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Assessment of Nutritional Quality and Shelf Life of Traditional Fish Dried Products (Shidhil) from Punti (*Puntius ticto*) and Kholisha (*Trichogaster fasciata*) with Different Compositions

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Abstract: The present study was undertaken to optimize the formulation of Shidhil, a traditional fish dried product of Bangladesh, from two small indigenous fish species—*Puntius ticto* (punti) and *Trichogaster fasciata* (kholisha)—in combination with taro (*Colocasia esculenta*) paste. The research sought to improve the product by standardizing the taro-to-fish ratio based on sound nutritional profiles and reasonably acceptable shelf life. Six formulations were developed using three blending proportions (65:35, 70:30, and 80:20, taro: fish), and were subjected to comprehensive analyses, including proximate composition, mineral content, as well as shelf-life parameters like Peroxide and TVB-N value over a storage period of 120 days at ambient conditions. The findings revealed that higher fish content significantly improved protein, lipid, ash, and mineral levels and increased taro content maximized carbohydrate levels in optimal products. Among kholisha-based products, formulation K1 (65% taro, 35% fish) exhibited the highest nutritional values with 36.93% protein, 12.29% lipid, and 5120 mg/100g calcium, along with 2040 mg phosphorus, 67.9 mg iron, and 198.7 mg magnesium. For punti-based products, S1 (65% taro, 35% fish) demonstrated superior nutrient density with 35.27% protein, 16.02% lipid, 893.98 mg potassium, 39.08 mg zinc, and 217.34 mg magnesium, as well as strong oxidative stability. Formulations S2 and K2 (70:30 taro: fish) were found to be optimal, offering balanced nutrition, better texture, and extended shelf life. Both maintained peroxide values below 0.21% and TVB-N levels under 0.25%, indicating excellent preservation without chemical additives. This study confirms the nutritional and functional potential of punti and kholisha for developing standardized, shelf-stable Shidhil. The optimized formulations promote food security, reduce post-harvest losses, and create livelihood opportunities by valorizing underutilized aquatic species. These findings offer a scientific basis for traditional food innovation using locally available resources.

Keywords: *Shidhil, Taro, Shelf Life, Proximate Composition, Peroxide Value, Total Volatile Base Nitrogen.*

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I. INTRODUCTION

Fish holds a vital position in the Bangladeshi diet, offering both cultural and culinary significance as well as being a major source of animal protein and micronutrients. Amidst the myriads of food preservation methods, drying has been one of the oldest and most widely practiced techniques, especially in rural and remote locations with no access to modern refrigeration. One of these age-old products that has stood the test of time is Shidhil, a fish-dried product traditionally made from small, often underappreciated fish species and vegetable binders like taro. This product is quite common in the northern regions of Bangladesh, especially in Rangpur, Nilphamari, and Kurigram districts (Hossain et al., 2022). Despite its cultural significance and prospective nutritional value, Shidhil is understudied, inconsistently produced, and minimally available in the market.

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Shidhil is typically prepared by mixing desiccated small local dry fish powder with plant ingredients, commonly taro stem, and then drying the mixture. The product is a source of affordable protein, especially for economically disadvantaged populations. This artisanal product, however, has quality inconsistencies because of its non-standardized preparation. Raw material selection depends more on availability than nutritional content (Rahman et al., 2016a). Among Bangladesh's large number of small fish species, Punti (*Puntius ticto*) and kholisha (*Trichogaster fasciata*) are nutritionally promising but underutilized species. (Bogard et al., 2017). Although highly available and inexpensive, the potential of these fishes in developing structured dried products such as Shidhil has not been addressed much in the research literature (Rahman et al., 2016b). Research indicates that losses associated with dry fish products in parts of Bangladesh can be as much as 35% annually (Hossain & Shikha, 2021). The above concerns are aggravated by harmful pesticides meant to repel insects, posing risks to human health and environmental stability (Bala & Mondol, 1998).

Although the country has claimed self-sufficiency in food production for the last few years, ensuring a nutritionally balanced diet, particularly in economically low-income groups in rural areas, is still a dilemma. Therefore, to address this unavoidable problem, harnessing locally available, nutrient-rich food sources has become increasingly urgent. Diversified utilization of Small Indigenous Species (SIS), could provide a sustainable and culturally acceptable option. These aquatic species are rich in high-quality protein, essential fatty acids, and bioavailable micronutrients such as calcium, zinc, and vitamin A, hold the answer to the reduction of "hidden hunger"—nutrient deficiencies that exist even in the absence of caloric deficiency (Bogard et al., 2017). One such traditional product from SIS is Shidhil, an unexploited but nutritionally rich resource to contribute greatly to food and nutrition security in rural regions with its optimization.

Despite its high nutritional value and region-specific cultural acceptance, the production of Shidhil remains predominantly manual. This leads to inconsistent nutrient quality, substandard hygiene, and limited shelf life (Hossain et al., 2022). These limitations must be overcome by research and empirical observations to realize its complete potential as a safe and healthy food product. This study is of particular significance in several ways. First, it proposes using two promising but hitherto little exploited SIS—punti (*Puntius ticto*) and kholisha (*Trichogaster fasciata*)—for developing an optimized Shidhil. They are nutritionally valuable and readily accessible in the local aquatic environment, particularly during the post-monsoon season when fish drying is a significant preservation technique (Rahman et al., 2016). Their use enriches the nutritional value of Shidhil and supports biodiversity conservation by including underutilized species in the food chain (Gopakumar, 2002).

Although highly popular at the household level in rural environments, Shidhil processing is random and non-standardized, leading to heterogeneous nutritional content, short shelf life, and susceptibility to microbial contamination (Hossain et al., 2022). This disparity, along with the lack of formulation guidelines from a scientific perspective, presents a tangible research gap—one this research seeks to address.

Traditional dried fish products like Shidhil are in demand in north Bangladesh due to their affordability and nutritional value (Rahman et al., 2017). If Shidhil's nutritional value and shelf life can be significantly improved, and it will be more appropriate and acceptable as a food security option for rural people based on its improved composition and drying process.

Small indigenous fish like *P. ticto* and *T. fasciata*, contain abundant essential micronutrients like calcium, iron, zinc, and vitamin A. They indicated that consumption of whole SIS—head, bones, and organs—ensures optimum intake of nutrients and greater bioavailability (Islam et al., 2023). In addition, Temesgen and Retta (2015) stated that taro is a nutritionally dense underexploited root crop with elevated carbohydrate and fiber content and principal minerals. The leaves are even richer in protein and essential amino acids like phenylalanine, leucine, and valine, with up to 23% protein content. Furthermore, rich dietary fiber helps with gut health, cholesterol, and glycemic control. Optimized drying and storage techniques could improve these fish-based foods' nutritional content and shelf life, thereby improving food and nutrition security in resource-poor environments.

It has been found that various starch-rich ingredients such as taro, potato, and sweet gourd were incorporated into powdered dried fish to create stable, region-specific food blocks suitable for long-term storage. The fish-taro combinations yielded the most promising outcomes, with protein and lipid retention significantly higher than in fish-only samples (Sarker et al., 2023). The research group also highlighted the taro's capacity to inhibit oxidative degradation through its physical binding of lipids and its ability to control water activity, thus slowing microbial spoilage. Although Punti and Kholisha are locally available and culturally acceptable, but their inclusion level yet not scientifically optimized for Shidhil production.

Therefore, the present piece of research was aimed to optimize the formulation of the traditional dried fish product Shidhil by utilizing two nutrient-dense small indigenous species (SIS), *Puntius ticto* (punti) and *Trichogaster fasciata* (kholisha), blended with taro paste (*Colocasia esculenta*) in varying proportions. The primary objectives were to evaluate the effects of different fish-to-taro ratios on the nutritional composition, shelf-life stability, and sensory acceptability of Shidhil, and to identify the most suitable formulation for household use and potential commercialization.

II. MATERIALS AND METHODS

- *Experimental Site and Period*

The study was conducted at the Fish Processing and Quality Control Lab of the Department of Fishing and Post-Harvest Technology, Sher-e-Bangla Agricultural University, Dhaka 1207 during the period of July 2024 to June 2025. Some of the biochemical analysis was carried out at the

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laboratory of Animal Nutrition and Feed under Department of Livestock Services, Farmgate, Dhaka-1215.

➢ *Collection of Fish Samples and Taro*

Fresh fish specimens of punti (*Puntius ticto*) and Kholisha (*Trichogaster fasciata*) were collected from two different sources for this study. The fish samples were procured from Sathibari bazar, Mithapukur (Figure 1). Immediately after procurement, the fish were carefully packed in airtight bags to maintain quality. Procured samples were further dried naturally and sieved to remove any unwanted objects. The samples were then carried to the Laboratory of the Department of Fishing and Post Harvest Technology at Sher-e-Bangla Agricultural University, Dhaka, for further processing. The taro (*Colocasia esculenta*) used in this study was sourced from local market, ensuring collection from a clean and well-maintained environment. Both taro leaves and stems were collected for use in the process of preparing Shidhil.

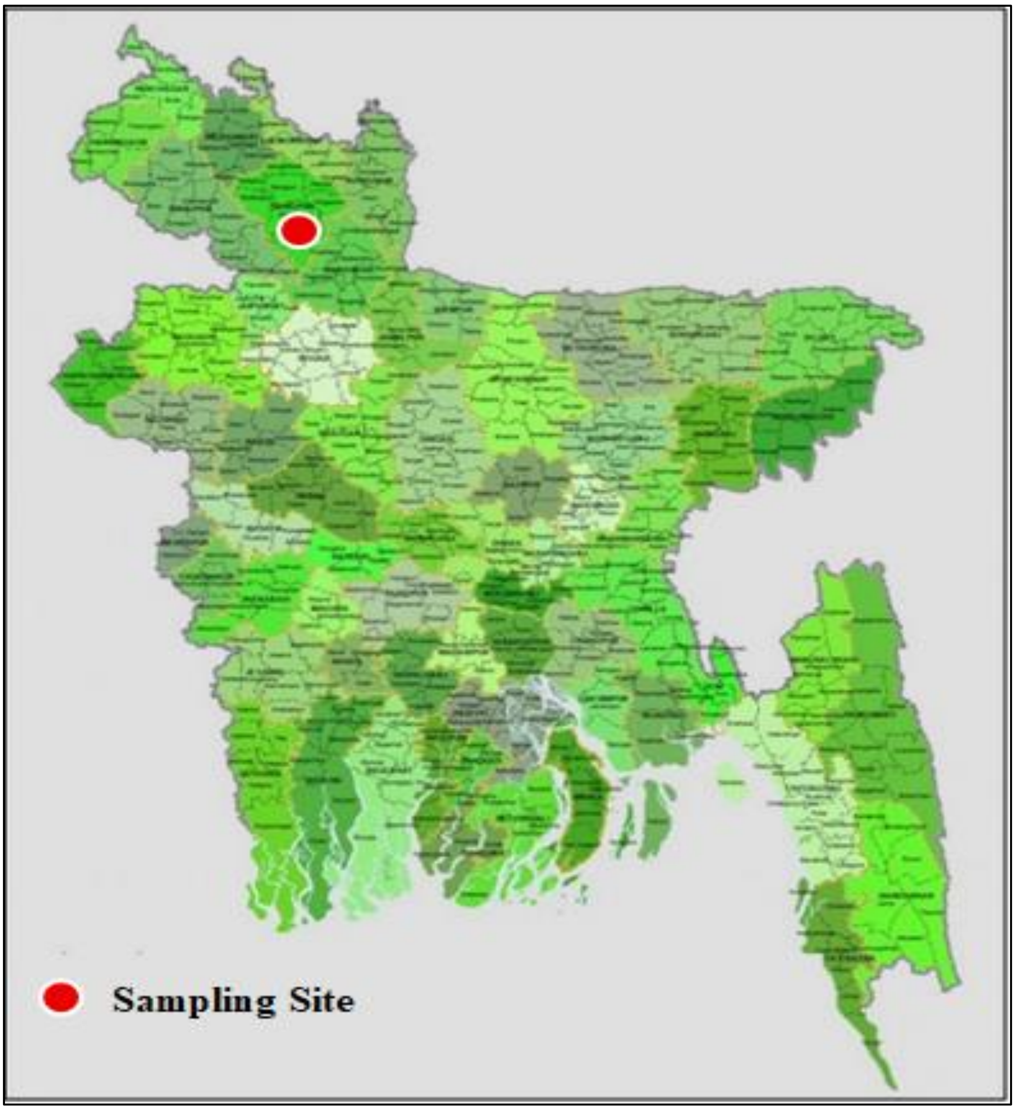

Fig 1 Sampling Site of the Present Research Work

➢ *Preparation of Shidhil*

- *Preparation of Fish Samples*

After collection, all fish samples underwent gutting to remove the internal organs, ensuring hygienic processing. After removing the guts, the fish were thoroughly washed with clean drinking water to remove any remaining dirt or unnecessary material. The next step was to prepare the fish using the traditional sun-drying method (Figure 2). The fish were dried in direct sunlight for seven days. Weather conditions were monitored during drying to ensure adequate sunlight, and care was taken to ensure that the fish were not affected by dust, insects, or other contaminants. Once the drying process was completed and the fish reached a firm and low moisture state, they were collected and packed in clean zippered polythene bags. These airtight bags were labeled and stored at normal laboratory temperature for future analysis and testing to ensure that the quality of the dried fish remains intact.

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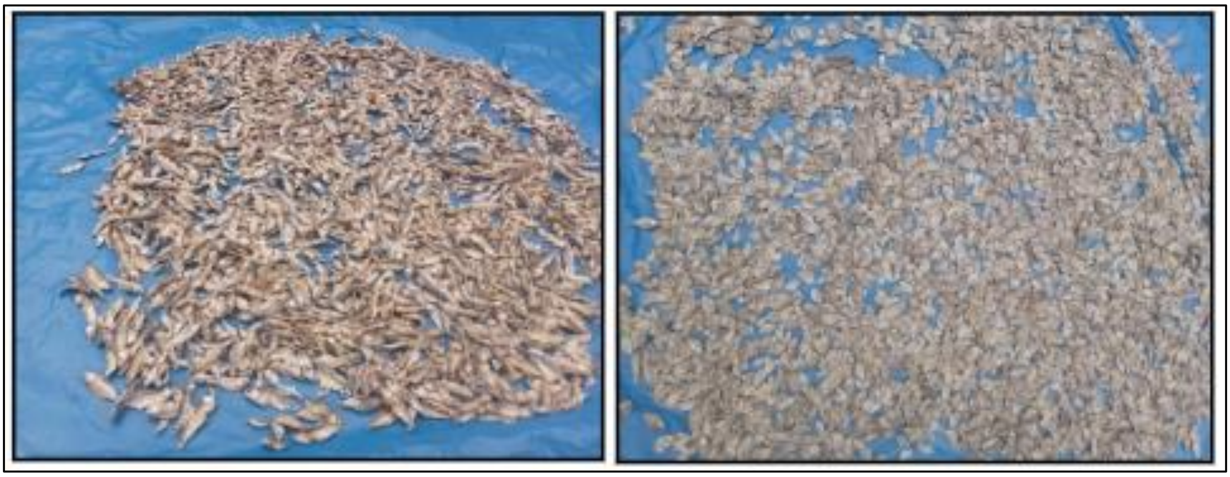

Fig 2 Traditional Drying Process of kholisha (*Trichogaster fasciata*) (Left) and Punti (*Puntius ticto*) (Right)

- *Preparation Procedure of Shidhil*

To prepare the improved shidhil, the dried fish samples were ground separately in a clean grinder. The powder of each fish species was kept in separate and clean containers to avoid mixing or contamination, and these were stored for later mixing with taro. At the same time, fresh taro (*Colocasia esculenta*) was collected, peeled well, and cut into small pieces (Figure 3).

Fig 3 Mixture of Ingredients (Left) and Prepared Shidhil Patty (Right)

Then these taro pieces were boiled for a few minutes until they become slightly soft. After boiling, the taro pieces were spread on a clean, soft mesh to drain the excess water. After the water was drained, the boiled taro pieces were ground in a grinder to make a smooth paste. Then the fish powder and taro paste were mixed in a specific ratio (Table 1), filled onto large, clean taro leaves, and wrapped safely.

Table 1 Different Compositions of 'Shidhil' Prepared Using Punti (*Puntius ticto*) and Kholisha (*Trichogaster fasciata*)

Fish Species Used	Product Type	Treatment	Amount of Taro Paste (g)	Amount of Fish Powder (g)
Punti	65% taro and 35% fish	S1	552.5	297.5
	70% taro and 30% fish	S2	595	255
	80% taro and 20% fish	S3	680	170
Kholisha	65% taro and 35% fish	K1	552.5	297.5
	70% taro and 30% fish	K2	595	255
	80% taro and 20% fish	K3	680	170

This mixture was left overnight and allowed to ferment naturally. The next day, the prescribed amount of turmeric powder and mustard oil was mixed. The mixture was then shaped into round patties. These patty-shaped pieces were dried under direct sunlight for seven days (Figure 4). After drying, they were packed in zippered polythene bags and stored at different temperatures for further analysis.

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Fig 4 Sun Drying of Prepared Shidhil Patties

➢ *Analysis of Proximate Composition*

After proper drying, Shidhils were immediately carried to the laboratory of Animal Nutrition Division of Department of Livestock Services, Dhaka for analysis. Proximate compositions of Shidhil were determined by the conventional method of (AOAC, 2005) with slight modification.

- *Estimation of Moisture:*

At first, the initial weight of the samples was taken. Then samples were dried in an oven at about 105°C for about 24 hours until a constant weight was reached and cooled in a desiccator and weighed again. Then the samples were minced in an electric grinder. The percentage of moisture content was calculated by the following equation:

Percentage (%) of moisture = (Weight loss/Original weight of sample) × 100

- *Estimation of Protein:*

The micro-Kjeldahl method was used to determine the fish's protein content. In a Micro-Kjeldahl flask, samples weighing 0.5 g are digested with strong sulfuric acid for 45 minutes in order to convert organic nitrogen to ammonium sulphate. After diluting the digest and using sodium hydroxide to make it alkaline, it was distilled. After being collected in a boric acid solution, the released ammonia was titrated using 0.1 N H_2SO_4. The following formula was used to determine the sample's protein percentage:

Percentage (%) of protein = (c-b) × 14 × d × 6.25/a × 1000 × 100

Where, a = sample weight (g),b = volume of NaOH required for back titration and neutralize 25ml of 0.1N H_2SO_4 (for sample),c = volume of NaOH required for back titration and neutralization of 25ml of 0.1N H_2SO_4 (for blank), d = normality of NaOH used for titration, 6.25 = conversion factor of N to protein and 14 = atomic weight of N.

- *Estimation of Fat:*

Ethyl ether, a nonpolar solvent, was used to extract the fat from the dried samples that remained after the moisture content was determined. Following extraction, the components were weighed and the solvent was removed. The fat content percentage was calculated as follows:

Percentage (%) of fat = (Weight of extract/Weight of sample) × 100

- *Estimation of Ash:*

The ash content of a sample is the residue left after ashing in a muffle furnace at about 550-600°C till the residue become white. The percent of ash was calculated as follows:

Percentage (%) of ash = (Weight of ash / Weight of Sample) × 100

- *Estimation of Carbohydrate*

Carbohydrate content was determined by calculating the difference between 100% and the sum of values of moisture, protein, fiber, lipid, and ash.

- *Mineral Content Determination*

Due to laboratory limitations, mineral concentration analysis was conducted at the Institute of Food Science and Technology (IFST), BCSIR, Dhaka. Minerals were determined using Pearson’s method (Nazim et al. 2013). Weight of the sample was taken and ash was prepared in muffle furnace. The stock solution was prepared by using hydrochloric acid and then minerals (Fe, Ca, Zn, K, P and Mg) were determined by using the Atomic Absorption Spectrophotometer (AAS), Model: Thermo Scientific, ICE 3000 series.

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➤ *Chemical Analysis*

- *Tvb-N*

With some adjustments, Total Volatile Base Nitrogen (TVB-N) was determined using the procedures outlined in AOAC (2005). Using a blender, 90 milliliters of 6% perchloric acid were mixed with 10 grams of ground material for two minutes. The homogenates were then filtered via Whatman no. 1 filter paper. Ten milliliters of 20% NaOH were used to alkalize the filtrates prior to distillation. Following distillation, 0.01N HCl was used to titrate the collected distillate. The TVB-N value, which is given as mg/100g of sample, was evaluated in order to investigate the sample's shelf life. The following formula was used to calculate TVB-N, which was then expressed as a milligram percentage.

$$\text{TVB-N (mg \%)} = [14 \times N \times (X-Y) \times 100 \times 100] / S$$

Where, N = Normality of sulphuric acid, X = ml of sulphuric acid required for titration of sample, Y = ml of sulphuric acid required for the titration of blank and S = Weight of sample in gm.

- *Peroxide Value*

The American Oil Chemists' Society (1990) method was used in determining the peroxide value (PV). One milliliter of KI solution (14 g KI/10 ml distilled water) was added after the material had been dissolved in thirty milliliters of glacial acetic acid–chloroform solution (3/2 v/v). After one minute, 30 milliliters of distilled water was added, and the mixture was titrated with 0.01 N sodium thiosulfate until the yellow hue disappeared. After adding 5 milliliters of starch indicator, the solution was titrated once more using 0.01 N sodium thiosulfate until the blue hue vanished. The following formula was used to determine the PV.

$$\text{PV (mEq/kg)} = (V-B \times N_f \backslash W) \times 1000;$$

Where, V is the volume of sodium thiosulfate consumed, B is the volume of normal sodium thiosulfate consumed during a blank titration, W is the weight of the sample (grams) and N_f is the normality of sodium thiosulfate multiplied by a factor.

III. RESULTS AND DISCUSSION

➤ *Proximate Composition Analysis*

Proximate composition of the Shidhil samples (S1, S2, S3 for punti and K1, K2, K3 for kholisha) blended with proportions of changing taro shows considerable variation in macronutrient distribution, which indicates the impact of different fish-taro blend on nutritional density across the formulation (Figure 5).

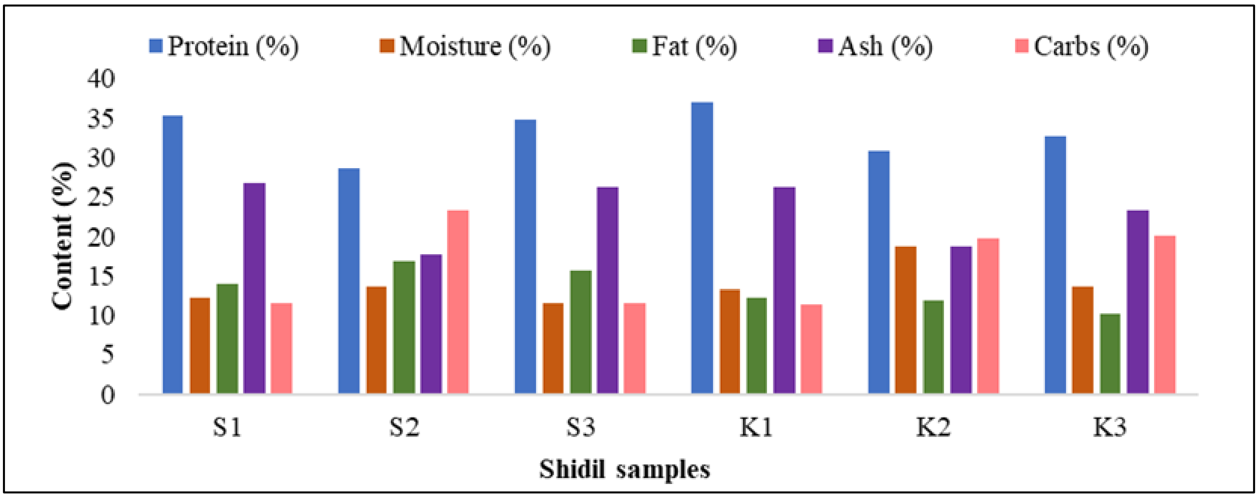

Fig 5 Proximate Composition of Shidhil Made from Punti and Kholisha with Different Composition

- *Moisture Content*

The moisture content of prepared products was recorded between 11.51% and 18.79%. In punti, S3 had the lowest (11.51%) moisture content conducive to extended shelf life and minimizing microbial hazards. S2 had a higher (13.53%) value because it had a greater proportion of taro that might have held more bound water during drying. kholisha-based K2 contained the most moisture (18.79%), indicating a likely stability compromise during storage under poor conditions. K3, on the other hand, had comparatively less moisture (13.56%) than K2, even though it contained more taro, which could be due to better drying efficiency or less sample layer thickness during processing. Lower moisture (<15%) is typically preferable in dried fish products for microbial safety, as pointed out by Islam et al. (2021).

- *Lipid Content*

Lipid content ranged between 10.22% (K3) and 16.8% (S2), indicating that despite lower fish percentages, the fish types and inherent natural lipid characteristics determine the final lipid profile (Figure 5). S2 contained maximum lipid despite lower fish percentage, which could be explained by lipid redistribution during drying or intrinsic richness in the particular batch of punti used. Lipid content was maximum in K1 (12.29%) among the kholisha samples and fell progressively with taro increment. Because of the health-imparting qualities of fish lipids and especially the omega-3 fatty acids, maximum lipid content in dehydrated foods improves functional quality. However, higher lipid content can promote oxidative spoilage, so suitable packaging is necessary.

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- *Carbohydrate Content*

As anticipated, taro addition increased carbohydrate levels. S2 and K2 at 70% taro recorded the highest carbohydrate level of 23.33% and 19.73%, respectively. However, S1 and K1 (35% fish) recorded lower levels of 11.64% and 11.41% (Figure 5). The inverse relation between fish percentage and carbohydrates substantiates the nutrient-balancing capacity of taro. Although the elevated carbohydrates would reduce protein density, they elevate energy supply and improve texture and taste.

- *Mineral Content*

According to Figure 6, total ash content, indicative of total mineral concentration, was highest in S1 (26.8%) and lowest in S2 (17.8%), while S3 showed a moderate value of 25.9%. Among kholisha-based samples, K1 exhibited the highest ash content (26.0%), followed by K2 (18.5%) and K3 (23.0%), reflecting the influence of fish proportion on mineral enrichment.

The Shidhil samples from both fish were also tested for some major minerals. Figure 6 presents important mineral contents of different compositions of Shidhil. Among minerals tested in the present study, Calcium content ranges from 2920.85 mg (K2) to 5120 mg (K1). The high calcium level in K1 indicates a high inclusion of fish bones in the formulation, a positive feature for nutritional supplementation of calcium. Phosphorus content was also high, with K1 (2040 mg) having the highest and S3 (1490 mg) the lowest, with an excellent calcium to phosphorus ratio for bioavailability. Potassium content appeared to be in the third highest concentration, with value ranges from 501.21 mg/ 100g in K3 and 893.98 mg/ 100g in the S1 sample, indicating the richness of this mineral, particularly in the product prepared from kholisha.

On the other hand, in compare to above mentioned minerals zinc, iron, and magnesium were present in the samples in much lower concentration. Highest concentration of both zinc and magnesium were found in S1 sample with a value of 39.08 and 217.34 mg/100 g, respectively. Whereases, K1 sample was found to richest in Iron content with a value of 67.9 mg/ 100 g. From the mineral analysis overall result it was evident that kholisha-based Shidhil is comparatively rich in micronutrients. These minerals certainly possess beneficiary effect as they are essential in hemoglobin synthesis, immunity, and enzyme functions, which justifies the local perception of dried fish as a medicinal food in rural diets (Hossain & Roy, 2016).

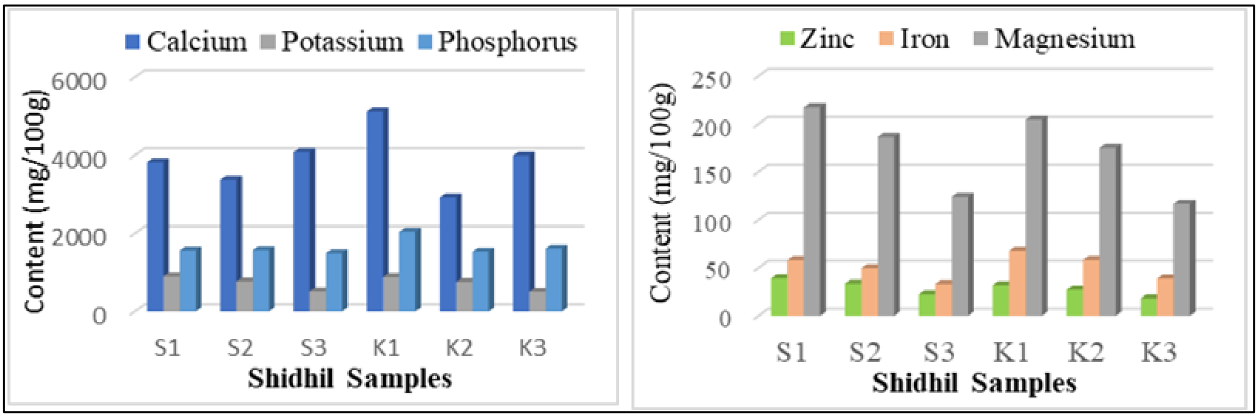

Fig 6 Mineral Content of Shidhil Made from Punti and Kholisha with Different Compositions

- *Overall Nutritional Insights*

The formulation of Shidhil using different ratios of fish and taro reveals critical insights into how composition influences nutritional value, economic feasibility, and potential applicability in addressing food and nutrient security. The data collected from proximate and mineral analysis across all sample groups confirm that the proportion of fish to taro plays a pivotal role in determining the nutritional performance and stability of the final product. This compositional diversity reflects the versatility of Shidhil as a traditional food that can be tailored to meet various dietary needs and socioeconomic contexts (Daba et al., 2023). Among all tested formulations, K1 demonstrated superior nutritional characteristics, delivering the highest levels of protein, ash, and calcium, with values of 36.93 percent, 26.16 percent, and 5120 milligrams respectively. These findings are consistent with the known nutritional profile of *Trichogaster fasciata*, a species recognized for its dense skeletal structure and elevated mineral content. According to Kato et al. (2022), small fish consumed whole, such as kholisha, contribute significantly to dietary calcium and iron intake, particularly in populations where dairy and red meat consumption is limited.

The higher protein and mineral content in fish-dominant samples like S1 and K1 can be attributed to the biochemical composition of muscle and bone tissues, which remain structurally intact during the drying process. In contrast, formulations with increased taro content, such as S2, S3, K2, and K3, exhibited higher carbohydrate concentrations and reduced protein density. This trade-off between protein and carbohydrate concentration reflects a classic nutrient displacement effect that is often seen in food blending (Mungure et al., 2023). While taro contributes energy and texture, it dilutes the protein density due to its inherently low protein content, typically less than 3 percent on a dry weight basis (Ahmed et al., 2022).

However, the value of taro as a complementary ingredient should not be underestimated. Its inclusion introduces several functional advantages (Temesgen & Retta, 2015). Taro is rich in dietary fiber and complex

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carbohydrates, and it is also a source of key micronutrients such as potassium and magnesium (Ndhlovu et al., 2020). Additionally, its mucilaginous texture contributes to improved binding and palatability of the dried product. In traditional food systems, plant like taro have been utilized not only for their energy contribution but also for their role in creating compact, storable products with enhanced consumer appeal (Tamang et al., 2021). The inclusion of carbohydrate-dense vegetables like taro improved the energy content and reduced production cost, while maintaining acceptable sensory quality (Hasan et al., 2021). This aligns with observations in the current study, where samples with moderate taro inclusion demonstrated better texture and visual appeal, particularly S2 and K2. Moisture content is another critical parameter that influences both shelf life and microbial stability. While moisture levels exceeding 15 percent may pose a risk for microbial proliferation, the controlled drying conditions applied in this study successfully maintained moisture content below this critical threshold (Mwale et al., 2022). This allowed for the benefits of improved mouthfeel without compromising safety or storability. Notably, moderate moisture content is also linked to improved rehydration, a desirable trait for consumer satisfaction in dried products (Okoro et al., 2021).

Mineral analysis further revealed the superior nutritional density of fish-rich formulations. Calcium values above 5000 milligrams per 100 grams represent a substantial contribution to daily requirements, particularly for children, pregnant women, and the elderly (Mahmoud et al., 2019). Iron, phosphorus, and zinc levels were also significantly higher in S1 and K1. According to Woyengo and Nyachoti (2019), bone-containing fish products offer a highly bioavailable form of minerals due to the fine bone matrix that becomes easily digestible during cooking or rehydration. Traditional dried fish represents a bioavailable and culturally embedded solution for addressing persistent micronutrient deficiencies in underserved rural diets (Balde et al., 2022). Furthermore, taro may indirectly support mineral absorption. Studies have shown that some compounds in taro, including certain soluble fibers and resistant starches, can improve mineral uptake by modulating gut pH and microbial activity (Kimani et al., 2022). This indicates that the synergy between fish and taro is not limited to balancing macronutrients but may also enhance the bioavailability of micronutrients, although this warrants further in vivo investigation. Rahman et al. (2017) explored the integration of locally available root crops with dried fish in developing fortified food products for nutritionally vulnerable groups. Their study revealed that formulations combining taro with small indigenous fish significantly enhanced mineral retention, especially calcium and iron, while improving texture and consumer acceptability. Ali et al. (2021) also reported the retention of significant amounts of protein and minerals, particularly calcium and phosphorus in blended products, suggesting their potential as cost-effective nutrition carriers for low-income populations.

In a nut shell, the nutritional insight gathered from this study affirms the value of fish-taro formulations in developing practical, nutrient-dense, and culturally relevant food solutions. The findings confirm that both Punti and Kholisha are nutritionally effective bases, with Kholisha offering slightly greater mineral retention under equal conditions. Blends with moderate taro inclusion offer a balance between nutritional adequacy, cost efficiency, and consumer acceptability. These results reinforce the potential of Shidhil to contribute meaningfully to food and nutrition security, especially when integrated into broader public health strategies and supported by community-level production systems.

➢ *Food Quality Parameters*

- *Peroxide Value*

The samples' Peroxide values obtained after 120 days of room temperature storage, presented in Figure 7, were found to be low, confirming a high level of freshness and low lipid oxidation when tested. Among punti-based samples, S1 (65% taro + 35% fish) had the lowest POV at 0.17 %, indicating greater lipid stability and resistance to oxidative degradation.

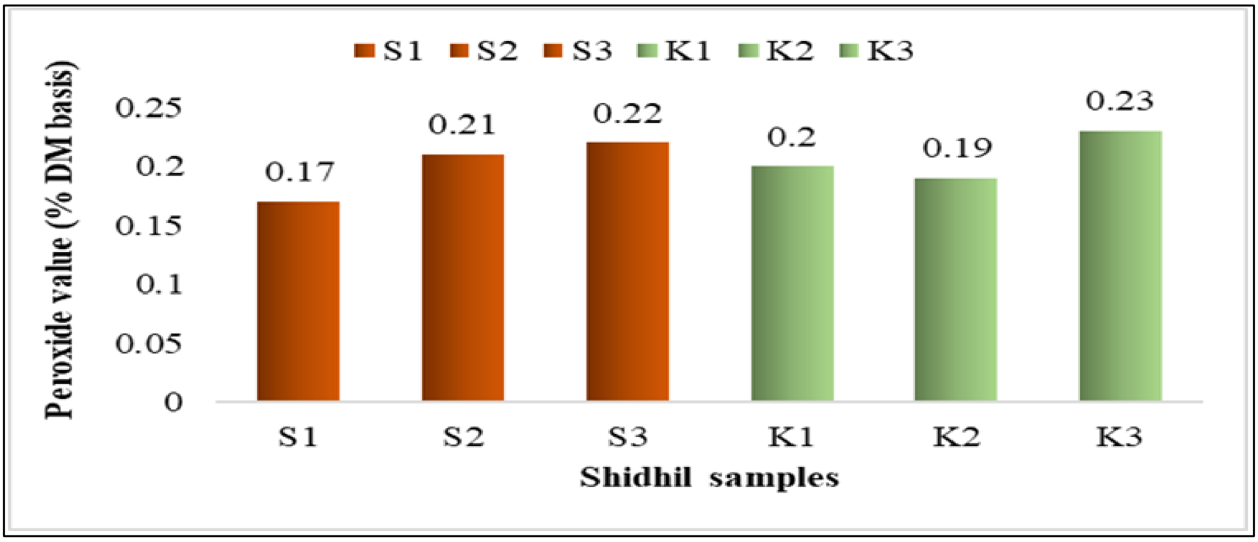

Fig 7 Peroxide Value (PV) of Different Shidhil Products Made from Punti and Kholisha after 120 Days of Room Temperature Storage

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With increasing taro proportion and decreasing fish proportion, POV values increased stepwise: S2 (70% taro + 30% fish) had 0.21 %, and S2 (80% taro + 20% fish) had 0.22 %. This trend agrees with earlier reports in which higher fish content resulted in better oxidative stability due to better preservation of natural antioxidants and less contact with atmospheric oxygen (Gopakumar, 2002). Peroxide value (POV) is one of the most critical parameters for measuring the degree of primary lipid oxidation and oxidative stability in fat-containing food products. Lipid oxidation influences the nutritional quality and impairs the sensory quality and marketability of dried fish products (Huss, 1995). POV was used to assess oxidative spoilage and shelf life potential of the traditional dried fish product Shidhil, made from two freshwater fish—punti (*Puntius ticto*) and kholisha (*Trichogaster fasciata*)—and blended with different proportions of taro.

The same pattern also appeared with the kholisha-based formulations. K2 (70% taro + 30% fish) had the lowest POV of 0.19 %, followed by K1 (65% taro + 35% fish) with 0.20 %, and K3 (80% taro + 20% fish) with 0.23 %. While differences between analogous samples of the two fish species were comparatively small, punti-based fish dried product had slightly lower POVs throughout. This can be due to interspecific variation in the fatty acid profile or antioxidant profile of the species, as demonstrated by Siddique et al. (2019), who reported interspecific variation in the lipid stability of native freshwater fish of Bangladesh.

All samples having POVs well below 5% value are considered for good lipid quality in dried fish products (Codex Alimentarius Commission, 2013). Low POVs confirm the success of traditional drying in maintaining the lipid quality and indicate an antioxidant effect being exerted by taro through either the provision of a physical barrier against oxygen or the control of water activity. In addition, findings show a definite correlation between increased fish content and better oxidative stability. The synergistic action of natural fish antioxidants and physicochemical interactions within the taro-fish matrix can explain this. Notably, S1 and K1 had the highest fish proportions and were the most stable and shelf-suitable products. These results suggest that a taro-fish ratio of 65:35 can be ideal when product quality, nutrient retention, and shelf life are considered. Therefore, from the perspective of oxidative stability, POV analysis confirms the function of fish ratio on the oxidative stability and shelf-life potential of Shidhil. While both Punti and Kholisha yielded acceptable results, products based on punti provided slightly better stability. The results are part of formulation strategies for traditional dried fish products and offer valuable input on composition optimization for better shelf life without synthetic preservatives (Nyandoro et al., 2023).

Banda et al. (2021) evaluated the shelf life and oxidative behavior of mixed-ingredient dried fish formulations stored at room temperature. They reported that products containing small fish and starch-based binders, including taro and yam, showed slower peroxide formation over 90 days. The protective matrix formed by the starch delayed lipid oxidation, especially in samples with 30 to 35 percent fish content. This supports the current formulation approach of Shidhil, where oxidative stability was enhanced by balanced ratios of fish and taro. They concluded that taro-based matrices minimized rancidity by stabilizing lipids through physical binding, making the blend more suited for ambient storage in rural contexts. Their findings validate the integration of traditional plant-based thickeners in dried fish formulations, reinforcing the premise of this research in pursuing enhanced preservation and nutrition using locally available materials.

- *TVB-N Value*

Total Volatile Nitrogen (TVB-N) is an established biochemical index for quantifying fish and fishery product's freshness and storage life. TVB-N mainly consists of ammonia, dimethylamine, and trimethylamine—volatile substances produced by microbial action and the enzymatic breakdown of proteins. As these nitrogenous substances build up over time, they indicate the degree of spoilage and serve as an essential indicator to determine the shelf life of dried fish products such as Shidhil (Ozogul et al., 2010).

TVB-N values determined for six Shidhil formulations-three developed from punti (S1, S2, S3) and three from kholisha (K1, K2, K3), are presented in Figure 8. Notably, all the samples recorded TVB-N values well below the generally utilized spoilage point of 0.3% (Connell, 1995), pointing towards good freshness and stability. These low values of TVB-N are due to the proper drying process and taro's antimicrobial properties, which would have inhibited enzyme activity and microbial growth. S2, one of the punti-based Shidhil, recorded the least TVB-N (0.25 %), indicating that the blend of 70% taro and 30% fish showed a suitable matrix for stability. On the other hand, S3, which contained the lowest proportion of fish (20%), recorded the highest TVB-N among punti samples (0.32%), which may be attributed to lower protein content, resulting in comparatively faster release of nitrogenous volatiles in the initial stages of degradation. Among the samples only S3 and K1 slightly exceeded the acceptable TVB-N value.

In the case of Shidhil, which is kholisha-based, K2 also had the lowest TVB-N (0.25 %), which was the same pattern as punti-based preparations. This consistency supports the suitability of a 70:30 taro-to-fish ratio for the best shelf life independent of fish utilized. Although K1 and K3 had comparatively higher TVB-N values (0.32 and 0.27 %, respectively), they were still within limits and indicated minimal spoilage.

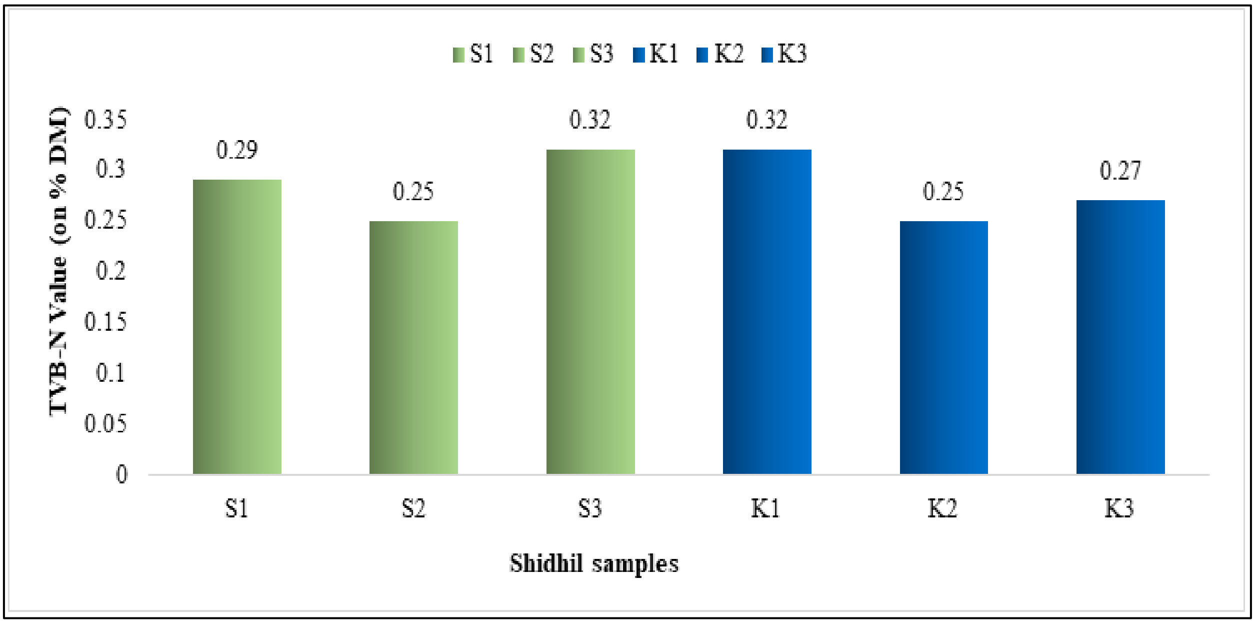

Fig 8 Total Volatile Base Nitrogen (TVB-N) Values of Different Shidhil Products Made from Punti and Kholisha after 120 Days of Room Temperature Storage

The minimal sample variation can also be attributed to inherent structural differences in protein and lipid composition between punti and kholisha that affect the rate of hydrolysis of proteins and susceptibility to microorganisms (Kuda et al., 2012). The addition of taro is not only a bulking agent but also helps to extend shelf life by altering the product's moisture dynamics and biochemical environment (Banda et al., 2021; Ssenyonga et al., 2022). This is consistent with previous studies that show that carbohydrate matrices can inhibit oxidation and microbial spoilage of fish products during storage (Ahmed et al., 2020). Besides, incorporating taro at different levels gave an insight into how formulation composition affects nitrogenous degradation kinetics, which is essential to achieve a longer shelf life in traditional dried fish preparations. Briefly, TVB-N analysis showed that all the Shidhil samples, regardless of fish type and composition, had excellent shelf stability and little spoilage. However, samples S2 and K2, 70% taro, stood out as the most stable, demonstrating an ideal compromise between nutritional quality and microbial safety. These results demonstrate the value of formulation optimization for traditional fish drying and form the rationale for incorporating functional plant-based ingredients for improving food safety and acceptability (Tumwine et al., 2023).

Jahan et al. (2022) investigated the oxidative resilience and spoilage dynamics of blended dried fish products made from native species including punti. Their comparative analysis found that fish combined with carbohydrate-dense bases such as taro and yam exhibited markedly reduced peroxide and TVB-N values over a three-month period. This was particularly evident in formulations where fish content did not exceed 35%, likely due to the protective barrier formed by gelatinized plant starch. The study highlighted how starch-based binders absorb excess moisture and prevent oxygen penetration, thereby limiting microbial growth and enzymatic degradation. Additionally, research group of Banna et. al (2022) noted that the carbohydrate matrix from taro played a functional role in reducing lipid oxidation during storage. These findings align with the present study's formulation strategy, emphasizing taro's dual role in nutritional enrichment and preservation of dried fish-based traditional foods. Moreover, the authors observed that calcium and iron concentrations remained unaffected during storage, suggesting that nutritional integrity could be maintained through appropriate fish-plant matrices. Their evidence substantiates the idea that traditional sun drying, when combined with optimized composition, can preserve product quality and extend shelf life without chemical preservatives.

IV. CONCLUSION

In the current study, both punti and kholisha have been proved as viable candidates for Shidhil production, with species-specific advantages. Kholisha contributed greater protein and mineral levels, whereas punti demonstrated better oxidative stability. For both species, product with 35% fish were found to be nutritionally superior, while 30% inclusion of fish provided the best balance between nutrient density and shelf life. This study highlights the potential of Shidhil as a standardized, nutrient-rich, and shelf-stable traditional product. Shidhil can be as a culturally relevant and commercially viable solution to address nutritional deficiencies in Bangladesh Its development will hopefully support the rural food security, and microenterprise opportunities, particularly for women involved in artisanal fish processing. Economically, the results imply the possibility of creating new employment opportunities for rural populations. Furthermore, the research aligns with the national objectives of sustainable food systems and nutrition interventions rooted in community engagement.

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➢ *Competing Interests*

Authors have declared that no competing interests exist.

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