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Research Note

The Effect of Different Processing Methods on the Proximate Composition of Banded Gourami (*Trichogaster fasciata*)

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Fish is considered as an important component of the human diet owing to their rich nutritional profile, including high levels of proteins, n-3 polyunsaturated fatty acids, notably eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), along with various essential micronutrients, such as minerals and vitamins. The Food and Drug Administration (FDA) recommends fish for human nutrition, food security, and medicine. Prior research advocates that fish consumption on a regular basis minimizes the risks of heart-related diseases, malnutrition, and nutritional deficiencies in humans (Kumar et al., 2022). Available literature further suggests that the consumption of fish two times a week noticeably improves human health as they are rich in the long-chain polyunsaturated fatty acids, mainly omega-3 and omega-6 fatty acids that prevent the occurrence of many human diseases (Stansby, 1985; FAO, 2008; Tawfix, 2009; Lilly et al., 2017; Tilami & Sampels, 2018). An increasing number of studies also demonstrate that fish consumption provides positive health effects and alleviates hunger and malnutrition (Cahu et al., 2004). Therefore, the demand for fish and fishery products is constantly increasing on account of the health benefits of consuming fish. At present, India is one of the largest fish-producing countries in the world sharing 7.58 percent of the total global fish production (Handbook on Fisheries Statistics, 2022). For the past five years, there has been a rapid rise in the average per capita fish consumption of the country, and now it has reached 9 kg per annum against global per capita fish consumption of 16 kg (FAO, 2022). At present, India produces 121.21 lakh tonnes of marine fishes and 41.27 lakh tonnes of freshwater fishes for the human consumption (Handbook on Fisheries Statistics, 2022).

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In Manipur, fish constitutes a staple diet for the majority of the population. The estimated fish production from Manipur in the last year was 0.33 lakh tonnes of freshwater fish, including Indian major carps, minor carps, and exotic carps accounted for 93 % of the total, while the remaining 7 % was attributed to other freshwater fish species (Handbook on Fisheries Statistics, 2022). Among the freshwater fishes, banded gourami, *T. fasciata* is one of such popular and commonly consumed fish in Manipur due to its superior taste. In Manipur, this fish mostly undergoes some sort of processing such as smoking, steaming, and frying before consumption to enhance the nutrient content, taste, texture, and flavor. The effects of various processing methods on the proximate composition of several freshwater fish species have been reported (Devi & Sarojnalini, 2014; Sarojnalini & Devi, 2014; Dayami & Sarojnalini, 2022). Our recent research has also indicated that this particular fish species is abundant in essential amino acids (Nanaobi et al., 2022). However, there is no information available in the literature pertaining to the proximate composition of fresh and processed fish of banded gourami. Therefore, the present study was carried out to determine the effect of smoking, steaming, and frying on the proximate composition of this freshwater fish.

For this experiment, fresh samples of banded gourami were collected with the assistance of local fishermen from Loktak Lake, Manipur, India. The fish were collected during the winter season, from November 2021 to January 2022. The average weight of the fish ranged from 6.73 to 7.26 grams, with a total length between 7.50 to 7.90 centimeters. The whole body of the fish was used for the analysis. To study the effect of different processing methods, the fish was processed by the three methods: smoking, steaming and frying.

For the smoking process, fish samples weighing 250 grams each were thoroughly washed with clean water. Subsequently, the washed fish were placed on blotting papers to remove any excess water. The samples were then arranged into 2 to 4 square fit size iron sieves (locally called Yang kharai), and smoking was carried out in a mud kiln (Lairang). Heat was generated using rice husks, and different types of wood. Consequently, smoking was carried out at 50 to 80 °C for 2 hours. Once the fish attained a golden brown color, they were flipped and the fire was extinguished. The remaining red charcoal from the fire was utilized to complete the smoking process. For the steaming process, the fish samples, each weighing 250 grams, were placed in a tightly sealed container to prevent direct contact with water while steaming. Subsequently, the sealed container with the fish was then carefully placed inside a pressure cooker. Steaming was conducted at a water temperature of 102 °C for a duration of 10 minutes. For the frying process, fish samples (250 g) were fried using sunflower oil at 150 °C for 5 minutes. The samples were then homogenized and were then subjected to analysis to determine their proximate composition (moisture, crude protein, crude lipid, and total ash content).

The moisture content was determined by subjecting the fish samples to drying in an oven at 60 °C until a constant weight was obtained, following the guidelines outlined by AOAC (2000). To determine the crude protein content, a modified Micro-Kjeldahl method, as per AOAC (2000), was employed. The crude protein value was estimated by multiplying the total nitrogen content (% N) by the conversion factor 6.25. For determining the crude lipid content, the standard protocol as described by Folch et al. (1957) was followed. The total ash content was determined by subjecting the samples to 550 °C in a muffle furnace for 2-3 hours, as described by AOAC (2000). The energy value (caloric value) was determined using the formula provided by Jabeen & Chaudhry (2011).

Results are expressed as mean ± standard deviation, and all the samples were run in triplicate. Statistical analyses of the samples were performed using IBM SPSS statistics version 21. The data were analyzed using one-way analysis of variance (ANOVA) and the significant differences between means were determined by post hoc Tukey's test.

In the present study, proximate composition *viz*. moisture, crude protein, crude lipid and total ash increased ($p<0.05$) when fish was subjected to three different processing methods; smoking, steaming and frying (Table 1).

The results indicated that fresh fish had the highest moisture content, whereas processed fish showed a reduction in moisture level. The moisture content was observed to be 12.66 ± 0.01 % in smoked fish, 72.62 ± 0.02 % in steamed fish, and 25.53 ± 0.15 % in fried fish. The results of the present study were similar to earlier studies, which also found that the moisture content of the fish decreased after different

Table 1. Proximate composition of banded gourami processed by different methods

Fish Sample	Moisture (%)	Crude protein (%)	Crude Lipid (%)	Ash (%)	Energy value (kcal/100g)
Fresh	74.21 ± 0.02^{a}	11.86 ± 0.02^{d}	4.31 ± 0.01^{d}	5.39 ± 0.01^{d}	103.15
Smoked	12.66 ± 0.01^{d}	51.13 ± 0.02^{a}	11.70 ± 0.17^{b}	17.51 ± 0.01^{a}	337.82
Steamed	72.62 ± 0.02^{b}	13.44 ± 0.01^{c}	5.20 ± 0.10^{cd}	6.72 ± 0.01^{cd}	108.64
Fried	25.53 ± 0.15^{c}	29.16 ± 0.11^{b}	31.07 ± 0.01^{a}	10.11 ± 0.01^{b}	412.79

[Values are expressed as mean ± SD (n=3)
Values given in the same column by different superscripts varies significantly ($p<0.05$)]

processing methods (Dayami & Sarojnalini, 2022; Kumar et al., 2022). The elevated moisture content in fish renders them more vulnerable to microbial and enzymatic spoilage (Kumar et al., 2017). Therefore, smoking and frying might be preferable than steaming due to their potential to reduce moisture content, which could help extend the shelf life and enhance the overall safety of the processed fish.

Fish is an excellent source of proteins, and amino acids including limiting amino acids such as lysine and methionine. The results obtained for crude protein content of fish showed that its level increased ($p<0.05$) after all the three processing methods. The increase in protein content can be attributed to the decrease in water content during processing. The protein content was: 51.13 ± 0.02 % in smoked fish, 29.16 ± 0.11 % in fried fish, and 13.44 ± 0.01 % in steamed fish. The lowest protein content of 11.86 ± 0.02 % was recorded in the fresh fish. The crude protein content of the fish were found to increase when they were subjected to different processing methods (Gokoglu et al., 2004; Aberoumad & Pourshafi, 2010). The observed increase in crude protein content of fish after being exposed to different processing methods could be due to the aggregation of proteins as a result of the removal of water molecules during the heating as demonstrated in the previous studies (Kumolu-Johnson et al., 2010; Ghabshi et al., 2012; Lixin et al., 2022).

Fish lipid is a good source of essential fatty acids such as omega-3 fatty acids, especially eicosapentaenoic acid and docosahexaenoic acid, which play an important role in preventing cardiovascular diseases, atherosclerosis, depression, and stroke (Biji et al., 2016; Krishnamoorthy et al., 2017). There was significant increase ($p<0.05$) in the crude lipid content of fish in both smoking and frying methods. However, no significant difference was observed in crude lipid content between the steamed fish and the fresh fish. All three processing methods increased the lipid contents of fish, by almost 7.2 times by frying (31.07 ± 0.01 % in fried fish vs. 4.31 ± 0.01 % in fresh fish). The increase in the lipid contents was only 2.7 times higher when smoked (11.70 ± 0.17 %) and lipid contents of fish improved only 1.2 times when steamed (5.20 ± 0.10 %). The data obtained in the present study are consistent with some of the earlier studies, which also showed that the crude lipid content of the fish increased when fishes such as *Anguilla anguilla*, *Amblypharyngodon mola* and *Ctenopharyngodon idella* were subjected to different processing methods (Ersoy, 2011; Devi & Sarojnalini, (2012; Golgolipour et al., 2019). The high lipid content observed in the fried fish could be due to the absorption of oil and loss of moisture content during the frying process. Future studies on the fatty acid composition of banded gourami, *T. fasciata* when subjected to different processing methods are therefore recommended in order to establish the effect of different processing methods on the variation in the fatty acid composition of this fish.

Ash is the inorganic mineral present in fish once the water and organic matter are removed. Total ash content is the measurement of total mineral content in the fish tissue (Nair & Mathew, 2000; Hei & Sarojnalini, 2012). The ash content showed a significant increase ($p < 0.05$) in smoked fish and fried fish compared to steamed fish and fresh fish. The highest total ash content was noticed in the smoked fish (17.51 ± 0.01 %), followed by fried fish (10.11 ± 0.01 %), steamed fish (6.72 ± 0.01 %), and the lowest value in the fresh fish (5.39 ± 0.01 %). It was reported in earlier studies that the total ash content increased when fish was subjected to different processing methods (Clucas & Ward, 1996; Mustapha et al., 2014). The ash content was much higher when fish was smoked than when fried or steamed. The reason for the significant increase in ash content in smoked and fried fish could be attributed to the substantial loss of moisture during the smoking process (Salán et al., 2006).

The energy value of the fish samples significantly ($p < 0.05$) increased in fried and smoked fish samples. The highest energy value was observed in fried fish (412.79 kcal/100g), followed by smoked fish (337.82 kcal/100g) and steamed fish (108.64 kcal/100g), and the lowest value was found in fresh fish (103.15 kcal/100g). These results were similar to studies by Tenyang et al. (2022), which demonstrated a significant increase in energy value in fried and smoked *Polypterus bichir*. Fish lipid plays a vital role in determining the energy content of fish products.

This study demonstrated that the processing methods (smoking, steaming, and frying) significantly influenced the proximate composition of banded gourami, *T. fasciata*. Fresh fish exhibited mean values of 74.21 ± 0.02 % moisture, 11.86 ± 0.02 % crude protein, 4.31 ± 0.01 % crude lipid, and 5.39 ± 0.01 % total ash. Remarkably, all processing methods resulted in a significant increase ($p < 0.05$) in crude protein, crude lipid, and total ash contents. Smoked fish exhibited higher levels of crude protein (51.13 ± 0.02 %) and total ash (17.51 ± 0.01 %) compared to other methods. In contrast, fried fish showed the most substantial increase in crude lipid content (31.07 ± 0.01 %) and energy value (412.79 kcal/100g). The comparison between fresh and processed fish revealed substantial effects of the processing methods on the evaluated parameters in this study. In summary, while the results provide valuable information about the impact of different processing methods on the nutritional composition of banded gourami, the preference for a specific method should take into account individual or cultural preferences, health considerations, and dietary goals. It's important to choose a processing method that aligns with one's overall dietary and taste preferences while also considering the nutritional content.

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