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Research Article

Biochemical composition of fish wastes: Potentiality for formulation of cost-effective fish feed for sustainable aquaculture

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Abstract

Fish waste that is typically thrown away and could harm the environment can be easily converted into fish feed, making it a valuable resource. In this work, we investigated the biochemical composition and mineral content of fish waste that was collected from three distinct local fish markets (Palashi Bazar fish market, Hatirpool fish market and Jatrabari fish market) in Dhaka. The moisture content of fish wastes collected from three different fish markets ranged from 5.10% to 6.84%. Jatrabari fish market has the highest protein content (67.64%) followed by Palashi Bazar fish market (64.77%) and Hatirpool fish market (62.42%). On the other hand, Palashi Bazar fish Market (21.95%) and Hatirpool fish market (21.10%) have similar fat content, while Jatrabari fish market (20.92%) has slightly lower fat content. Among the minerals calcium content of fish waste (487.98 mg/100g) was the highest and iron content was in the lowest amount (2.15mg/100g). In case of variation from different sources Palashi Bazar Fish market has the highest calcium content (487.98 mg/100g) compared to Hatirpool fish market (451.69 mg/100g) and Jatrabari fish market (429.87 mg/100g). Iron and Phosphorus content also varied based on the location from where they were collected. This study provides some valuable insights on the nutritional content of fish waste and thus suggests the implication of fish waste in fish feed industry to lower the cost of fish feed and make aquaculture sustainable in Bangladesh.

1. Introduction

Fish is a perishable food item that has a high potential for waste and loss [1]. The amount of fish waste has undergone a dramatic increase across the world [2]. More than 50% of fish tissues, including the fins, heads, skin, and viscera, are reportedly discarded since they are viewed as "wastes". This huge amount of waste which is produced through fish farming, fishing, and processing is a problem for the entire world [3]. In the residual waste of fisheries production, there are still many nutrients which will remain intact if these wastes are reutilized to produce fish feed [4]. Fish waste typically includes minerals, 19% fat, and 58% proteins. Additionally, palmitic acid and oleic acid, which make up 22% of the mono-saturated acids in fish waste [5]. However, as discards resulting from poor fishing techniques and sufficient management may be too small, damaged, inedible, or of little market value as well as the discarded fish include unmarketable ones that are damaged during the fishing process, these discards are rarely utilized and are typically thrown away as garbage [6].

Moreover, fish wastes are considered as pollutants causing a serious impact on the environment [7]. Aquaculture waste release into aquatic ecosystems can result in various environmental changes [8]. Dumping of these wastes not only results in the loss of a large amount of bioactive-rich materials but also aggravates pollution problems [9]. Several studies have been conducted to find certain environmentally friendly and profitable options for the utilization of fish processing wastes such as converting them into fertilizers and animal feed as well as human stuff [10]. Generally, the discarded parts of fish are ground into fish meal as a major component for livestock and aquaculture feed [11]. Feed from fishery waste has great potential as a high-end product [12]. The main current uses for fish and shrimp waste are: separation of collagen and antioxidants for cosmetics, biogas, biodiesel, fertilizers, diet applications, food packaging, enzyme separation, fish sauce, fishmeal, and fish silage [13]. Fish waste is used primarily in the fishmeal industry since it contains approximately the same amount of proteins as fish meat [14]. Fish waste can be processed to produce numerous fertilizers, and commercial fish-based fertilizers are currently used for agricultural and horticultural crops [15].

Fish plays a crucial role in the nutrition security of Bengali people as two thirds of the animal protein consumed in Bangladesh comes from fish [16]. Moreover, fish (62.6 g) accounts for roughly 60% of the annual animal protein intake when taken into account per capita daily intake, ranking third after starches (471.3 g) and vegetables (167.3 g) [17, 18]. Additionally, when compared to other food groups in the food basket, only fish intake surpasses the daily recommended amount (60 g). Fish not only supplies macronutrients like protein, it is also a good source of micronutrients such as Vitamin A, D and minerals like Calcium, Iron, Iodine and Zinc [19].

The disposal of fish waste is a current and pressing issue, urging novel solutions to implement sustainable waste management practices [20]. It is necessary to give a second life to this waste so that we can reduce pollution and make the fish industry related to fish more efficient [21]. To reduce costs and increase the benefits of aquaculture, we need to develop ways to use these valuable wastes in food or animal feed [22]. However, there are few studies have been undertaken regarding fish waste despite the fact that in the past forty years, there has been a significant growth in the production of inland and marine fish in Bangladesh's fisheries sector [22]. In this burgeoning aquaculture industry feedstuff is an important component, with its cost accounting for approximately 70% of total production inputs [23]. The price of feed ingredients, especially fish meal, has been progressively rising in recent years, which has resulted in researchers exploring alternatives to cope with the rising cost [24]. In this study, we analyzed the fish waste from three different fish markets of Dhaka City which is the capital of Bangladesh to find out their biochemical composition and explored their potential use in the fish feed industry. By reusing fish waste in the production of fish feed, it is possible to get rid of its harmful environmental effects to a large extent as well as support the aquaculture industry to make its growth more sustainable.

2. Materials and methods

2.1. Sample collection and preparation

Fish waste samples were collected from the three local fish markets, Palashi Bazar fish market, Hatirpool fish market and Jatrabari fish market of Dhaka, Bangladesh. From those market places, fish scale, skin, and bone were separated and the rest of the fish waste (head, viscera, meat containing portion of discarded fish) was taken together in a polythene bag. Then they were brought to BCSIR laboratory and washed well and the fat content was separated so that it did not become a part of the sample content. After washing, samples were cut with a knife and divided into small pieces. Then they were sun-dried. The wastes were

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covered by net during drying, so that crows or other birds or animals cannot eat or destroy them. After drying in the sun for 3-4 days samples were further oven dried for 6 hours at about 80 °C in the laboratory. After drying, fish waste samples were made into powder with a blender. Further analysis work had been completed from that powder.

2.2. Chemicals and reagents

Hydroquinone, anhydrous sodium sulfate (≥99.0), concentrated sulfuric acid (≥99.0), sodium sulfite, and selenium dioxide (>96.0) were purchased from Merck. CO. (Darmstadt, Germany). Boric Acid (>99.0), sodium hydroxide, potassium persulfate (>99.0), and ammonium molybdate were collected from Thermo Fisher Scientific (Heysham, UK). Standard of calcium, iron and phosphorus were bought from Inorganic Ventures (Christiansburg, VA, USA). Chemicals used in this analysis other than these were of analytical grade and used in the same condition as they were received. Shimadzu UV-3600i plus Spectrophotometer (Tokyo, Japan) was used to measure the absorption of experimental solutions.

2.3. Proximate content analysis

The samples were proximally analyzed (for crude fat, protein, ash, moisture, and carbohydrate content) in accordance with the Association of Official Analytical Chemists' procedures. For the purpose of determining the ash content (AOAC 942.05), a specific amount of the sample was retained in a crucible and placed in a muffle furnace (L (T)15/12, Nabertherm, Germany) at 600 °C. At 105 °C, the moisture content was measured (AOAC 930.15 [25]. Using the Soxhlet Extraction technique (AOAC 2003.05) and n-hexane, the crude fat of the sample was determined. The crude protein content was determined using the Kjeldahl technique (AOAC 978.04) [26]. The protein content of each sample was calculated using the following formula: %Protein = N 6.25 where N is the amount of nitrogen present, and 6.25 is the conversion factor of protein. The Kjeldahl digestion unit (DLK 42/26, automated digestion, VELP Scientifica, Italy) was used for acid digestion and the distillation chamber (UDK 129, distillation unit, VELP Scientifica, Italy) was used for distillation to determine the crude protein content of the samples. The value of total carbohydrate was the difference between 100 and the total of all components (crude protein, fat, moisture, ash). A percentage (g/100g) was used to indicate all the proximate contents.

2.4. Estimation of minerals content

Determination of the Iron and phosphorus content of the fish waste samples were done by measuring the absorbance using the spectrophotometric colorimetric method which was performed through a UV spectrophotometer (UV-1800 240V, SHIMADZU CORPORATION, Japan). On the other hand, the calcium content of the samples was measured using the flame photometry (LX406FP, LABDEX, UK) reported by the method Vieira et al with some modifications [27]. To prepare mineral solution, a certain amount of each (5 g) selected samples were left for ash in a muffle furnace**.** Then, the dry ash was treated with a solution of HCl, HNO_3 nitric acid, and deionized water. Then the treated samples were subjected to the analysis of Fe, Ca and P. The amount of minerals in the sample dry powder was expressed as mg per 100 g.

2.5. Statistical analyses

The results are expressed as mean ± standard deviation of triplicate analyses of the parameters. Statistical differences in the mean values were analyzed at a 5% level of significance ($P < .05$) by one-way ANOVA (Duncan's Multiple Range Test). Statistical software SPSS (version 22.0, Chicago, IL, USA) was used for the analyses.

3. Results and discussion

The proximate composition of the fish waste from different local markets of Dhaka city is presented in Table 1. Biochemical content among the three markets were compared. Moisture is an important unit due to its holding capacity of all other components in a biological substance. However, the excess moisture content in fish waste will make any product made of it susceptible to microbial attack and thus highly perishable. The moisture content of fish wastes collected from three different fish markets ranged from 5.10% to 6.84% which is analogous to the work carried out by De et.al on certain dry fishes [28]. Fish waste collected from Jatrabari fish Market appears to have the lowest moisture content (5.10%) compared to Palashi Bazar fish market (6.04%) and Hatipool fish market (6.84%). The moisture value differs significantly (P <.05) based on their collection

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Table 1. Proximate composition of the fish waste powder

Name of fish market	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Carbohydrate (%)	Energy (Kcal/100g)
Palashi Bazar	6.04±0.06[b]	5.86±0.13[b]	21.95±0.06[a]	64.77±0.03[b]	1.39±0.11[a]	470.97±0.08[a]
Hatirpool fish market	6.84±0.1[a]	8.68±0.2[a]	21.1±0.06[b]	62.42±0.34[c]	0.96±0.5[a]	451.85±0.31[b]
Jatrabari fish market	5.1±0.19[c]	5.53±0.13[b]	20.92±0.13[b]	67.64±0.16[a]	0.81±0.25[a]	471.0±0.76[a]

Different superscripts (a-c) within the same column indicate significant difference at $P < .05$

site and this variability in moisture content could be due to differences in handling or processing methods employed by each fish market.

Ash content represents the total amount of mineral content in a sample but does not reveal the content of any specific mineral. Ash usually remains undigested in animals and thus higher ash content may dilute the amount of nutrients available to fish if these wastes are used for the preparation of fish feed. In this study the ash content of the collected fish waste is comparable to the previous studies carried on dried fish from local market [29]. Hatirpool fish market has the highest ash content (8.68%), followed by Palashi Bazar fish market (5.86%) and Jatrabari fish market (5.53%).

Protein functions as a very crucial nutrient due to its role in the growth, development and repair of body tissues. In this experiment, Jatrabari fish market has the highest protein content (67.64%) followed by Palashi Bazar fish market (64.77%) and Hatirpool fish market (62.42%). The higher protein content in Jatrabari fish market may be due to the availability of large sizes of fishe from which a huge amount of muscle as a source of was included in the waste samples as fins. Overall, the amount of protein content found in fish wastes is also consistent with the previous study that was carried out [30].

Fat is a high energy yielding nutrient as it gives almost 2.5 times of energy compared to per gram of carbohydrate and protein. In this analysis Palashi Bazar fish Market (21.95%) and Hatirpool fish market (21.10%) have similar fat content, while Jatrabari fish market (20.92%) has slightly lower fat content. The observed differences in fat content might be attributed to variations in fish species, feeding habits, or processing methods, which can affect the accumulation and distribution of fat in the fish.

All three fish markets have relatively low carbohydrate content, with market Palashi Bazar fish market (1.39%) having the highest amount, followed by market Hatirpool fish Market (0.96%) and Jatrabari fish market (0.81%). This is not contrary to the previous literature, as fish is generally considered a low-carbohydrate food source.

Table 2. Mineral composition of the fish waste powder

Name of fish market	Calcium (mg/100g)	Iron (mg/100g)	Phosphorous (mg/100g)
Palashi Bazar	487.98±2.15[a]	2.15±0.03[b]	201.88±0.29[b]
Hatirpool fish market	451.69±1.54[b]	3.11±0.09[a]	193.33±2.69[c]
Jatrabari fish market	429.87±2.89[c]	3.46±0.28[a]	273.88±0.25[a]

Different superscripts ([a-c]) within the same column indicate significant difference at $P < .05$

Fish market Palashi Bazar fish Market (470.97 Kcal/100g) and Jatrabari fish market (471.0 Kcal/100g) have similar energy content, while market Hatirpool fish Market (451.85 Kcal/100g) has a slightly lower value. The differences in energy content can be influenced by various factors, including fat content, protein content, and the presence of other nutrients.

Table 2 shows the Mineral composition of the fish waste powder. Palashi Bazar Fish market has the highest calcium content (487.98 mg/100g) compared to Hatirpool fish market (451.69 mg/100g) and Jatrabari fish market (429.87 mg/100g). Calcium is essential for maintaining healthy bones and teeth, as well as proper nerve and muscle function [31]. Jatrabari Fish market has the highest iron content (3.46 mg/100g) compared to markets Palashi Bazar fish market (2.15 mg/100g) and Hatirpool fish market (3.11 mg/100g). Iron is an important nutrient for the production of red blood cells and the prevention of anemia [32]. Finally, Jatrabari fish market also has the highest phosphorous content (273.88 mg/100g) compared to the other two markets. Phosphorous plays a key role in bone health, energy metabolism, and DNA synthesis [33]. Overall, the mineral content

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found in the fish waste were closed to the mineral content in dried fish mentioned by Banna et al. in their review paper [34].

4. Conclusions

The cost of feedstuff makes up around 70% of all production inputs, making it a crucial part of the aquaculture business. Researchers are looking into alternatives to fish meal as a result of the price of feed ingredients, particularly fish meal, steadily growing in recent years. The high price of fish feed is a persistent threat to the livelihoods of both fishermen and small business owners engaged in aquaculture in underdeveloped nations like Bangladesh. Lowering the price of fish feed is essential for making aquaculture sustainable, and using fish waste as a substitute could be a workable and affordable alternative. Additionally, using fish feed properly will increase the sustainability of the environment.

Authors' contributions

Conceptualization, supervision, analysis, interpretation of the data, editing of the manuscript, M.Z.U.A.M.; Writing the manuscript and analyzing the data, N.H.B.; Writing, drafting, data analyzing, reviewing and editing of the manuscript, M.Z.A.S.; Reviewing of the manuscript, M.N.M.; Data analysis, reviewing and editing of the manuscript., M.S.H., M.B., M.M.R. and K.S.; Reviewing of the manuscript, M.A.S.; Formal analysis, R.A.S.

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Availability of data and materials

All data will be made available upon request to the corresponding author according to the journal policy.

Conflicts of interest

The authors declare no conflict of interest.

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