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Research Article

Production and Evaluation of Quality Characteristics of Edible Fish Powder from Tilapia (*Oreochromis mossambicus*) and Silver Carp (*Hypophthalmichthys molitrix*)

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Fish is recognised as the most nutritious animal protein source, but because of its high deterioration nature, a huge number of fish are being wasted and susceptible to nutritional losses, resulting in a significant hurdle for expanding fish production. This research aimed to lessen these losses through the use of fish powder and to enhance the nutrients in people's diets. In order to prepare fine fish powder, a dried fish paste was milled and sieved. Proximate analysis, mineral content, and physical and microbiological qualities were determined using standard analytical procedures. The protein content of Tilapia and Silver Carp fish powder was 63.63 g/100 g and 73.58 g/100 g, respectively. An appreciable amount of potassium, calcium, magnesium, phosphorus, iron, and zinc was also found in Tilapia and Silver Carp fish powder. The powder also holds an angle of repose of 29.4° and 26.7°, which assures a good flow property. Both Tilapia and Silver Carp fish powder have shown a near neutral pH value (6.40 and 6.32). The hedonic rating scale was used to assess the acceptability of fish powder-fortified cakes. The results showed that the cake fortified with Silver Carp fish powder outperforms the control and Tilapia fish powder sample in terms of taste, flavour, colour, texture, and overall acceptance, while the panellists also preferred the Tilapia fish powder sample. As a result of this research, a high-quality nutritious fish powder from Tilapia and Silver Carp can be prepared and adopted as a food fortifier.

1. Introduction

Undernourishment counts as an invisible impediment to the success of developing countries. In a report, FAO estimated about 768 million people were undernourished worldwide [1]. Protein-energy malnutrition (PEM) and micronutrient deficiencies are two of the major public health problems and these problems can be compensated by increasing the availability and intake of protein from different sources. Meat and meat products cover the major portion of protein sources globally but the production of meat needs vast resources [2, 3] and the consumption of red meat leads to several noncommunicable diseases (NCD) [4].

On the other hand, fish can be not only considered a safe animal protein source but also contain other beneficial nutrients such as potassium, magnesium, calcium, iron, and zinc, which helps to improve physical health and prevent many physical and neurological diseases [5]. The main issue with fish and fishery products is their shelf life. Usually, last for less than a month in modified atmosphere packaging at freezing temperature [6]. Therefore, several studies suggested that using fish powder has a vast opportunity, as it can be blended into our regular food as a supplement. Furthermore, children as their nature, are normally not concerned about a healthy diet and rarely prefer fish in their dishes, and are impatient with bakery products. If those bakery products were fortified with fish powder, the nutritional content of flour would increase and the daily requirement could be fulfilled [7]. Also, whenever there is a food scarcity problem due to natural disasters or else, an emergency food product with an extended shelf life and balanced nutrients are necessary [8]. This ready-to-consume food supply must contain all the nutrients in a compact and stable form. Fish powder can be a significant source of safe, nutritionally complete stable food supplements to compensate for this problem, and use as a food additive to enrich the nutritional value of various foods [9].

Traditionally some fishes are preserved through sun drying on a small scale but this process is performed in unhygienic conditions. Moreover, studies in Bangladesh showed alarming pollutants such as dichlorodiphenyltrichloroethane (DDT), and heptachlor in sun-dried fish [10, 11]. These can lead to severe health problems. On the other hand, oven-dried fish also extends the shelf life of fish at a lower cost in a hygienic way. In comparison with sun-dried fish, it takes a shorter time to dry and has better product quality with lower moisture content and higher protein, lipid, and mineral content [12].

In 2022, Bangladesh was ranked 3rd in inland fish production just after India and China [13]. Associate with modern and efficient technologies such as RAS and Biofloc, the production of freshwater fish such as Tilapia, Catfish, and Silver Carp is increasing day by day. About 42.77 lakh (4.27 million) Metric tons of fish were produced in 2017-2018 where Silver carp and Tilapia were the highest cultivated fish species after Rui and Pangas with 6.71% and 10.62% of annual inland fish production [14]. Resulting in Tilapia and Silver Carp becoming two of the most available, cheapest, and most nutritious fish in the market. Therefore, it is a feasible option to extend the shelf life of these two species by mechanical drying and transform them into new value-added food products which will help to keep up with this huge production and provide the nutrients of fish to the consumer in a new way.

This research work has attempted to produce fish powder from Tilapia and Silver Carp under a low temperature since high heat might temper the nutritional component of fish. Apparently, this paper hypothesised that there would be a difference between these two fish powders, as well as the acceptability of their products. Therefore, the present investigation was carried out in order to assess the quality characteristics of fish powder from Tilapia and Silver Carp, and observe the usability and acceptability of the powder through laboratory analysis.

2. Methods

2.1. Materials. Early in the morning, alive, fresh Tilapia (*Oreochromis mossambicus*) and Silver Carp (*Hypophthalmichthys molitrix*) were acquired from a local retailer in Dinajpur Sadar (25.6279° N, 88.6332° E) and transported to the experimental location for additional preparation. To prevent microbial development and activity during shipping, the containers were kept chilled under hygienic conditions. Petroleum ether, selenium powder, $CuSO_4$, K_2SO_4, H_2SO_4, NaOH, Boric Acid, HNO_3, $HClO_4$, ammonium molybdate, hydrazine sulphate, $NaHCO_3$, ferroin sulphate, ammonium cerium (IV) sulphate, zinc sulphate monohydrate, ammonium chloride, EDTA, and all other chemicals of analytical grade were procured from Merck, Darmstadt, Germany.

2.2. Preparation of Fish Powder. After being sprayed with tap water, the fishes were weighed and beheaded. The scales were removed, as well as any extraneous elements. Belly flaps, blood, and viscera were also removed. The fishes were thoroughly cleaned to eliminate any lingering blood and intestinal waste. Fish fillet paste can be used to make dried fish powder. To make this fish paste, Tilapia (*Oreochromis mossambicus*) and Silver Carp (*Hypophthalmichthys molitrix*) were filleted (with skin) by taking out the spine using a sharp stainless-steel knife. Those fillets were chopped into small pieces and washed in cold water (8°C) to eliminate any access guts, blood, dirt, and other impurities. From there, as indicated in Figure 1, different experimental approaches were used to achieve the best result.

According to Adeleke and Odedeji [15], blanching the fillets with brine solution and drying appears to be the optimum strategy for lowering drying time and producing good-quality powder. As a result, following cleaning, the fillets were immersed in a 5% NaCl solution (1 : 4 w/v) for 10 minutes to reduce the initial moisture content through osmotic dehydration [16] and blanched for 10 minutes at 80°C in the same solution to reduce enzymatic activity and the initial microbial count [17]. Following that, the fillets were filtered through a colander to eliminate extra water before being minced in a blender (JP1009, Jaipan Industries Ltd., Maharashtra, India). After sufficient blending, a semiliquid paste was prepared for the drying process. This paste was spread on a stainless-steel tray, covered with clean aluminium foil with a thickness of 1-2 mm, and placed in a heated oven drier (Universal Oven UN55, Memmert GmbH + Co. KG, Büchenbach, Germany) at 65 ± 5°C for 8 hours with continuous inspection until constant moisture content was attained. A crisp fish flake was formed after drying. This flake was then crushed in a grinder and sieved through a strainer with a 1 mm opening (sieve no. 18) to obtain a fine powder. Finally, this powder was packaged in 0.5 mm thick high-density polyethylene (1 g/cm^3) bags and stored at room temperature (25 ± 5°C) for further research (Figure 2). The percentage of the yield was calculated according to the following equation with the total weight of dry powder and the total weight of whole fish:

$$\%\,\text{Yield} = \frac{\text{Total weight of dry powder}}{\text{Total weight of whole fish}} \times 100. \tag{1}$$

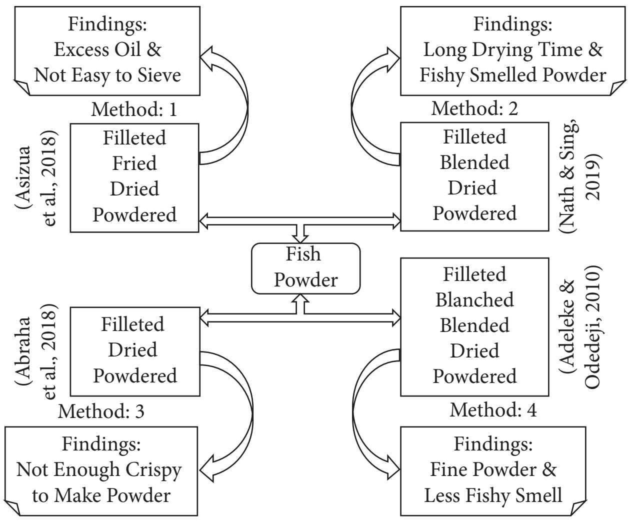

Figure 1: Experimental approaches.

2.3. Physical Analysis. The pH content of fish powders was determined using the method described by Bragadóttir et al. [18], which involved calibrating a pH metre (HI2211 pH/ORP metre, HANNA Instruments) attached with an Ag/AgCl combination electrode with pH 4.0 and pH 7.0 buffer solution.

The water and oil holding capacities were determined as the method described by Ofori et al. [19] and calculated using the following equation:

$$\text{Water or Oil Holding Capacity}\,(\%) = \frac{\text{Bound Water or Oil}}{\text{Weight of Sample}} \times 100. \tag{2}$$

Foaming capacity was determined as the method described by Obinna-Echem et al. [20] and calculated using the following equation:

$$\text{Foaming Capacity}\,(\%) = \frac{\text{Final Volume of the foam} - \text{Initial Volume of the foam}}{\text{Initial Volume of the foam}} \times 100. \tag{3}$$

The Emulsifying activity was determined using the centrifuge method described by Butt and Batool [21], and calculated using the following formula:

$$\text{Emulsifying activity}\,(\%) = \frac{\text{Height of the emulsified layer}}{\text{Height of total contents of the tube}} \times 100. \tag{4}$$

The angle of repose for the fish powder was determined by the tilting box method and fixed funnel method [22] separately and then average for a more accurate result.

The bulk density of dried fish powder was determined using the method described by Foh et al. [23], which involved placing five grams of dry fish powder in a graduated cylinder tube and tapping it ten times before taking a reading.

A portable colorimeter (BC-200, Biaobase, Shandon, China) was used to determine the colour of the dried fish powder sample. CIELAB spaces were used to express the colour. The sample's brightness (L^*), redness (a^*), and yellowness (b^*) are all included in this reading. The colorimeter also provided the chroma value, which is the level of saturation, as well as the hue angle, which is the position of the colour in the colour wheel [24].

2.4. Proximate Analysis. The AOAC (2016) standard procedures were used to determine the proximate composition of fish powder (moisture, ash, protein, fat). The moisture content of dried fish powder samples was analysed at an elevated temperature of 105°C and reported the loss in weight in terms of moisture, while ashing was accomplished through incineration in a muffle furnace at 550°C until white ash was obtained. The protein content of fish powder was determined using the micro-Kjeldahl distillation method. Meanwhile, the lipid content of the powder was determined using a petroleum ether extraction utilising a Soxhlet apparatus [25]. Rather than being studied directly, the total amount of carbohydrates in samples has been estimated by subtracting method, and the Atwater factor was used to calculate energy [26].

2.5. Mineral Analysis. Minerals of powder products such as potassium (K), calcium (Ca), magnesium (Mg), phosphorus (P), iron (Fe), zinc (Zn), and boron (B) were determined using established procedures. Approximately 0.5 g of each sample was placed in digestion tubes, along with a blank tube. Each tube received 5 mL of 68% nitric acid, which was mixed thoroughly and left overnight. The tubes were then placed in the digester, with an exhausted manifold covering the tube head. All of the samples were digested at 125°C for

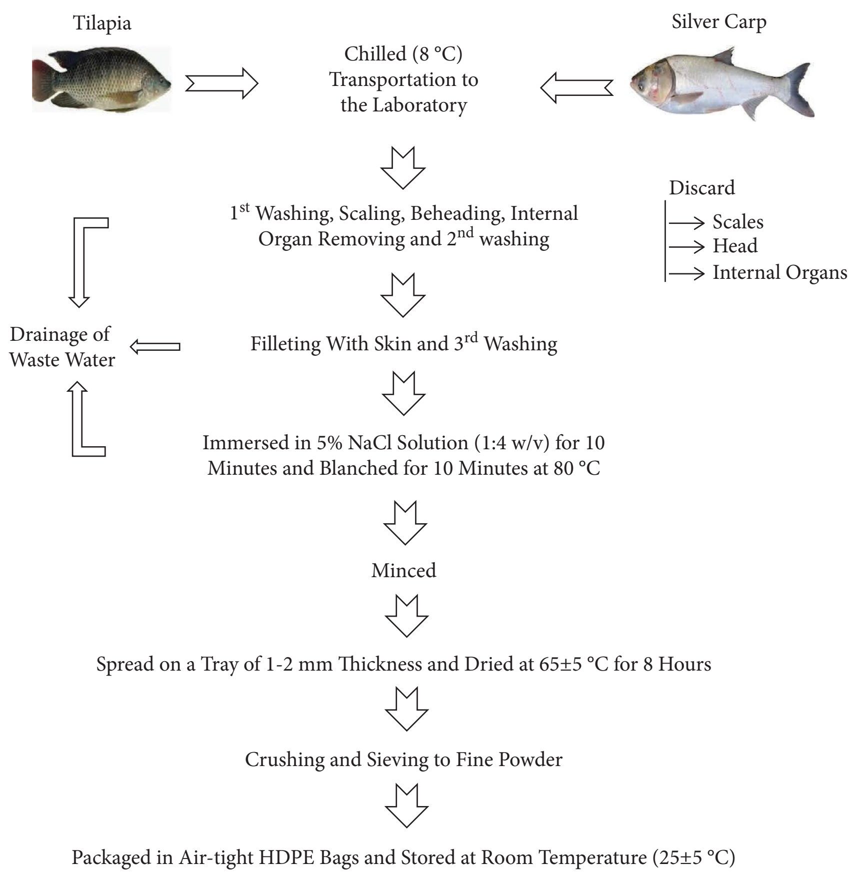

Figure 2: Flow chart of fish powder production.

4 hours after the boiling process began. The digestion mixture was transferred into a volumetric flask and filled to a capacity of 100 mL after chilling. The dilutions were then stored in a closed bottle after being filtered with a dry filter for further examination [27].

The flame photometer was calibrated using a standard stock solution of potassium. Following calibration, digested samples were poured into the flame photometer for examination [28]. Ca, Mg, Fe, and Zn were measured using an Atomic Absorption Spectrometer (AA-7000, Shimadzu, Japan). The AAS was calibrated with a standard solution before measuring digested samples [29, 30]. A flame photometer was used to determine K levels (PFP7, Jenway Ltd. UK). The B and P of the digested sample were determined using a UV-VIS spectrophotometer (UV-1900, Shimadzu, Japan). After calibration, absorbance was measured at 420 nm and 890 nm for B and P, respectively [31].

2.6. Total Plate Count (TPC). The *in vitro* spread plate technique method was used to carry out the Total Plate Count (TPC). Commercially available nutrient agar powder (M001, HiMedia Laboratories Pvt. Ltd., Nashik, India) was taken to prepare the media. 28 g of powder mixed with 1000 mL of boiling distilled water (100°C). After that, the prepared media was sterilised (121°C) along with all other necessary equipment. The medium was poured into a Petri dish and cooled carefully to dilute each step of the mass, and uniformly spread 0.1 mL sample. After incubation at 37°C for 24 hours, individual colonies were carefully counted and expressed in colony-forming units (CFU/g) [32].

2.7. Sensory Analysis of Fish Powder-Fortified Cake. The consumer's acceptability of fish powder-fortified products was evaluated through the sensory analysis of fish powder-fortified cake. Four different concentrations (0%, 1%, 3%, and 5%) for each fish powder were applied to replace wheat flour to make cakes, referred to as the control, T-1, T-3, T-5, S-1, S-3, and S-5, respectively, according to the method described in Huang and Yang [33]. All the ingredients of the cakes are demonstrated in Table 1, along with the processing for different samples, which is shown in Figure 3. After baking, the cakes were cooled to room temperature for efficient slicing and to avoid moisture forming under the wrapper. All the samples were labelled with a random code and presented in a randomised order to avoid any biased result [34]. The cake was then sliced into 5 cm × 5 cm × 2 cm pieces and packed with a label in a high-density polyethylene bag for serving. A panel of 33 volunteer students as untrained panellists was asked to evaluate different organoleptic attributes of the cake, such as taste, flavour, colour, texture, and overall acceptance. Before the analysis, panellists were briefed about the sensory attributes. Samples were evaluated for their taste, flavour, colour, texture, and overall acceptability on a 9-

point hedonic scale, where 1 represented extreme dislike and 9 the opposite extreme.

2.8. Statistical Analysis. The statistical analysis was carried out using an Excel spreadsheet and SPSS (Statistical Package for Social Sciences) Version 26 (SPSS Inc, Chicago, USA). To establish significant differences between samples ($p \leq 0.05$), an independent T-test was employed to compare the means of two separate groups. Tukey's HSD test was applied to find out the significant differences in the mean of sensory qualities among samples. A Box plot diagram was used to describe the sensory properties of the cake samples. The data were presented as means with standard deviations (SD).

3. Results and Discussion

3.1. Physical Properties. Different physical properties such as yield, pH, water holding capacity (WHC), oil holding capacity (OHC), emulsifying activity (EA), foaming capacity (FC), and bulk density (BD) of Tilapia and Silver Carp fish powder have been determined as shown in Table 2. The angle of repose (AoR) and colour for both samples were also determined.

Yields of Tilapia and Silver Carp fish powder were procured at about 12.11% and 12.69%, respectively. The yield percentage of both samples was very close to other studies to make fish powder from different species [35, 36]. It can be increased up to 17% by mincing whole fish with bone in a mincer rather than separating the bones [37]. Both samples showed a similar pH of 6.40 ± 0.04 and 6.32 ± 0.12. In the present study, the pH of both samples was close to neutral and showed similar results from different studies [9, 26]. Moreover, some active compounds in fish powder are highly stable at neutral pH, which plays an important role in the stability of these compounds [38]. Hence, it may conclude if any active compounds are present in any of the samples, they will be stable due to a neutral pH.

Water holding capacity and oil holding capacity for Tilapia fish powder was 108.80% and 131.20%, whereas for Silver Carp fish powder it was 111.10% and 156.80%, respectively. As fish powder consists mostly of protein and due to the hydrophilic and hydrophobic properties of the protein, the powder can be bound with oil as well as water. These two properties play a vital role in food processing since these directly influence the interaction with the product. Both samples can bind to the oil much more than water due to the availability of nonpolar amino acids and protein surfaces [39]. The study also found that the sample is likely to be bound with fat more than water [18]. Some studies found a higher amount of absorbance with both oil and water, but the water holding capacity can be affected by the process of preparation as the properties of a protein can be affected by those processes [9]. The highest amount of foaming capacity found in Tilapia fish powder was 7.43% and for the Silver Carp, it was 6.28%. The foaming capacity is used to represent as whipping characteristics of any powder sample [40]. In different studies, a wide range of foaming capacity was observed from 20% to 160% for different treatment methods and different chemicals [9, 41]. Low foaming capability may be brought on by insufficient electrostatic repulsions, lower solubility, and thus, an excessive amount of protein-protein interactions [21]. A decrease in foaming stability may be caused by protein denaturation, whereas a greater result for foaming stability implies highly hydrated foams. Consequently, the findings of the current inquiry are consistent with those of the earlier ones. Of the two samples, Silver Carp has the highest amount of emulsifying activity (13.04%), whereas Tilapia has slightly reduced activity (10.63%). Multiple studies have indicated that fish powder can act as a binder or emulsifier by interacting with other proteins to form gels because the sample contains a lot of protein [42, 42]. Furthermore, emulsifying activity can be altered for various processing techniques and the chemicals employed for those techniques [43].

The angle of repose for Tilapia fish powder was 30° and 29.4°, respectively in the tilting box and fixed funnel method. For Silver Carp fish powder, it was determined 28° and 26.7°, respectively. The angle of repose is an important feature of granular material for handling and processing. For good flow properties, the angle of repose for the product must be under 40° [44]. As both samples contained below 40°; they showed a good flow property during handling. The bulk density (g/cm^3) of a powder is the density measured without any influences. The bulk density of Tilapia and Silver Carp fish powder was 0.567 g/cm^3 and 0.672 g/cm^3. Basically, bulk density depends on the particle size and initial moisture content of the powder. The high bulk density of powder shows its suitability for use in food preparation. On the other hand, the low bulk density would be an advantage in the formulation of complementary food preparation [43]. As a consequence of the current analysis, a change in bulk density implies that it may be suitable as a thickening agent in food items and dietary preparations.

The colour parameters of the fish powder samples are listed in Table 3. The lightness (L^*) value of both samples revealed that Silver Carp powder is significantly brighter than Tilapia fish powder. Red-green (a^*) value was not significantly different between the two samples. Blue-yellow (b^*) value was significantly higher in Tilapia fish powder, which represents a vibrant yellow colour. In addition, Silver Carp fish powder presented a lower chroma (C^*) value which is considered to be a quantitative attribute of pale colour. The hue angle (h^*) of both samples was nearly identical, which confirms both samples are situated in the same line of the colour wheel. Colour is an appearance indicator and one of the most important sensory quality attributes for the evaluation of acceptance by consumers when buying a food product. Nearly all of the fish's blood and internal organs were washed and removed during the washing process. However, some blood may still be present in the fish powder, which may have prevented there from being any discernible variations in the fish powders' red colour. Besides, the nonenzymatic Maillard reaction of amino acids between the proteins and the reducing sugars from the Silver Carp fish powder may cause a substantial increase ($p \leq 0.05$) in the yellow colour, as it contains more protein than tilapia fish powder.

Table 1: Ingredients required for cake formulation.

Samples	Wheat flour (g)	Fish powder (g)	Sugar (g)	Oil (ml)	Egg (g)	Baking powder (g)	Salt (g)
Control	100	0	100	150	100	2	3
T-1%	99	1	100	150	100	2	3
T-3%	97	3	100	150	100	2	3
T-5%	95	5	100	150	100	2	3
S-1%	99	1	100	150	100	2	3
S-3%	97	3	100	150	100	2	3
S-5%	95	5	100	150	100	2	3

Here, control = without any fish powder, T-1 = Tilapia fish powder 1%, T-3 = Tilapia fish powder 3%, T-5 = Tilapia fish powder 5%, S-1 = Silver Carp fish powder 1%, S-3 = Silver Carp fish powder 3%, and S-5 = Silver Carp fish powder 5%.

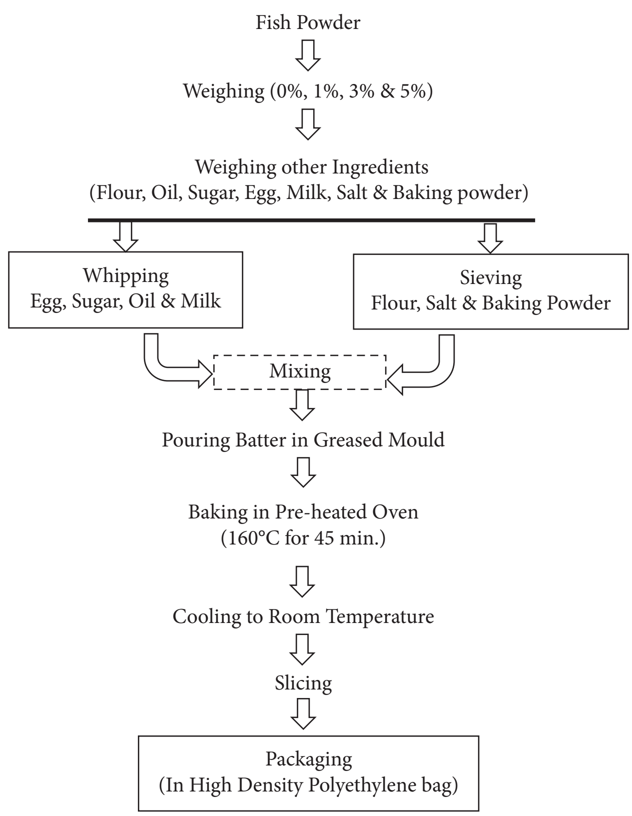

Figure 3: Processing flow chart of fortified fish cake.

Table 2: Physical properties of Tilapia and Silver Carp fish powder.

Species	Yield (%)	pH	WHC (%)	OHC (%)	FC (%)	EA (%)	BD (g/cm^3)
Tilapia	12.11	6.40 ± 0.05^a	108.8 ± 0.45^b	131.2 ± 0.56^b	7.43 ± 0.17^a	10.53 ± 0.09^b	0.57 ± 0.07^a
Silver Carp	12.69	6.32 ± 0.14^a	111.1 ± 0.35^a	156.8 ± 0.70^a	6.28 ± 0.13^b	13.22 ± 0.16^a	0.67 ± 0.05^a

Values are means ± SD. Different superscript letters within a column indicate significant differences ($p \leq 0.05$).

Table 3: Colourimetric values for Silver Carp and Tilapia fish powder.

Species	L^*	a^*	b^*	C^*	h^*	Visual representation
Tilapia	70.38 ± 0.15^b	14.10 ± 0.8^a	38.31 ± 0.62^b	40.83 ± 0.52^b	69.80 ± 0.71^a	
Silver Carp	75.07 ± 1.98^a	11.53 ± 0.14^a	30.51 ± 1.07^a	32.62 ± 1.05^a	69.29 ± 0.42^a	

Values are means ± SD. Different superscript letters within a column indicate significant differences ($p \leq 0.05$).

3.2. Proximate Composition. Moisture, ash, protein, fat, and carbohydrate were evaluated for both samples as proximate components. The proximate composition values for Tilapia and Silver Carp fish powder are shown in Table 4. Tilapia and Silver Carp fish powder had a moisture content of 4.69% and 3.76%, respectively. The moisture content of Tilapia and Silver Carp fish powder was similar to other identical studies [9]. The microbiological activity in the product is directly proportional to its low moisture content. According to other studies, microbial development is flattened below 8% moisture level, preserving quality and sensory features for a longer period [44]. Thus, it can be concluded that both samples might be in a safe range for storage. In terms of ash content, there was no significant difference ($p > 0.05$) between the two samples. The ash content of Silver Carp fish powder was comparable to other findings [26]. The present study discovered that Tilapia fish powder had a 2.5-fold higher ash content than freeze-dried surimi powder from Tilapia in another study [45]. Even though the spine and large fish bones were removed during processing, some small fish bones remained in the fish paste, and the presence of different minerals such as potassium, calcium, and phosphorus was ensured by a higher number of inorganic contents. Protein was the most prominent component in both fish powders. Both samples had a protein level of 63.63% and 73.58%, respectively. Since the protein level of raw Tilapia is lower than Silver Carp, it would be clear that fish powder from Silver Carp had substantially higher protein content than Tilapia. That agrees with the findings of similar research [23, 46]. According to the research of 14 distinct dried fish species, protein content varies from 17% to 78% depending on the species and processing method [47]. The fish powder's high protein content may play a significant role in its applications. Since it contains this huge amount of protein in a compact form, it can open up a variety of uses both nutritionally and commercially. According to our investigation, Tilapia showed higher fat (22.38%) compared to Silver Carp. Excess lipid concentration in fish powder can oxidise quickly, resulting in a rancid flavour that renders the powder unusable [48]. Another study discovered that, depending on how the fish powder is processed, fat content in one species can range from 3.5% to 17.80% [49]. This also indicates that the fat content in the current sample can be similarly reduced by treating fish fillets with NaOH, NaOCl, EtOH, HCl, or citric acid. The carbohydrate contents of both samples ranged within the inconsiderable amount as described for different species [50]. The current study found that compared to Silver Carp, Tilapia has a higher energy content (465.48 kcal/100 g). Furthermore, the energy content is very close to the findings of fish powder from different species [26]. Energy content is a direct expression of total proximate composition. The proximate composition of fish varies based on species, food, age, sex, capturing time, environment, and other factors [51].

3.3. Composition of Minerals. Due to their nutritional importance, toxicological potential, interactive effects with processing and texture of particular meals, and flavour, the mineral determination of foodstuffs is essential. The results of mineral content from both fish powder samples are presented in Table 5. In the present investigation, samples were observed to be abundant in mineral components like potassium, calcium, magnesium, and phosphorus. The source of adequate mineral contents of these samples was mainly the bones of the fish. Among all the trace elements, potassium was present in most quantities per 100 g of sample. Both fish powder samples were rich in potassium. As a majority of the mineral content was derived from fish bones that would normally be discarded, yet the presence of the tiny bones may have enhanced the availability of potassium. Moreover, Silver Carp fish powder showed higher contents of potassium (K) and calcium (Ca) than tilapia fish powder. Calcium is the second most abundant trace element in terms of quantity. The obtained calcium value is lower than that reported by Kasozi et al. [52] as calcium is extremely soluble in water and a significant amount of it may have been lost during the washing, blanching, and drying process. According to Fong-in et al. [53], Tilapia bone powder can be considered a source of calcium in several food products without altering their texture. It is, therefore, crucial to examine the processes by which calcium is added to food items to improve their nutritional value. Among other minerals, Tilapia contains 0.91 g/100 g of magnesium and 0.68 g/100 g of phosphorus, whereas Silver Carp contains a similar amount of magnesium (0.96 g/100 g) but nearly double the amount of phosphorus (1.19 g/100 g). The low phosphorus concentration obtained could be attributed to the removal of the fish's head, bones, and scales [54]. Also, the development of the calcium-phosphorus complex, the two have a sympathetic relationship wherein a deficiency in one element impacts the availability of the other. Studies have also shown that ingesting calcium without magnesium causes tooth decay [55]. There are no significant differences ($p > 0.05$) in iron, zinc, or boron concentration between the two samples, respectively. Boron has the smallest trace element count present in the two respective samples. The amount of zinc in our samples was very similar to the study of Kasozi et al. [52] where they prepared a fish powder from Tilapia. The amount of trace elements discovered in fish samples varies by species, people, age, sampling time [56], and season of capture [57]. Based on the ample mineral content in both powders, it can be suggested that consuming low-priced fish powder could improve micronutrient levels in the lower socioeconomic class.

3.4. Total Plate Count (TPC). Quantitative microbiological analysis helps to assess the quality of dried fish. In the results of our investigation, the total number of colonies in the two samples varied between 4.8×10^4 CFU/g and 5.2×10^4 CFU/g (Table 6). In their studies, Abbey et al. [58] found that mechanical drying minimises microbial attack, hence the powder should be safe. In addition, these fish items will be subjected to a heating or cooking process to eliminate the presence of microorganisms. The safe and acceptable TPC limit for fishery products is approximately 10^6 CFU/g [59]. According to our findings, there are certain safeguards in place. We can ensure that these fish powders are safe for consumers and the market from this standpoint.

Table 4: Proximate composition of Tilapia and Silver Carp fish powder (g/100 g).

Species	Moisture	Ash	Protein	Fat	Carbohydrate	Energy (kcal/100 g)
Tilapia	4.69 ± 0.25^{a}	6.94 ± 0.34^{a}	63.63 ± 0.84^{b}	22.38 ± 0.79^{a}	2.37 ± 0.42^{a}	465.48 ± 6.9^{a}
Silver Carp	3.76 ± 0.32^{a}	7.26 ± 0.21^{a}	73.58 ± 0.61^{a}	13.65 ± 0.45^{b}	1.76 ± 0.36^{b}	424.19 ± 3.83^{b}

Values are means ± SD. Different superscript letters within a column indicate a significant difference ($p \leq 0.05$).

Table 5: Mineral contents found in Tilapia and Silver Carp fish powder.

Minerals	Tilapia (g/100 g)	Silver Carp (g/100 g)
Potassium	3.25 ± 0.14^{b}	3.43 ± 0.05^{a}
Calcium	1.20 ± 0.06^{b}	1.45 ± 0.04^{a}
Magnesium	0.905 ± 0.01^{a}	0.97 ± 0.04^{a}
Phosphorus	0.70 ± 0.22^{b}	1.19 ± 0.08^{a}
Iron	0.02 ± 0.02^{a}	0.031 ± 0.012^{a}
Zinc	0.06 ± 0.008^{a}	0.06 ± 0.007^{a}
Boron	0.002 ± 0.001^{a}	0.005 ± 0.002^{a}

Values are means ± SD. Different superscript letters within a row indicate significant differences ($p \leq 0.05$).

Table 6: Total plate count of Tilapia and Silver Carp fish powder.

Samples	Total plate count (CFU/g)
Tilapia fish powder	4.8×10^{4}
Silver carp fish powder	5.2×10^{4}

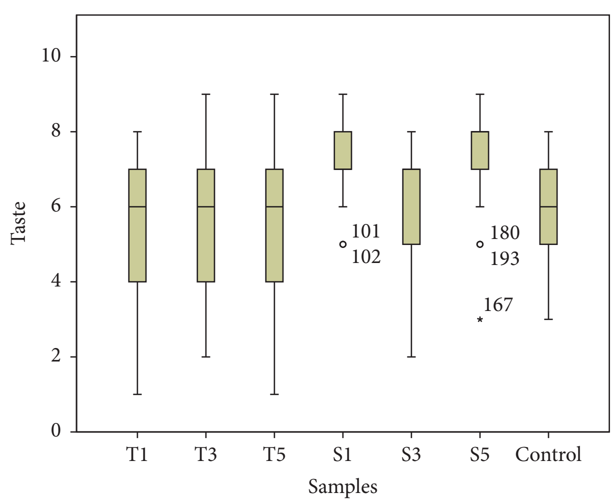

Figure 4: Box-plots obtained for the taste of prepared cake samples.

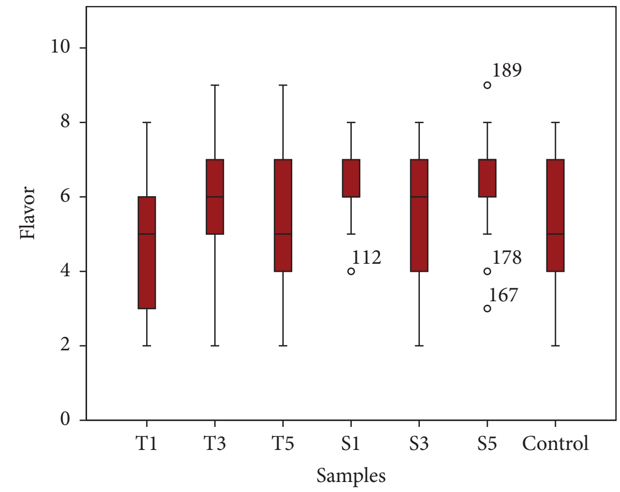

Figure 5: Box-plots obtained for the flavour of prepared cake samples.

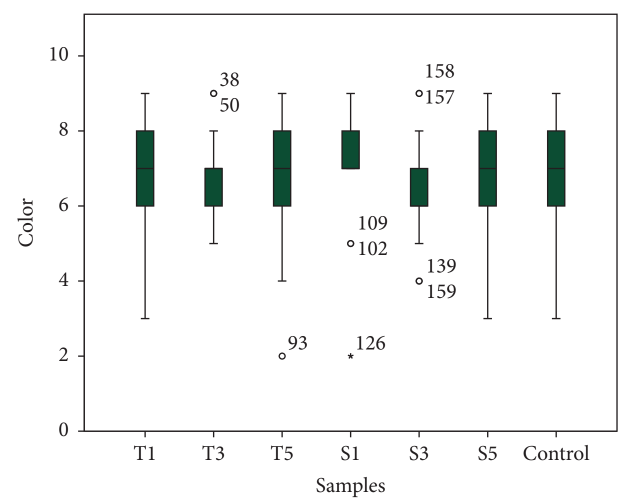

Figure 6: Box-plots obtained for the colour of prepared cake samples.

3.5. Sensory Analysis of Fish Powder-Fortified Cake. Fish powder-fortified cakes were prepared with different concentrations and sensory attributes presented with the controlled samples in different figures (Figures 4–8). A box plot diagram was used to describe the different sensory properties according to the panellist's perceptions. There were no significant differences ($p > 0.05$) in terms of taste for T-1, T-3, T-5 and the control sample, respectively. Figure 4 shows that the majority of panel members gave slightly less than 6 points on the hedonic scale for the taste of Tilapia fish powder cake samples. Although minor panel members rated S-1 and S-5 as neither like nor dislike (point 5), Silver Carp powder cakes performed significantly better than other samples. Only T-1 and T-5, as compared to the control sample, exhibited relatively poor sensory quality in terms of flavour, with a low mean score. On contrary, S-1 and S-5 showed higher flavour perception quality than other samples (Figure 5). Among sensory quality parameters, no significant changes ($p > 0.05$) were observed for colour and texture by the visual evaluations of the panel members. Observing Figures 6 and 7, it can be seen that all colour and texture attributes had medians above a 5-point scale (neither like nor dislike), with the majority of the cases being close to 8 (like very much) for all samples. In terms of overall

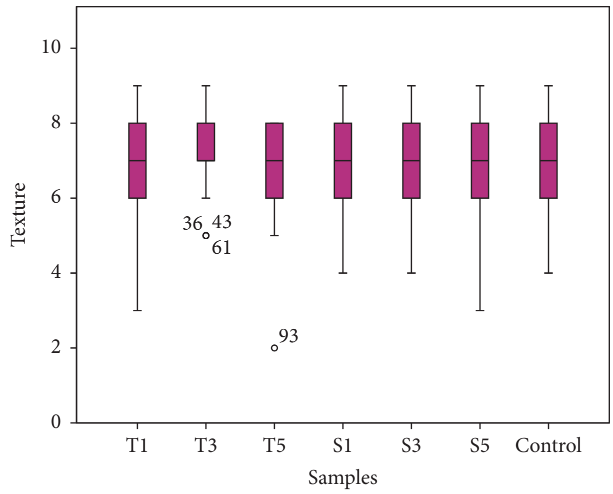

FIGURE 7: Box-plots obtained for the texture of prepared cake samples.

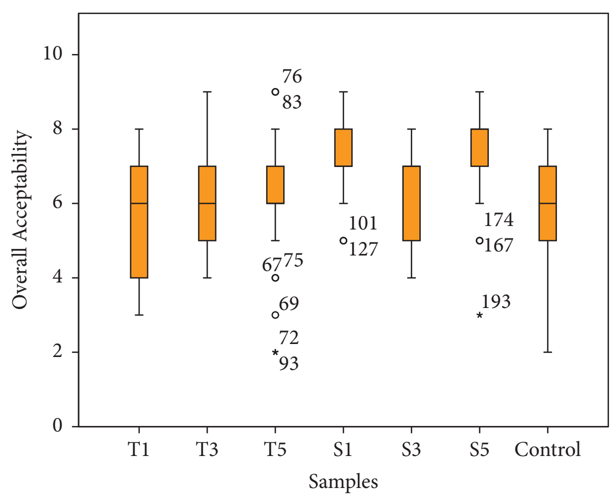

FIGURE 8: Box-plots obtained for the overall acceptability of prepared cake samples.

acceptability, S-1 and S-5 presented an appreciable sensory profile almost totally situated in the region of acceptance (>7.00) as illustrated in Figure 8. Except for T-1, all samples showed higher overall acceptancy than the control. In a word, all of these results indicated that Silver Carp fish powder will have good acceptance than Tilapia fish powder, revealing good perspectives to broaden the application of fish powder in the food industry.

4. Conclusions

The results of this study revealed an efficient amount of dry powder is achievable from Tilapia and Silver Carp which are rich in protein, potassium, calcium, and other valuable micronutrients. The general acceptability of these powders was confirmed through a sensory analysis of fish powder-fortified cake. So, it can be inferred that Tilapia and Silver Carp can be transformed into a stable dry nutritious fish powder and may be further developed as a food additive that can enhance the nutritional value of the final product.

Abbreviations

PEM: Protein-energy malnutrition
NDC: Noncommunicable diseases
DDT: Dichlorodiphenyltrichloroethane
RAS: Recirculating aquaculture system
EDTA: Ethylenediaminetetraacetic acid
EtOH: Ethanol
CIE: International Commission on Illumination
AAS: Atomic absorption spectrometer
TPC: Total plate count
CFU: Colony-forming unit

Data Availability

The datasets analysed during the current study are available from the corresponding author upon reasonable request.

Consent

All authors have expressed their authorisation to engage in this publication.

Conflicts of Interest

The authors declare that they have no conflicts of interest that are compatible with the subject matter of this article.

Authors' Contributions

Md. Murtuza Kamal and S. M. Kamrul Hasan contributed to the research concept and design. Material construction, data compilation, and interpretation were done by Md. Iftekhar Kabir, Towkir Ahmed Ove, Safayetul Karim, Md. Murtuza Kamal, Md. Raihanul Haque and Most. Jesmin Akhter. The initial outline of the text was composed by Md. Iftekhar Kabir and Md. Murtuza Kamal, and all other authors, commented on early versions of the article. All authors viewed and accepted the final document.

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