wt. of original sample(wet basis)}} \times 100$$

Determination of crude fiber: Crude fiber was determined by following the method of AOAC[14]. The crude fiber content of feed ingredients was then determined according to the following formula:

$$\text{Crude fiber (\%)} = \frac{\text{Wt. of crucible with dried residue} - \text{Wt. of crucible with ashed sample}}{\text{Wt. of original sample}} \times 100$$

Determination of crude fat: Crude fat was quantified through Soxhlet extraction technique[8,15] using hexane (65-70°C) as the solvent using the following formula:

$$\text{Crude fat (\%)} = \frac{\text{Corrected weight of fat}}{\text{Weight of original sample}} \times 100$$

Determination of nitrogen free extract (NFE): Nitrogen free extract (NFE) was determined by the difference between the original weight of the sample and sum of the weights of its moisture, crude protein (CP), crude fat (CF), ash and crude fiber as determined by their appropriate analysis followed by Castell and Tiews[16]:

$$\text{NFE (wet basis) (\%)} = 100 - (\%\ \text{moisture} + \%\ \text{CP} + \%\text{CF} + \%\ \text{ash} + \%\ \text{CFb})$$

Statistical analysis: Data for moisture (%), dry matter (%), crude protein (%), total ash (%), crude fiber (%), crude fat (%) and NFE from proximate analysis were subjected to one-way Analysis of variance (ANOVA) using the Statistical Package for Social Science (SPSS) var. 20. When a mean effect was significant, the ANOVA was followed by Duncan Multiple Range Test (DMRT) at 5% level of significance[17]. The percentage data was subjected to arcsine transformation before analysis.

RESULTS AND DISCUSSION

Comparison of proximate composition of plant origin feed ingredients is shown in Table 1 and animal origin feed ingredients in Table 2. Pictorial presentation of all studied plant and animal fish feed ingredients is shown in appendix Table 1. There was significant differences ($p<0.05$) in the mean values of all the proximate composition of plant origin feed ingredients. The moisture level of plant origin feed ingredients ranged between 9.13±1.35-14.14±0.65%, where the highest value was found in wheat bran and lowest in sesame oil cake. According to Akiyama[18] high level of moisture (>12%) accelerates the spoilage during storage. However, among the plant ingredients, 77.78% of mustard oil cake and rice bran (A-grade), 7.14% soybean oil cake, 50.00% of rapeseed oil cake, wheat bran and de oil rice bran samples were in lower standard, while among animal origin feed ingredients all the samples of fish meal and meat and bone meal were within the standard limit in terms of moisture content according to national fish feed ingredients standard of Bangladesh[19].

In plant origin feed ingredients the highest value of crude protein was found in soybean oil cake (46.28±2.92%) and lowest in rice bran (B-grade) (8.49±0.64%). Soybean oil cake and soybean full fat are increasingly being utilized in shrimp and fish feeds due to their nutritional quality, lower cost and availability. Soybean full fat's crude protein content was 37.79±1.53% which almost similar with the findings of Ali and Hoq[20] and NRC[6]. Therefore, soybean oil cake can be a better choice for incorporation in fish feed to meet protein requirement of fish. Despite this favorable composition, the

Table 1: Proximate composition of plant origin feed ingredients

	Proximate composition (dry matter basis %)						
Parameters	Moisture	Dry matter	Crude protein	Total ash	Crude fiber	Crude fat	Nitrogen free extract (NFE)
Mustard oil cake	13.31±1.59^{ab}	86.69±1.60^{bc}	33.04±5.74^{c}	9.90±2.24^{cd}	9.36±2.48^{cd}	3.75±1.95^{d}	30.65±5.01^{cd}
Soybean oil cake	12.67±1.64^{ab}	87.33±1.64^{bc}	46.28±2.92^{a}	6.80±0.89^{fg}	6.12±1.39^{e}	1.05±0.41^{d}	27.08±4.56^{d}
Sunflower oil cake	12.67±2.09^{ab}	87.34±2.09^{bc}	27.91±1.13^{d}	6.49±0.91^{fg}	21.16±1.32^{a}	2.09±0.27^{d}	29.70±2.77^{cd}
Sesame oil cake	9.13±1.35^{c}	90.87±1.35^{a}	28.45±3.47^{d}	7.99±1.67^{ef}	13.50±1.07^{b}	7.12±1.58^{c}	33.82±2.22^{c}
Rapeseed oil cake	12.31±0.98^{ab}	87.69±0.98^{bc}	38.90±0.93^{b}	7.67±1.01^{ef}	10.45±1.94^{cd}	0.99±1.31^{d}	29.69±2.50^{cd}
Rice bran (A-grade)	12.84±1.77^{ab}	87.16±1.77^{bc}	14.57±1.50^{f}	10.43±2.16^{c}	8.66±3.18^{de}	12.29±3.26^{b}	41.22±5.15^{b}
Rice bran (B-grade)	11.74±2.59^{b}	88.26±2.59^{b}	8.49±0.64^{h}	20.09±2.89^{a}	11.72±1.00^{bc}	2.53±0.30^{d}	45.43±5.57^{b}
De oil rice bran	12.06±0.54^{ab}	87.94±0.54^{bc}	18.47±1.77^{e}	14.09±0.89^{b}	10.58±1.37^{cd}	1.35±0.38^{d}	43.45±0.73^{b}
Maize	12.79±1.51^{ab}	87.21±1.51^{bc}	8.95±1.76^{gh}	1.78±0.87^{h}	2.49±0.92^{f}	2.84±1.01^{d}	71.16±3.64^{a}
Wheat bran	14.14±0.65^{a}	85.87±0.65^{c}	12.37±2.98^{fg}	18.02±4.18^{a}	10.13±1.28^{cd}	2.21±1.73^{d}	43.14±1.70^{b}
Wheat flour	12.70±1.05^{ab}	87.30±1.05^{bc}	11.83±1.73^{fgh}	1.43±0.48^{h}	1.89±0.35^{f}	1.62±0.75^{d}	70.53±2.09^{a}
Soybean full fat	12.40±0.62^{ab}	87.61±0.62^{bc}	37.79±1.53^{b}	4.96±0.55^{g}	5.96±0.73^{e}	18.93±1.07^{a}	19.97±2.53^{e}
Corn meal	12.67±1.11^{ab}	87.33±1.11^{bc}	13.63±1.43^{f}	1.92±0.30^{h}	2.13±0.17^{f}	1.44±0.21^{d}	68.21±1.54^{a}
F-value	2.494	2.494	207.184	62.017	33.573	66.917	138.795
p-value	0.006	0.006	0.000	0.000	0.000	0.000	0.000

Table 2: proximate composition of animal origin feed ingredients

	Proximate composition (dry matter basis %)						
Parameters	Moisture	Dry matter	Crude protein	Total ash	Crude fiber	Crude fat	Nitrogen free extract (NFE)
Fish meal	10.61±1.01^{b}	89.39±1.02^{a}	57.27±6.66^{b}	20.31±7.45^{de}	2.99±2.90^{ab}	7.93±1.95^{ab}	0.89±0.84^{b}
Meat and bone meal	10.52±1.02^{b}	89.48±1.02^{a}	49.08±2.88^{c}	27.65±1.39^{bc}	1.59±0.43^{ab}	10.33±2.02^{a}	0.82±0.89^{b}
Dry shrimp meal	16.68±1.76^{a}	83.32±1.76^{a}	42.90±3.42^{cd}	25.46±1.74^{bcd}	2.52±0.49^{ab}	8.09±0.88^{ab}	4.35±1.51^{a}
Dry trash fish	15.16±4.87^{a}	84.84±4.87^{a}	30.44±2.11^{e}	46.96±4.54^{a}	2.39±0.53^{ab}	4.08±1.86^{c}	0.98±0.74^{b}
Dry fish local	15.08±3.12^{a}	84.93±3.12^{a}	39.65±7.35^{d}	32.91±8.55^{b}	3.33±1.44^{a}	6.85±2.84^{b}	2.15±2.03^{b}
Protein concentrate	8.69±0.53^{b}	91.31±0.53^{a}	64.24±3.37^{a}	17.51±4.24^{e}	1.02±0.23^{b}	8.11±1.50^{bc}	0.45±0.58^{b}
f-value	7.541	1.514	28.392	16.291	1.709	5.058	5.149
p-value	0.000	0.213	0.000	0.000	0.161	0.002	0.001

nutritional value of soybean oil cake may be lower than expected, mainly due to the presence of anti-nutritional factors, such as protease inhibitors, lectins, phytates and tannins[21]. Mono-gastric animals such as fish are now reduced in growth due to anti-nutritional factors used in fish feed[22]. Therefore, successful utilization of these resources in aquafeed requires removal or inactivation thtrash processing prior to usage[23]. According to Li and Robinson[24] ingredient which content less than 20% protein are considered as energy feedstuffs rather than protein feedstuffs. Therefore, among the samples of plant origin feed ingredients, mustard oil cake (33.04±5.74%), soybean full fat (37.79±1.53%), rapeseed oil cake (38.90±0.93%), sesame oil cake (28.45±3.47%) and sunflower oil (27.91±1.13%) cake can also be used as protein source along with soybean oil cake. There was significant difference in the mean values of crude protein content of animal origin feed ingredients with the highest value was found in protein concentrate (64.24±3.37%) and lowest in dry trash fish (30.44±2.11%). Although protein concentrate has the highest protein content, it has limited used in fish feed formulation. Second highest protein contents in animal origin feed ingredients was found in fish meal (imported) (57.27±6.66%) and it is most common feed ingredient used for protein source in fish feed. Meat and bone meal (MBM) have been widely used as protein sources for aqua feed due to high protein content and good essential amino acid profile. Mazid *et al.*[25] reported that MBM contains 40-50% protein and our finding (49.08±2.88%) was also within this range. Craig and Helfrich[2] stated that complete fish diets should have protein content of 18-50%. Therefore, fish meal and MBM can be easily replaced by soybean oil cake for used in fish feed as soybean oil cake has more or less similar protein content like fish meal and MBM. In the present study, all the samples (100%) of three category rice bran, rapeseed oil cake, 50% wheat bran and 89% mustard oil cake were within national standard limit in terms of crude protein. On the other hand, similar to FM and MBM, all the samples of soybean oil cake were in within national standard in terms of crude protein content as all the samples contains more than 40% crude protein.

Total ash content of plant and animal origin feed ingredients also have significant differences ($p<0.05$) among them. Among the plant origin feed ingredients highest ash content was found in rice bran (B-grade) (20.09±2.89%) and

lowest in wheat flour (1.43±0.48%), while in animal origin feed ingredients highest ash content was found in dry trash fish (46.96±4.54%) and lowest in protein concentrate (17.51±4.24%). Al Mahmud *et al.*[26] reported that ash content of local fish meal, mustard oil cake, rice barn, wheat bran, wheat flour were 34.97, 6.99, 14.79, 8.96 and 2.50%, respectively where present findings was almost similar with local fish meal and wheat flour. Standard for total ash content for all ingredients are not available in feed rules of Bangladesh. Among the tested samples of plant origin feed ingredients samples of only 33.33% mustard oil cake exceed the maximum set limit while other ingredients were within the national standard. Among animal origin feed ingredients, all the samples of MBM were in within standard set limit in terms of total ash content, where 37.5% of FM samples were above the national standard limit[19]. There was significant ($p<0.05$) difference among the plant and animal origin feed ingredients in crude fiber content. Among plant origin feed ingredients the highest crude fiber was found in sunflower oil cake (21.16±1.32%) and lowest in wheat flour (1.89±0.35%). Among animal origin feed ingredients, higher crude fiber were found in the samples of local dry fish (3.33±1.44%) and lower in protein concentrate (1.02±0.23%). Bhuiyan *et al.*[27] reported that fiber content of mustard oil cake, soybean oil cake, sesame oil cake, rice bran (A-grade), wheat bran, wheat flour were 12.12, 18.49, 11.18, 20.85, 10.98 and 1.12%, respectively which all were higher than present findings except for the value of wheat flour. NRC[6] stated crude fiber content in rapeseed oil cake, corn meal, sunflower oil cake, soybean full fat, soybean oil cake were 11.1, 2.8, 21.0, 5.0 and 7.3% where all were close with the present findings. Bhuiyan *et al.*[27] found that fiber content of fish meal/dry fish was 2.17% which is close to the present result. Among the samples analyzed, 72.22% mustard oil cake, 75.00% rapeseed oil cake, 97.22% rice bran (A-grade), 100% de oil rice bran, 50.00% wheat bran and 100% of soybean oil cake samples were in within standard limit in terms of total fiber content according to Fish Feed Rules[19]. Therefore, it is beneficial to add these feed ingredients in fish feed to reduce total feed cost in aquaculture feed. However, all the samples of MBM were in within the standard limit in terms of total fiber content according to feed rules (2011).

There was a significant difference ($p<0.05$) in the mean values of crude fat contents among plant and animal origin feed ingredients. Highest crude fat was found in soybean full fat (18.93±1.07%) and lowest in rapeseed oil cake (0.99±1.31%). Among animal origin feed ingredients the highest crude fat was found in MBM (10.33±2.02%) and the lowest in dry trash fish (4.08±1.86%). According to NRC[6], crude fat content of soybean oil cake, sun flower oil cake, sesame oil cake, rapeseed oil cake, rice bran (A-grade), wheat bran, wheat flour and corn meal, shrimp meal and meat and bone meal were 1.5, 2.3,7,3.2, 14.5, 4, 1.2, 3.2 and 11%, respectively which is close to the present findings except for rapeseed oil cake, wheat bran and dry small shrimp. Channarayapatna[28] reported that crude fat content of soybean oil cake, soybean full fat, de oil rice bran, maize, fish meal and meat and bone meal were 1.86, 19.47, 1.48, 4.16, 9.85 and 10.63%, respectively which is almost similar with the existing results excluding soybean oil cake and maize. Among the samples studied 88.89% mustard oil cake, 41.67% rice bran (A-grade), 50.00% rapeseed oil cake, 55.56% soybean oil cake and 100% of wheat bran and rice bran (B-grade) were in lower standard in terms of total fat content according to Fish Feed Rules[19]. However, 87.50% fish meal, 100% of MBM and de oil rice bran samples were within in standard limit according to Fish Feed Rules[19]. There was also significant difference ($p<0.05$) in the mean values of NFE in both plant and animal origin feed ingredients. Among the plant origin feed ingredients NFE were the highest in maize (71.16±3.64%) and the lowest in soybean full fat (19.97±2.53%), while in animal origin feed ingredients the highest NFE was found in dry shrimp meal (4.35±1.51%) and the lowest in protein concentrate (0.45±0.58%). According to Bhuiyan *et al.*[27], NFE of rice bran, wheat flour, wheat bran, soybean meal, sesame oil cake, mustard oil cake and dry fish local were 42.0, 75.6, 66.75, 37.39, 34.97, 34.38 and 4.34%, respectively that is close to the present findings except for wheat bran. Ali and Hoq[20] stated that NFE content of mustard oil cake, wheat flour, maize, sesame oil cake, shrimp meal, dry fish was 30-40, 70-75, 65-70, 30-35 and 2-4%, respectively which was more or less similar with the contemporary results.

CONCLUSION

It can be concluded that high price fish ingredients can be replaced by locally available fish feed ingredients to formulate low cost quality fish feed for aquaculture industry. A balanced mixture of feed ingredients will provide more balance nutrients than only use of inadequate feed components to formulate the fish feed.

SIGNIFICANCE STATEMENT

Information on nutritive value of local market feed and proximate composition of feed is essential. Therefore, the present study will provide necessary information regarding to proximate composition of locally available feed ingredients to be chosen in formulation of nutritious feed for aquaculture species in Bangladesh.

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