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Research Article

Development and Quality Assessment of value-Added Fish Products

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Abstract

Protein energy malnutrition, stunting, and micronutrient deficiencies are the most significant risk factor for diseases and mortality in children particularly in least developed countries. This study investigated the proximate, mineral, and overall sensory acceptability of three value added Nile tilapia based products namely; chakli, papad, and noodle. Proximate composition analysis of moisture, crude protein, lipid and ash were carried out according to the methods of the Association of Analytical Chemists. The data showed that there was a significant difference ($p < 0.05$) in moisture content of chakli, noodle, and papad were 8.37%, 7.98% and 7.65%, respectively. The highest protein, fat, ash, and carbohydrate was 32.7%, 2.97%, 4.48, 57.65% obtained from noodle, papad, papad, and chakli, respectively. All the value added products have high amount of calcium which is important for maintaining bone health, nerve function and muscle function. The value added product (noodle) was liked moderately by the panelists for new market opportunities, and improve community livelihoods. It was concluded that, the incorporation of dried fish fillet powder in the development of value added fish products increased ash, protein, and fat but total carbohydrate decreased. Further studies on microbial quality and storage stability or shelf life should be investigated.

Keywords: Nile Tilapia; Value Added Fish Products; Chakli; Papad; Noodle

Introduction

Ethiopia is one of the countries with a high prevalence rate of malnutrition in children under five years of age (EPHI, 2023). Protein energy malnutrition, stunting, and micronutrient deficiencies are the most significant risk factor for diseases and mortality in children particularly in least developed countries. One potential solution to these challenges is the development and commercialization of fish value-added products, which can enhance the utilization of fish and fishery products, create new market opportunities, and improve community livelihoods [1].

Malnutrition encompasses under nutrition, overweight and obesity, with under nutrition manifesting as stunting (low height for age), wasting (low weight for height) and micronutrient deficiency (hidden hunger). Hidden hunger (iron, zinc, iodine, vitamin A, vitamin B_{12}, folic acid) can occur even without a deficit energy intake. To combat hidden hunger, food-based solutions, such as incorporating foods rich in essential micronutrients, are recognized as effective measures to reduce reliance on methods like fortification and supplementation (Akhtar., *et al.* 2013). Fish is a rich source of high-quality proteins, omega-3 fatty acids, essential vitamins, and minerals that play a pivotal role in human health and

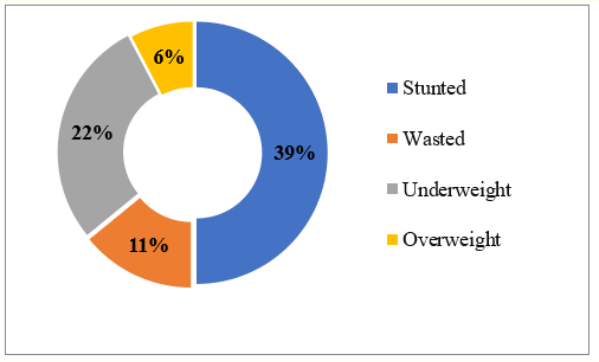

Figure 1: Malnutrition status in Ethiopia.

nutrition (Chowdhury., *et al*. 2025). Despite being a rich source of various micronutrients, the potential contribution of fish and fish products to alleviating hidden hunger is often overlooked (Bene., *et al*. 2015). Nonetheless, a large proportion of total landed fish remains unused due to inherent problems related to unattractive color, flavor, texture, small size, and high fat content. Most of these underutilized fish belong to the abundantly available pelagic species, which are landed as bycatch [2]. The developed products had nutrients that are beneficial to human health at desirable concentrations and are recommended for inclusion in the diet of vulnerable groups for a prosperous community free from hunger and malnutrition [3]. Developing fish value-added products such as fish samosas, sausages, fillets, and powders presents a promising solution, potentially enhancing resource utilization, reducing waste, and expanding markets (Kyule., *et al*. 2025). Different types of value-added products such as fish Chakli, fish papad, fish noodle, and other surimi-based products can be made from fish (Akter., *et al*. 2013). Fresh pasta enriched with protein concentrate made from Nile tilapia filleting residue [4]. Fish Chakli (Marmaaree), fish papad (chips), fish noodle (paastaa) are some of the most important value-added fish products which are very popular to urban consumers in Asian countries. It has been suggested that convenient products can be produced from low value fish. Value added fish products are not produced commercially in Ethiopia in large scale.

Noodles are a popular product due to their low cost, ease of transportation, long shelf life, and their nutritional properties, as pasta provides significant amounts of carbohydrates, protein, and complex B vitamins [5]. A fish noodle is an extruded fish product. This inclusion is a good way to increase fish intake in the country once people are buying more industrialized and fast food products, easy to prepare and nutritious, but low-calorie. Value added fish wafer and noodles using low cost Tilapia as an alternative for conventional. The fish based products developed were nutrient dense and therefore favorable for good health and development of the targeted vulnerable population [3]. Customers prefer tilapia (*Oreochromis niloticus*), one of the most popular farmed freshwater fish species, because of its flavor and affordable market pricing. Value-added fish products, such as fish sticks, can help meet the customer need for ready-to-eat foods, as well as satisfy hunger, supply important nutrients, and save time and money [6]. The use of whole tilapia in the production of fish balls can increase the benefits of calcium and phosphorus rich fish byproducts. Osteoporosis prone individuals need calcium and phosphorus-rich foods [7]. Development of convenient fish products is one way to increase its consumption [8].

The recognition of fish as a healthy food by health conscious consumers has led to the development of convenient fish products such as fish sausages, fish balls, fish burgers, as a way to promote consumption. Nile tilapia, (*Oreochromis niloticus*) is a common fish mainly consumed worldwide and used in development of fish based sausages because of its flavored white meat and the absence of Y-shaped bones [8].

Generally the noodles available in the market are made of wheat flour, oil, salt and some other extra added flavor in some special case. These noodles are highly rich in carbohydrate but poor in protein content. But their lacking often causes due to scarcity of protein and fat in the diet. Considering this point, an idea has been generated to increase the amount of protein and fat content of noodles in a cheaper way by incorporating fish muscle protein with wheat flour.

Nile tilapia is the most common, popular and widely available fish species in Ethiopia. Therefore, Nile tilapia may be chosen as fish protein source to develop nutritious fish noodles. So far in Ethiopian literatures on the development of noodles from Nile tilapia and related study is scare. Considering above mentioned facts, the present study was conducted to develop protein enriched noodles incorporating Nile tilapia fish muscle with wheat flour (bigger source of carbohydrate) and other ingredients at different levels of muscle inclusion. Development of different types of value-

added ready-to-eat products (i.e., fish balls, fish fingers, fish sticks, fish cutlets, etc.) could be a better option. Value added products prepared from beef and poultry are served to the fast-food shops in the market. However, value added fish products are not produced commercially in Ethiopia. The objective of this study was to develop value-added fish products such as, fish chakli, fish papad, fish noodle and assess the nutritional quality, and sensory quality of value-added fish products.

Material and Method

Preparation of Nile tilapia fillet powder

For this experiment, 20 kg (20 x 80 = 1600 birr) of Nile tilapia (*Oreochromis niloticus*) was purchased from the local market. Nile tilapia yielded 32% fillet; the remaining percentage was offal. As a result, 20 kg x 0.32 = 6.4 kg of Nile tilapia fillet was obtained. The fish specimen was filleted using a stainless-steel knife. Immediately after filleting, it was transported cool using an icebox to Batu Fish and other Aquatic Life Research Center Laboratory. The filleted flesh was cut into pieces of fillet having dimensions of length, width, and thickness of 2 cm x 2 cm x 1 cm, respectively. The fillet was dried using an oven (Advantage-Lab's laboratory drying oven, Model: 2030, Jachthoornlaan 8, 2970 Schilde, Belgium) for 2 h at 90°C and finally for 6 h at 60°C (Komolafe., *et al*. 2013). The average moisture content of Nile tilapia was 80%. Hence, 0.96 kg of dried fillet powder was produced. The dried fillet was finally ground with a laboratory miller (high-speed multi-functional crusher Al Marwani for spice, Model: 400A, Shanghai, China) into fine powder and stored in a polyethylene bag for analysis.

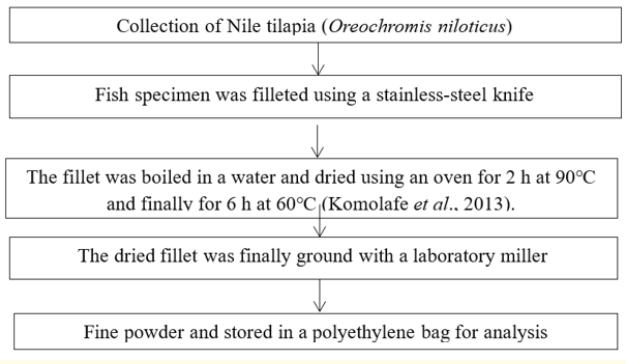

Figure 2: Nile tilapia fillet powder preparation flow.

Fish chakli

The ingredients required for the development of fish chakli is presented in Table 1. Whole fish was purchased from local market of Batu town. Fish was washed thoroughly to remove blood and any other extraneous material. The fillet was removed using stainless steel knife. The fillet was dried, grinded and mixed with other ingredient (rice flour, sodium bicarbonate, chili powder, salt, ginger, and garlic). Smooth soft dough molded into spiral manually using hand.

Ingredients	Amounts (gram)
Rice flour	100
Dried fish fillet powder	70
Baking powder	1
Chilli powder	2
Salt	2.5
Ginger	1
Galic	0.5

Table 1: Ingredients required for the development of fish chakli.

Fish papad

The ingredients required for the development of fish papad is presented in Table 2. Whole fish will be purchased from local market of Batu town. Fish will be eviscerated and washed thoroughly to remove blood and any other extraneous material. The muscle/flash will be removed from bone after boiling the fish for 10-15 minutes. The muscle will be grinded and other ingredient (The muscle will be grinded and other ingredient (beans, sodium bicarbonate, chilli powder, salt, ginger, and garlic) will be added. Dough will be rolled into thin discs of 0.6 to 0.7 mm thickness. The papads were dried in oven dryer at 54°C for 45 minutes to a moisture level 11- 12%. Papad is the dried product commonly preferred all over India as a side dish. The technology is already know and simple. Commonly papad is prepared with flour of black gram (*Phaseolus mungo* L) dal. Attempts have been made to prepare papad using other gram flours such as green gram, arhar, cowpea, Bengal gram etc. in place of black gram. Different species are used to add different taste to the papad. Fish was incorporated in papad to make papad more nutritious and tastier. The flour of black gram pulse (urad dal) was used as main ingredient.

Ingredients	Amounts (gram)
Cowpea	100
Dried fish fillet powder	70
Salt	2.5
Baking powder	1.5
Ginger	0.5
Galic	0.5

Table 2: Ingredients required for the development of fish papad.

Fish noodles

The ingredients required for the development of fish noodle is presented in Table 3. Nile tilapia fish, wheat flour and other major ingredients (salt, oil, and different spices) were procured from Batu market, Ethiopia. Fresh fish samples were cut by discarding the head, fins, tail, and viscera and then washed with clean water. Then the fish (only flashy parts of fish) was boiled with clean water for few minutes (10-12 minutes). After boiling the soft flesh pieces were deboned manually. The fleshes were minced manually (as noodles was prepared in a homestead manner) with hand. The fish mince was packed in a plastic container and stored in a refrigerator until further use.

Ingredients	Amounts (gram)
Wheat flour	70
Dried fish fillet powder	30
Water (mL)	40
Salt (g)	2
Garlic	0.5
Ginger	0.5

Table 3: Ingredients required for the development of fish noodle.

All the ingredients such as wheat flour, silver carp mince, salt, oil and spices were weighed as shown in Table I. The ingredients were mixed with warm water (water temperature was around 35 to 40°C) and kneaded for 10 minute to prepare dough. The dough was transferred to a vertical noodles making machine and longer types of noodles were made. The prepared noodles were then oven-dried for 2 days. The cooled and dried noodles were kept in polythene packs until further use.

Proximate analysis

Proximate composition analysis of moisture, crude protein, lipid and ash were carried out according to the methods of the Association of Analytical Chemists [9]. Moisture content was determined in a hot air oven at 105°C for 24 hours. Lipid content was extracted using diethyl ether by the Soxhlet method with the Soxhlet apparatus. The Kjeldahl method was used to determine the total nitrogen con-tent and then the crude protein level was subsequently calculated using nitrogen to protein conversion factor 6.25. The ash content of the sample was determined in a muffle furnace at 550°C for 6 hours.

Moisture content

Five grams (5g) of sample was transferred to the previously dried and weighed petri dish. Dish was placed in an oven and thermostatically controlled at 105 degrees for 3 hours. Dish was removed and placed in a desiccator to cool to room temperature and weighed. It was then dried again for 30 minutes, cooled down again and weighed until constant weight achieved. The determinations were duplicated and the average found.

Ash content

Five grams (5g) sample was weighed into a tarred crucible and was pre-dried. Crucible was placed in cool muffle furnace using tongs, gloves and protective eyewear. The ash content of starch was determined by igniting the starch for 4h at 550°C in furnace (Controller, B400/B4100, Nabertherm GmbH, Germany) according to AOAC [9] Official method 942.05. The samples were ignited for 4 hours at about 550 degrees Celsius. Muffle furnace was turned off and opened when temperature dropped to at least 250 degrees preferably lower. The door was carefully opened to avoid losing ash that may be fluffy. Safety tongs was used to transfer crucibles to a desiccator with a porcelain plate and desiccant. Desiccator was closed and allowed crucibles to cool prior to weighing.

Crude protein content

Protein Determination Digestion Two grams (2g) of sample and a half of selenium –based catalyst tablets and a few anti-bumping agents were added to the digestion flask. 25 mL of concentrated $H_2SO_4$was added and the flask was shook for the entire sample to become thoroughly wet. Flask was placed on digestion burner and heated slowly until boiling ceases and the resulting solution is clear. The sample was then cooled to room temperature and

digested sample solution was transferred into a 100ml volumetric flask and made up to the mark.

Distillation

To flush out the apparatus before use, distilled water was boiled in a steam generator of the distillation apparatus with the connections arranged to circulate through the condenser, for at least 10 minutes. The receiving flask was lowered and continued to heat for 30 seconds in order to carry over all liquid in the condenser. 25 mL of 2% boric acid was pipetted into 250 ml conical flask and 2 drops of mixed indicator added. The conical flask and its contents was placed under the condenser in such a position that the tip of the condenser is completely immersed in solution. 10 ml of the digested sample solution was measured in to the decomposition flask of the Kjeldahl unit, fixed it and add excess of 40% NaOH (about15-20 mL) to it. The ammonia produced was distilled into the collection flask with the condenser tip immersed in the receiving flask till a volume of about 150ml– 200ml is collected. Before distilling another sample and on completion of all distillations, the apparatus was flushed as in step1above. Steam was allowed to pass only until 5ml of distillate is obtained.

Titration

Distillate with 0.1N HCL solution was titrated. The acid was added until the solution became colorless. If additional acid is added the solution becomes pink. The nitrogen content was determined in duplicate, and run a blank determination using the same amount of all reagents as used for the sample. The blank will correct for traces of nitrogen in the reagents and should include digestion as well as distillation.

Whereas:

S = sample titration volume (ml)

B = blank titration volume (ml)

N HCl = concentration of solution HCl (0.02 N)

W = Weight of sample (g)

Total fat

Previously dried (air oven at 100°C) 250 ml round bottom flask was weighed accurately. Five grams (5.0g) of dried sample to thimble. A small of cotton was placed into the thimble to prevent loss of the sample. 150ml of petroleum spirit B.P 40-60°C was added to the round bottom flask and assembled the apparatus. A condenser was connected to the soxhlet extractor and reflux for 4 - 6 hours on the heating mantle. After extraction, thimble was removed and recovered solvent by distillation. The flask and fat/oil was heated in an oven at about 103°C to evaporate the solvent. The flask and contents were cooled to room temperature in a desiccator. The flask was weighed to determine weight of fat/oil collected.

Total carbohydrate

The total carbohydrate content was calculated by subtracting the sum of moisture, protein, fat, ash, and fiber from 100.

Mineral content

The mineral contents (K, Na, and Ca) were determined using flame photometer (Flame photometer, Model: FP 910, pg instruments, United Kingdom) according to Diddana., *et al*. (2021). Stock solutions of sodium, potassium, and calcium were used as standard solutions. A series of working standard solutions were prepared and used to construct standard curves using absorbance versus concentration. The mineral contents (mg/100 g) were determined according to the following equation:

Where A= concentration of sample solution, B= concentration of blank, V=volume of the extract

Sensory analysis

Sensory quality was evaluated by 20 experienced panelists for the determination of fish Chakli (Marmaaree), fish papad (chips), fish noodle (paastaa). Panelists scored for sensory characteristics such as appearance, color, flavor, taste, texture and overall acceptability on a nine point scale (Tokur., *et al*. 2006) where scores were assigned with '1' being the least and '9' being the highest for attributes. A score of 5 (neutral) was regarded as the acceptable margin for the product.

Data analysis

Experimental results were analyzed using the statistical package for the Social Sciences (SPSS) 20 (IBM, 2010). Results were expressed as mean ± standard deviation (SD). One-way ANOVA method was performed and mean was separated using Duncan's multiple range where significant differences between detected.

Results and Discussion

Proximate composition

The proximate composition of fish chakli, noodle, and papad sample is given in Table 4 and Figure 3. The data showed that there was a significant difference ($p < 0.05$) of moisture content of chakli, noodle, and papad were 8.37 ± 0.08, 7.98 ± 0.01 and 7.65 ± 0.01, respectively.

Figure 3: Value added fish products (A-chakli (marmaaree), B-papad (chips), C- noodle (paastaa).

Products	Moisture	Protein	Fat	Ash	Carbohydrate
Chakli	8.37 ± 0.08[a]	29.44 ± 0.30[c]	14.31 ± 0.02[a]	2.98 ± 0.00[b]	44.86 ± 0.36[b]
Noodle	7.98 ± 0.01[b]	32.70 ± 0.06[a]	0.52 ± 0.17[b]	2.16 ± 0.16[c]	56.61 ± 0.31[a]
Papad	7.65 ± 0.01[c]	31.09 ± 0.03[b]	2.97 ± 0.86[b]	4.48 ± 0.16[a]	53.76 ± 1.05[a]

Table 4: The proximate composition of chakli, noodle, and papad.

The mean moisture, ash, fat, protein, salt, and water activity were 81.76%, 0.98%, 1.88%, 14.04%, 0.14%, and 0.9869, respectively [10]. The moisture content, crude protein, crude fat, and crude ash content of Nile tilapia preserved using kench, brining, and granulated salting range from 40.1-526%, 28.4-32.4%, 7.8-9.2%, and 12.7-15.7%, respectively [11]. The moisture content crude protein, total lipid, and total ash ranged from 50.33- 78.6, 4.58- 13.15, 4.26 -38.41, and 3.43 -5.93, respectively [12]. The sample of sun-dried Nile tilapia fish comprised 14.27 ± 0.06% of crude proteins, 2.44 ± 0.013% of crude fat, and 1.69 ± 0.046% of total carbohydrate contents, respectively [13]. The moisture content, protein, fat, and ash content of wild Nile tilapia were 80.9, 17.4, 0.57, and 1.2%, respectively [14]. The fortification of noodles with moringa and sardine powders can be a viable approach for enhancing the nutritional value of the final product (Mpalanzi., *et al*. 2023).

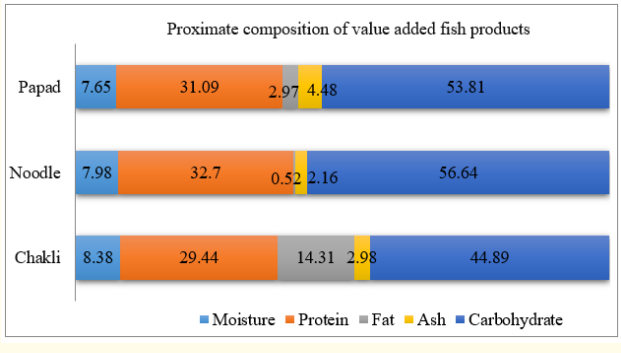

Figure 4: Proximate composition of Chakli, Noodle, and Papad.

Noodles with 30% silver carp mince had highest level of moisture content and had higher levels of protein, fat and calories (per 100 g) compared to 0, 20 and 25% silver carp mince in the noodle formulation [15]. Noodle developed from wheat flour (g) 70, silver carp mince (g) 30, water (ml) 40, oil (mL) 5, salt (g) 2, spices (g) 0.5 reported to contain Moisture (%), Lipid (%), Protein(%), Ash (%), Total carbohydrate (%), calories (per 100 g) 11.94 4.98 23.66 3.00 56.42 365.14, respectively [15]. The inclusion of up to 30% of tilapia protein concentrate in fresh pasta is able to linearly increase the crude protein and total lipids contents, decrease the caloric value of this product, and increase the calcium, phosphorus, magnesium, sodium, and zinc concentrations (Goes., *et al*. 2016). The inclusion of tilapia protein concentrate in noodles can significantly improve the nutritional value of this widely consumed product [4].

Fish noodles are essentially traditional noodles with a nutritious twist – they contain actual fish meat blended into the dough mixture. Unlike regular wheat or rice noodles that rely primarily on carbohydrates, fish noodles pack a significant protein punch by incorporating processed fish meat as a key ingredient. In the literature, it was reported that chakli developed using edible fish powder (*Scomberomorus guttatus*) incorporated with 50% wheat flour and rice flour resulted in a protein content of 25.44 ± 0.02 and 25.14 ± 0.01, respectively [16]. The protein content of wet noodles with the addition of bonylip barb protein concentrate meets the quality requirements of wet noodles. Protein content in wet noodles at 5% treatment increased due to the addition of

bonylip barb protein concentrate as an additional source of animal protein [17]. Noodles with the highest rohu (*Labeo rohita*) mince containing (30%) and wheat demonstrated a higher amount of moisture (13.07%), ash (6.7%), fat (1.87%), protein (30.08%), sodium (0.64 mg), and calcium (0.26 mg), accompanied by reduced carbohydrate (48.3%) [18].

Mineral contents

The phosphorous and calcium content of Nile tilapia fillet harvested from lake Ziway ranged from 16.4-17.2 mg/100g and 27.3-38.2 mg/100g, respectively [19]. The sodium, potassium, and calcium contents of Nile tilapia preserved using kench, brining, and granulated salting range from 2400-3500 mg/kg, 390-420 mg/kg, and 160-200 mg/kg, respectively [11]. The experimental design consisted of three treatments (carcass meal, mechanically separated meat meal - MSM, and head meal Carcass meal MSM meal Head meal contained calcium 48.20 57.00 mg/100g, and potassium 39.9 [12].

Value added products	Sodium	Potassium	Calcium
Chakli	54.0100 ± 3.54803^{b}	36.9800 ± 1.11940^{b}	545.4000 ± 7.01300^{a}
Noodle	35.0778 ± 0.45301^{c}	35.9111 ± 1.10321^{b}	476.7778 ± 5.68814^{b}
Papad	80.4625 ± 1.09037^{a}	42.9375 ± 0.94566^{a}	550.0000 ± 9.49060^{a}

Table 5: Mineral content of different value added fish products.

Sensory evaluation

The organoleptic properties of value added products were evaluated using a nine-point hedonic scale. Accordingly, fifty untrained consumers who were familiar with the consumption and quality aspects of value added fish products were randomly selected from Batu Fish and other Aquatic Life Research Center staff. The age of the panelists ranged from 24 to 56 years. The gender of the panelists was 38 male and 12 female. The panelists were asked for their willingness to judge the prepared products. Informed consent was obtained from the panelists before their involvement in the sensory evaluation for their willingness to judge the prepared products. The value added products were presented on a white plate and assigned a four-digit code and served to panelists along with a glass of water. Water was provided so that the untrained panelists could rinse their mouths in between each evaluation. The consumer evaluated (1 extremely dislike and 9 extremely like) texture, color, taste, aroma, and overall acceptability. The mean sensory scores for each attribute were pooled mean ± standard deviation was presented in Table 6. The liking score for chakli (marmaaree) and papad (chips) were like slightly, but that of noodle was like moderately [20].

Value added products	Texture	Odor	Flavor	Taste	Overall acceptability
Chakli	7.4	6.6	6.7	7.15	6.9
Noodle	6.7	7.3	7.09	7.9	7.2
Papad	6.4	6.65	6.55	7.05	6.6

Table 6: Sensory evaluation of value added products.

Conclusion and Recommendation

It was concluded that, the incorporation of dried fish fillet powder in the development of value added fish products increased ash, protein, and fat but total carbohydrate decreased. Incorporation of dried fish fillet powder into carbohydrate based snacks like noodle can contribute to the health benefit for the consumers. The value added product (noodle) was liked moderately by the panelists for new market opportunities, and improve community livelihoods. These value added fish products could be easily dried with oven dried, milled and stored for use in homes and also on National school feeding programs. Further studies on microbial quality and storage stability or shelf life should be investigated.

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