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Determination of proximate composition of native catfish (*Mystus cavasius*) fed with poultry offal's protein rich formulated feed in captive condition

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Abstract

The experiment was conducted to evaluate the effects of poultry offal feed on the body composition of Gulsha fish (*Mystus cavasius*) using four treatments and three replications for 60 days. Using AOAC method, dry matter (DM), moisture, crude protein (CP), crude fat (CF), and total ash were measured during experimental trial in a laboratory setting to assess the changes of proximate composition of Gulsha fish fed on four different poultry offal formulated feeds viz., Diet-1 (30% FM+0% POM); Diet-2 (20% FM+10 POM); Diet-3 (10% FM+20 POM), and Diet-4 (0% FM+30% POM). In dry matter basis, mean value of dry matter, moisture, crude protein, total ash and crude fat of fingerlings Gulsha were found to be 24.7%,75.3%, 63.27%, 10.6%, and 10.56%, respectively. After culturing with different formulated diets, the mean value of dry matter, moisture, crude protein, total ash and crude fat were found to be diet1 (23.53%, 76.47%, 67.22%, 10.58%, 12.09%), diet2 (22.63%, 77.37%, 71.17%, 10.16%, 12.38), diet3 (22.97%, 77.03%, 68.17%, 10.1%, 11.30%), and diet4 (23.02%, 76.97%, 65.32%, 10.24%,11.18&), respectively. The study found significant variation in proximate composition between fingerling Gulsha and cultured with formulated diets. Diet-2 had the highest protein content (71.17%), moisture content (77.37%), and fat content (higher in diet-2 compared to fingerling). The result suggests that feeding Gulsha with protein-rich poultry offal formulated fish feed as an alternative to fishmeal.

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Introduction

Bangladesh has South Asia's largest flooded wetland and diverse aquatic biodiversity. Fisheries region benefits from open water resources, diverse aquatic life, but faces wetland depletion (Shamsuzzaman, 2017). Bangladesh's fisheries sector is diverse, with 265 species in freshwater and 475 species in marine water. Annual production is 30,616 MT and fish contributes 60% to the nation's animal protein intake (DoF, 2010). Fisheries play a crucial role in nutrition, economic development, and foreign exchange earnings, accounting for 7% employment, 3.74% GDP, and 22.23% agricultural value addition (DoF, 2022). The sector has also occupied 1.28 million fisherman and 4.23 million fish farmers (DoF, 2022).

Gulsha, (*Mystus cavasius*), a popular freshwater catfish in Bangladesh, is a slurid species with a rich nutrient value (Hossain *et al.*, 2015) despite habitat destruction and human activities. Feed plays a vital for aquaculture growth and production. Fish feed ensures food safety and efficient growth for various fish species (Thorarinsdottir *et al.*, 2011). Economically productive aquaculture systems require low-cost, high nutrition feeds (Akiyama *et al.* 1988). Poultry offal meal (POM) is a low-cost alternative animal protein source with 57-65.5% crude protein (Redoy *et al.*, 2021). Aquaculture feeds primarily use fishmeal for protein but limited supply makes it sparingly needed (Bureau *et al.* 1999). Alternative fish diets should include essential amino acids, fatty acids, vitamins, and minerals for growth, health, and financial success (Thompson *et al.* 2012). Poultry offal is an economical substitute for fishmeal, providing essential amino acids, minerals, vitamins, and a high protein level. It is also relatively free of cost, making it a great alternative to fishmeal in aqua diets (Alofa & Abou, 2010; Giri *et al.*, 2010). Around half of its 126 million citizens live in deprivation, and half of children below six show chronic malnutrition (BBS, 2004). Nutritionists and food scientists believe that better health can be ensured through increased fish production, as fish muscle contains all necessary nutrient components for human body maintenance (Borgstrom, 1962). Fish protein is highly digestible and contains all essential amino acids, making it a suitable choice for human consumption (Nowshad, 2007). Proximate composition is the estimation of moisture, protein, fat, and ash components in fresh fish, accounting for 96-98% of total tissue constituents (Nowshad, 2007).

This assessment is crucial for nutritive value, processing, and preservation (Me, S.,1962). Protein, fat, and water content are important for consumers, scientists, and manufacturers, as they determine energy content (Mridha *et al.*, 2005; Murray *et al.*, 1992). Fish composition and size vary depending on life history demands. The study was examined to determine the factors affecting on energy content in commercial and hand-made fish meals.

Materials and method

Study area and duration

The study area was conducted at the laboratory, Department of Fisheries and Marine Science, Noakhali Science and Technology University, Bangladesh during December 2022- February 2023.

Experimental fish

Mystus cavasius fingerlings (with an average weight of 2g to 3g) was procured from Daulat fish hatchery and nursery at Mymensingh, Bangladesh. They were starved for 24 hrs before commencement of the feeding trial, then 20 fingerlings were stocked into each of twelve 35 L rectangular glass aquarium.

Experimental diets formulation

The diets were prepared by the following steps

a) Collection of ingredients

b) Processing of poultry offal

c) Chemical composition of fish feed ingredients: The chemical composition of feedstuff (fish meal, poultry offal meal wheat bran, de-oil rice bran, rapeseed meal, soybean meal) was performed in Animal Nutrition and Feed Section, DLS, Dhaka.

d) Experimental diets were formulated with different levels of poultry offal meal (POM) to replace fish meal components. The diets include four diets: D1, D2, D3, and D4.

Experiment design with different feeds and treatments

The experiment was carried out by using aquarium (43 cm × 35 cm × 30 cm) installed in the laboratory in semi circulatory aquarium system for a period of 60 days (December 2022-February 2022). The aquarium was aerated 24 hours by the aquarium air-pump with 25% level of water exchange daily and thermo-state water heater was applied to fix the water temperature. Four treatments were used in the experiment with three replications. All the treatments were subjected to the same stocking density and feed quantity. The fingerling of Gulsha had an initial weight of gm. The fingerlings were randomly distributed at a rate of 20 fish per aquaria. The aquarium was cleaned per week. D1R1, D1R2, D1R3 for the first treatment (control), D2R1, D2R2, D2R3 for the second treatment, D3R1, D3R2, D3R3 for the third treatment and D4R1, D4R2, D4R3 for the forth treatment. The experimental diet containing 35% protein was formulated to contain variable proportions of poultry offal meal (POM) to partially/totally replace with fish meal component. The first treatment (D1) was containing the fish meal 30% and without the (POM), the second treatment (D2) was 20% fish meal and 10% (POM), the third treatment (D3) was 10% fish meal and 20% (POM), and the forth treatment (D4) fed was with only 30% (POM)

Feeding

The fish was fed at the daily rate of 12 % biomass for 1st month and 10% biomass for 2nd month. The diets were administered thrice daily at 6.00am, 6.00 pm and 11.00pm in equal portions. The daily rations were adjusted accordingly after each monthly weighing.

Determination of proximate composition

The nutritive composition of fish was determined using convention method of Association of Official Analysis Chemists (AOAC) (1980)/95/2000).

Analysis of proximate composition

The moisture, protein, fat, and ash content were determined using the AOAC method (AOAC, 1995), Micro-Kjeldhal method and Bligh and Dryer method. The percentage of moisture, protein, fat, and ash content were calculated using the following formulas.

1. Moisture content (%) = $\frac{\text{Initial Weight (g)} - \text{Final Weight (g)}}{\text{Weight of sample (g)}}$ x 100

2. Ash (%) = $\frac{\text{Weight of ash}}{\text{Weight of sample}} \mathbf{x\ 100}$

3. Protein content (%) = $\frac{(a-b) \times 14 \times d \times 6.25}{a \times 1000}$ x 100

4. Crude lipid content (%) = $\frac{D-B}{A}$ x 100

5. Carbohydrate (NFE) (%) =100 – (% moisture +% protein +% lipid +% ash)

Data analysis

Data analyzed using ANOVA, Tukey's HDS post hoc, IBM SPSS 20.0, MS EXCEL 2016.

Result and discussion

The study was analyzed *Mystus cavasius* proximate composition in experimental diets for 60 days. Results showed varied protein, fat, ash, and moisture content after using varying levels of poultry offal. The findings offer valuable insights into the fish's proximate composition in aquariums.

Table 1. Nutrient contents of Diet-1, Diet-2, Diet-3, and Diet-4.

Components	Diet-1 Control (0%)	Diet-2 (33.33%)	Diet-3 (66.66%)	Diet-4 (100%)
Dry matter	92.44	88.97	89.87	89.35
Moisture	7.56	11.03	10.13	10.65
Protein	34.69	35.63	34.82	35.81
Lipid	15.62	15.24	14.06	19.71
Ash	11.86	11.3	12.37	12.64

Proximate composition of experimental diets (% Dry Matter Basis)

The value of nutrient contents (% DM basis) were found as Diet-1 (dry matter 92.44%, moisture7.56%, protein 34.69%, lipid 15.62%, ash 11.86%); Diet-2 (dry matter 88.97%, moisture11.03%, protein 35.63%, lipid 15.24%, ash 11.30%); Diet-3 (dry matter 89.35%, moisture10.13%, protein 34.82%, lipid 14.06%,

ash12.37%), and Diet-4 (dry matter 89.35%, moisture10.65%, protein 35.81%, lipid 19.71 %, ash 12.64 %), respectively are presented in Table 1.

Fingerling Gulsha's initial proximate composition before culture on dry matter basis

The results observed that the mean value of nutrient contents (Dry matter basis) of the Fingerling Gulsha were found as moisture 75.30%, dry matter 24.70%, crude protein 63.27%, ash 10.60%, and crude fat 10.56% (Table 2 and Fig. 2). The highest moisture content, dry matter, crude protein, ash, and crude fat was found in (S3:75.98%, S1:25.63%, S3:63.97%, S2:10.86, and S3:11.13%, respectively) and the lowest in (S1:74.37%, S3:24.02%, S1:62.05%, S1:10.29% and S1:9.68%, respectively) (Table 2). Interestingly, no crude fibre was found among the sample (Table 2). On dry matter basis proximate composition of Gulsha (*Mystus cavasius*) after culturing with different diet (Diet-1, Diet-2, Diet-3 and Diet-4).

Table 2. Fingerling Gulsha's initial proximate composition before culture based on dry matter.

Sample	Moisture (%)	Dry matter (%)	Crude protein (%)	Ash (%)	Crude fat (%)	Crude fiber (%)
S1	74.37	25.63	62.05	10.29	9.68	Nil
S2	75.55	24.45	63.78	10.86	10.86	Nil
S3	75.98	24.02	63.97	10.65	11.13	Nil
Mean	75.30	24.70	63.27	10.60	10.56	

Analysis of variance (ANOVA) revealed that the mean protein content among the cultured Gulsha with Diet-1, Diet-2, Diet-3, Diet-4 was found significant variation ($P<0.05$) (Table 3 and Fig. 3). A column indicates the comparison of the proximate value of Diet-1, Diet-2, Diet-3, and Diet-4 of cultured Gulsha on dry matter basis. The results found that the percentage of moisture was higher in Diet-2 (77.37%), while the lowest amount of moisture was in Diet-1 (76.47%). Further, the percentage of dry matter was found in maximum (23.53%) in Diet-1, while the lowest value (22.63%) was found in Diet-2. Moreover, the percentage of total ash was recorded in the highest (10.58%) in Diet-1 and the lower value was in Diet-3 (10.10%). Furthermore, the percentage of crude protein and crude fat were found higher (71.18%), (12.38%) in Diet-2, respectively whereas the lowest value of crude protein and fat (65.32%), (11.28%) were found in Diet-4. There was no crude fibre was found (Table 3).

Table 3. The proximate composition of Gulsha (*Mystus cavasius*) after culturing with different diet (Diet-1, Diet-2, Diet-3 and Diet-4).

Diet	Moisture (%)	DM (%)	CP (%)	Ash (%)	CF (%)	Cf (%)
Diet-1 (Control)	76.47±0.51	23.53±0.51	67.22±0.78	10.58±0.39	12.09±0.97	Nill
Diet-2	77.37±0.56	22.63±0.56	71.17±0.95	10.16±0.21	12.38±0.68	Nill
Diet-3	77.03±0.58	22.97±0.58	68.17±0.71	10.10±0.51	11.30±0.52	Nill
Diet-4	76.97±0.42	23.03±0.42	65.32±0.80	10.24±0.16	11.18±0.71	Nill
Mean	76.96	23.04	67.97	10.27	36.74	Nill

Here. DM= Dry Matter, CP= Crude Protein, CF= Crude Fat, Cf= Crude fiber.

Percent changes of proximate composition from initial to culture with different diets

The percent changes of protein comparatively higher in Diet-2 (12.49%) and the lowest in Diet-4 (1.66%) from the initial to cultured Gulsha with different poultry offal formulated feed. On the other hand, the percent of Ash was comparatively decreeing after using formulated fish feed. In case of dry matter, the percentage was decress in diet-1 after using poultry offal fish meal but except diet-1 there was no change in the ratio for other diets. Changes of fat were higher except diet-3. Besides, the percent changes of fat were

found higher (17.23%) in Diet-2 and the lowest in Diet-4 (5.87%). The percent changes of moisture comparatively higher in Diet-2 (2.75%) and the lowest in Diet-1 (1.55%) from the initial to cultured Gulsha with different poultry offal formulated feed (Table 4).

Proximate composition Analyzed samples for dry matter, moisture, protein, ash, and fat constituents. The proximate composition of fish varied from species to species and even within the same species from one individual to another (Stansby,1962).

Table 4. Percent (%) changes of proximate composition from initial to culture with different diets.

Contents	Moisture	Dry matter	Protein	Ash	Fat
Initial	75.30	24.70	63.27	10.6	10.56
% changes of proximate composition					
Contents	Moisture	Dry matter	Protein	Ash	Fat
Diet-1	1.55	-4.74	6.24	-0.19	14.49
Diet-2	2.75	0.00	12.49	-4.16	17.23
Diet-3	2.30	0.00	7.74	-4.72	7.01
Diet-4	2.22	0.00	1.66	-3.40	5.87

The study found that moisture content in fish muscle varied from 75.3% to 77.37%, with highest values in cultured fish Gulsha with diet-2 and lowest in fingerling Gulsha. The results are in a good agreement of the previous findings (Ahmed *et al.*, 2012; Jena *et al.*, 2018). Rahaman *et al.* (2020) conducted the study on the proximate composition of *Mystus cavasius* where the moisture contents were 77.10% and 77.75%, respectively in wet matter basis.

Fig. 1. Gulsha (Mystus cavasius).

The result showed *Mystus cavasius* contained 77.28% moisture. According to Rahman *et al.* (2003), *M. vittatus* contains 75.6% moisture which agrees more or less with this present investigation. This experimental result is similar with the findings of Ahmed *et al.* (2012) but deviated from the finding of paul *et al.* (2015) in native catfish which might be due to season or feeding habit.

Fish protein is high quality, essential amino acid-rich, and easily digestible for growth, repair, and development. The present study showed that protein content (%) varied from 63.27% to 71.18%. Protein content varies between initial fingerling Gulsha and cultured Gulsha with different diets.

The highest protein content (%) was found in after cultured with Diet-2 and the lowest value in the fingerling condition. The amount protein in fish was reported to be in a range of 13-20 % (wet basis) (Desrosier *et al.*, 1977). In another experiment, Govindan *et al.* (1985) also reported to be a range 9-25 % (wet basis) protein freshwater and marine fish. All the above studies suggest a wide range for protein to present in general fish. Protein content is subjected to the variation of factors such as size, sex, habitat, physiological condition and also season. (Mohsin *et al.*, 1990; Borgstrom, 1961; Khuda *et al.*, 1962). Catacutan and Coloso (1995) reported that high protein content on a dry matter basis was affected by feed quality. Pal and Chakrabarty (2012) observed the protein content 16.63%, 16.15-17.6%, 16.97-17.42% (wet basis) of *Mystus cavasius* during the rearing and feeding trial with different Vitamin C level for the different time of rearing (1days, 30days and 60days).

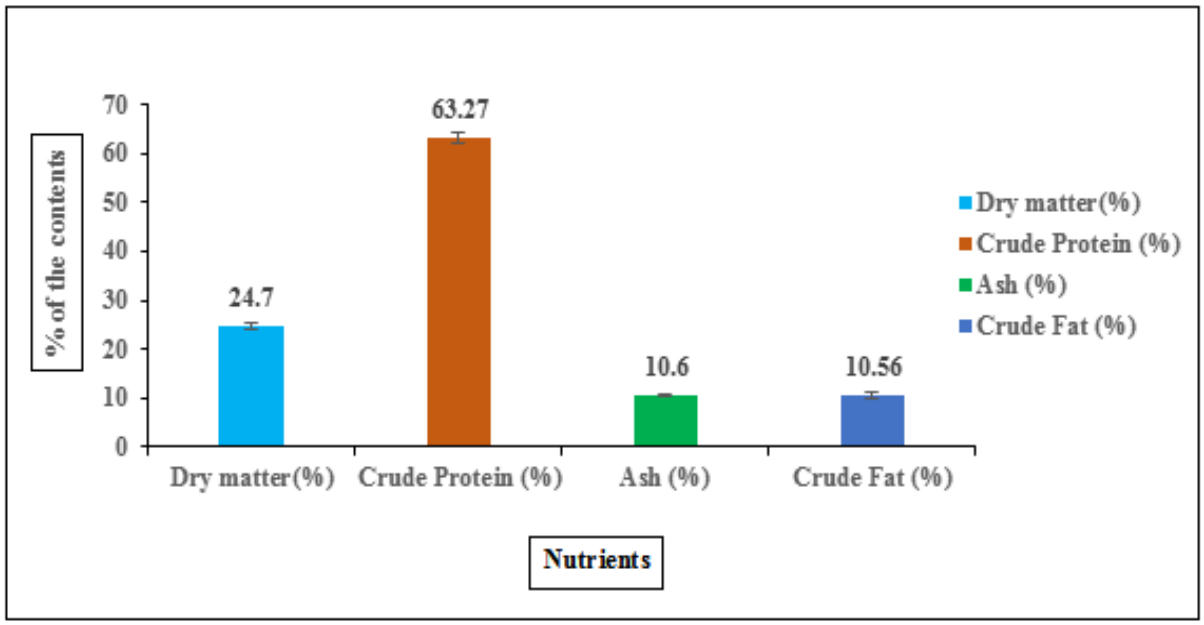

Fig. 2. Bar indicates initial proximate composition of Fingerling Gulsha before culture.

This result is dissimilar due to the method of determination (Wet basis and Dry matter basis). Kitts *et al.* (2004) conducted a study on chemical composition of various fish and found Chai Bo fish contained 55.0% crude protein, some mixed small whole fish contained 51.9% crude protein. Chakwa and Shaba (2009) reported that the African catfish (*Clarius gariepimus*) contained 53.5%-67.2% crude protein in general which are more or less similar to our study.

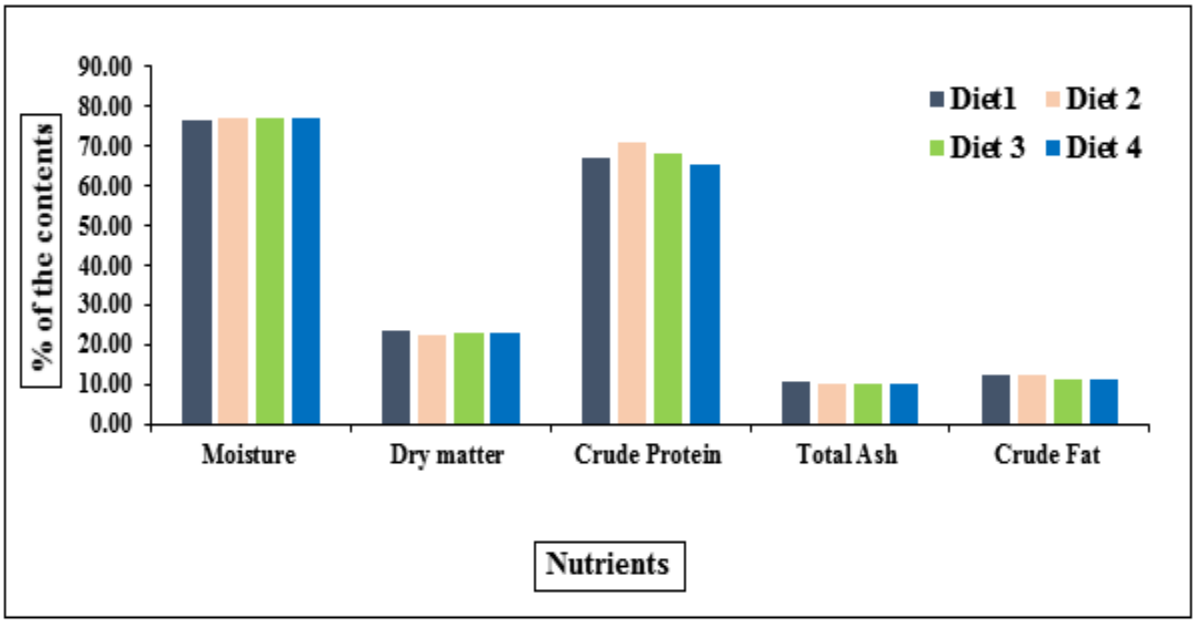

Fig. 3. Comparison of proximate analysis of Diet-1, Diet-2, Diet-3 and Diet-4 of cultured Gulsha.

The present study also approximately agreed with the subsequent result of crude protein in *Mystus tangara* (Ahmed *et al.*, 2012; Jena *et al.*, 2018; Hossain *et al.*, 1998). Lipids are crucial for fish growth and development, with lipid content varying between fingerling and cultured Gulsha with different feeds, influenced by species, season, age, and feeding habits (Salam *et al.*, 1995). The lipid content content of fingerling Gulsha and cultured Gulsha with Diet-1, Diet-2, Diet-3 and Diet-4 were 10.56 %, 12.09%,

12.38%, 11.30%, 11.28%, respectively. In the present study, the percentage of lipid content found to be higher in Diet-2 and the lowest lipid content value was found in fingerling condition of Gulsha. Hossain *et al.* (1999) observed that the Gulsha contained 2.76% lipid in wet basis and 13.44 % lipid in dry basis. The lipid content also coincides with preceding studies (Ara *et al.*, 2006). The result showed that *Mystus cavasius* contained 2.26 % in wet basis and 10.78 % in dry basis. The lipid content in the present study ranged from 10.56% to 12.38%, respectively on dry matter basis. Rahman *et al.* (1982) reported that crude fat content in some Bangladeshi zeol fish was 2.18%-9.38% which are more or less similar to the values obtained in the present study.

Ash content in fingerling Gulsha and cultured Gulsha varied with different feeds, with fingerling Gulsha having the highest value (10.60%) and cultured Gulsha having the lowest value with Diet-3. CSIR (1962) reported that the ash content of some selected fish species in India ranged between 1.53% to 2.60% (on wet basis) and 7.85% to 11.21%(on dry matter basis) which are more or less similar to the values obtained in the present study.

The ash content is relatively low in our present study. This finding is dissimilar from that of Hossain *et al.* (1999) who reported that tengra contained 4.30% protein in wet basis and 20.92 % in dry basis. Ara *et al.* (2006) also reported that tengra contained 20.92-22.60% ash. Mineral concentrations vary due to seasonal changes, age, food availability, habitat, water chemistry, salinity, temperature, and contaminants (Kucukgulmez., 2006; Hasan, 1996).

Conclusion

Naturally, Bangladesh has a plentiful supply of both marine and fresh water fish. Fish is a nutrient-dense food with a high protein and mineral content. The study found that feeding native catfish with a poultry offal-based formulated feed increased protein content and moisture content compared to fingerling conditions. However, there was no significant difference in fat content. This suggests that protein-rich poultry offal meals can be an effective, cost-effective source of protein for fish diets, improving growth performance, feed utilization, and health of Gulsha fish. Hence, the aqua farmer may easily determine the chemical composition of various feed ingredients in order to meet the biochemical and mineral requirements.

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Refrences

Ahmed S. 2012. "Nutrient composition of indigenous and exotic fishes of rainfed waterlogged paddy fields in Lakshmipur, Bangladesh". World Journal of Zoology **7(2),** 135-140.

Akiyama DM. 1988. "Soybean meal utilization by marine shrimp. AOCS world congress on vegetable protein utilization in human food and animal feedstuffs, Singapore".

Alofa CS, Abou Y. 2020. "A Mixture of Chicken Viscera, Housefly Larvae and Spirulina Waste as Replacement of Fishmeal in Nile Tilapia (*Oreochromis niloticus*) Diets". *Aquaculture Studies* **21(1),** 11-21.

AOAC. 1995. "Official Method of Analysis, 12th edn, Association of official Analytical Chemists". Washington DC 832.

AOAC. 1995. "Official Methods of Analysis of the AOAC International, 16th ed., Association of official analytical chemists". Washington DC 1285.

Ara H. 2006. "Proximate and mineral composition of four tengra (*mystus sp.*) fishes of Bangladesh". Khulna University Studies 51-54.

BBS. 2004. **"**Child Nutrition Survey of Bangladesh 2003. Bangladesh Bureau of Statistics and UNICEF".

Borgstrom G, Geiger E. 1962 "Fish protein nutritive aspects. Fish as Food". *G. Academic Press* **3,** 29.

Borgstrom G. 1961. "New methods of appraising the role of fisheries in world nutrition". *Fishing News Int* **1,** 33-37.

Bureau. 1999. "Apparent digestibility of rendered animal protein ingredients for rainbow trout (*Oncorhynchus mykiss*)". *Aquaculture* **180(3),** 345-358.

Catacutan MR, Coloso RM. 1995. "Effect of dietary protein to energy ratios on growth, survival, and body composition of juvenile Asian seabass, Lates calcarifer". *Aquaculture* **131(1),** 125-133.

Chakwa O, Shaba LM. 2009. "Effect of drying method on proximate composition of cat fish (*Clarialgarie pinus*)". Journal of World Agricultural Science **5(1),** 114-116.

CSIR. 1962. "Annual report". Pretoria: *CSIR* 1-60.

Do F. 2010. "Jatiya Matshaya Soptaho". Ministry of Fisheries and Livestock.

Do F. 2021. Yearbook of Fisheries Statistics of Bangladesh, "Fisheries Resource Survey System (FRSS)". Department of Fisheries; Ministry of Fisheries and Livestock **38,** 138.

Dresosier NW. 1977. "Element of food technology. The Books by AVI Publishing Company Inc. 384 p.

EL-Sayed, AFM. 2006. Tilapia Culture". *CABI Publishing, Wallingford* GB. 256.

Giri SS. 2010. "Replacement of by-catch fishmeal with dried chicken viscera meal in extruded feeds: effect on growth, nutrient utilisation and carcass composition of catfish *Clarias batrachus* (Linn.) Fingerlings". Aquaculture International **18,** 539-544.

Govidan TK. 1985. "Fish processing technology". *Oxford and IBH publishing Co. New Delhi, Bombay and Calcutta* **48,** 180-198.

Hassan M. 1996. "Influence of pond fertilization with broiler droppings on the growth performance and meat quality of major carps" (Doctoral dissertation, University of Agriculture Faisalabad (Pakistan).

Hossain MA. 1998. "Nutritional value of some small indigenous fish species (SIS) of Bangladesh". Bangladesh Journal of Fisheries Research **3(1),** 77-85.

Hossain MN. 2015. "Evaluation of nutritional properties of some small indigenous fish's species in Bangladesh". International Journal of Biosciences **6(6),** 102-109.

Jena D. 2018. "Proximate analysis of some small indigenous fish species (SIS) of Tripura, India". Journal of Entomology and Zoology Studies **6(4),** 470-474.

Khuda MQ. 1962). "Influence of age of fish on the distribution of protein in their body". Pakistan Journal of Scientific and Industrial Research **5,** 20-23.

Kitts DD. 2004. "Season variation in nutrient composition of Alaskan walleye Pollock". Canadian Journal of Zoology **82(9),** 1408-1415.

Küçükgülmez A. 2006. "Proximate composition and mineral contents of the blue crab (Callinectes sapidus) breast meat, claw meat and hepatopancreas". International Journal of Food Science & Technology **41(9),** 1023-1026.

Me S. 1962. "Proximate composition fish".

Mohsin AS. 1990. "Nutrition Today: March-April". Environment and Social **10,** 32312-BD.

Mridha MA. 2005. "Determination of biochemical composition of Cirrhinus reba (Hamilton, 1822) from Jessore. Bangladesh". Journal of Science & Technology University Peshwar, **29(1),** 1-5.

Murry J, Burt JR. 1962. "The composition of fish. Ministry of Agriculture". Fisheries and Food, Torry Research Station.

Nowsad AKM. "Participatory training of trainers". In Bangladesh Fisheries Research Forum, Mymensingh, Bangladesh. 2007.

Pal H, Chakrabarty D. 2012. "Evaluations of body composition and growth performance by applying different dietary vitamin C levels in stinging catfish, *Heteropneustes fossilis* (Bloch, 1792)". International Journal of Pharmacy and Biological Sciences **2,** 193-200.

Rahman MA. 2013. "Stocking density effects on growth and production of the threatened silurid catfish, *Mystus cavasius* (Hamilton) fingerlings in nursery ponds". Aquaculture Research **44(7),** 1132-1139.

Rahman SM. 1982. "Proximate composition and status of some small indigenous fish species in Bangladesh". Khulna University Studies **4(1),** 683-688.

Redoy MRA. 2021. "Dose titration of plantain herb (*Plantago lanceolata* L.) supplementation on growth performance, serum antioxidants status, liver enzymatic activity and meat quality in broiler chickens". Italian Journal of Animal Science **20(1),** 1244-1255.

Shamsuzzaman MM. 2017. "Fisheries resources of Bangladesh: Present status and future direction". Aquaculture and Fisheries **2(4),** 145-156.

Stansby ME. "Proximate composition of fish". 1962.

Thorarinsdottir R. 2011. "Local raw materials for production of fish feed for aquaculture".