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Research Article

Development and Characterization of a Novel Fish Skin-based Papad

Surashree Sarkar, Bahni Dhar* and Sikan Shubhankar Nayak

Dept. of Fish Processing Technology and Engineering, College of Fisheries, CAU (Imphal), Lembucherra, Tripura (799 210), India

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Corresponding Author

Bahni Dhar

✉: bahnicofcau@gmail.com

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Abstract

Sustainable foods are in increasing demand by a large section of population which needs creative ways to use fish parts that often go as waste. The present study involved developing a healthy snack (fish papad) by using fish skin, something usually discarded during processing. Further, study on the quality characteristics was done to evaluate the consumers liking and acceptability towards the product. Fresh Rohu fish (*Labeo rohita*) skin was taken, cleaned and soaked in a 20% salt solution. The skin was dried under the sun and the dried skin was ground into powder. Then 5% of this powder was mixed with wheat flour, spices and herbs to make a mixture. The mixture was shaped as round (papad shape), steamed, dried and finally fried in oil. Standard method was used to analyze the final product for its nutritional make-up, color, texture, microbial quality, oil absorption and sensory traits. The fish skin papad contained a high protein content (19.85%) and minerals (7.46%), with moderate fat (19.37%) and low oil absorption (11.92%). It stayed crisp, had a very low microbial count (1.512 log CFU g^{-1}) and scored high on overall acceptability (8.04 out of 9 on a hedonic scale). Overall, the findings of the study revealed the potential of fish skin in value addition to tasty, nutritious snack that would serve as a healthy one. This offers a sustainable way to manage fishery waste while adding value by converting the waste into edible products for health-conscious consumers.

Keywords: Consumer acceptability, Fish skin papad, Nutritional composition, Sustainable food, Waste valorization

Introduction

The global food industry is undergoing a significant transformation due to consumer demand for healthy, nutritious, sustainable and functional food products, a little different from the usual options. Because of this, food manufacturers and researchers are exploring novel approaches to utilize resources that are underutilized, cut down on waste and enhance efficient use of raw material.

Processing of fish and shellfish generates substantial amounts of waste, including heads, scales, skin, viscera, fins and internal organs, which together account for approximately 70% of the total fish weight (Waqar *et al.*, 2025). A lot of recent work has been focused on turning these by-products into marketable products (Vaishnav *et al.*, 2025). One such underutilized resource is fish skin, which the fishing industry usually throws away after fish processing. However, in many countries people do eat fish with the skin on, so it is not totally unfamiliar. Fish skin is packed with protein, useful collagen, omega-3 fatty acids and important vitamins and minerals. This makes it a very nutritious ingredient for developing food products or incorporating into foods (Islam and Mis Solval, 2025). The use of fish skin in food products is still at an early stage and requires creative, practical solutions to make use the maximum of its potential.

Papads are traditional snacks made from cereals or legumes and preferred for their crispy texture. Over the years, several studies have looked at adding vegetables or other ingredients to snack foods. But snack items using fish skin or fish waste remains largely unexplored when it comes to making papad. Most of the research work published either focuses on pulling collagen out of fish skin for nutraceutical uses (Cadar *et al.*, 2024; Islam and Mis Solval, 2025), or on making fish-based chips from fish mince (Hossain *et al.*, 2024). Very little

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attention has gone into creating value-added, ready-to-cook snacks that still remain unnoticed. On top of that, no earlier study has systematically looked at the physical, chemical, microbial and sensory qualities of fish-skin papad made through a simple, scalable and household-friendly method.

Papad is a popular Indian snack, so it offers a great opportunity to use fish body parts to develop something new and innovative. By incorporating fish skin powder to papad, a unique, nutritious and sustainable snack that puts this underused resource to good use, can be prepared.

Materials and Methods

1. Materials Used

The raw materials (fresh fish skin) were collected from Lembucherra local fish market and other spices and herbs required for making papad were obtained from a nearby market. Fish skin from rohu (*Labeo rohita)* was brought to the laboratory under ice and packed in polyethylene bags for keeping them in the lab in preserved condition. The spices used for the fish skin papad were ginger, garlic, onion, fennel seed powder (*Saunf*), salt and dried fenugreek leaves.

For different analysis, the chemicals and reagents were procured from Hi-Media. The glassware used were from Borosil. The entire study was carried out in the Department of Fish Processing Technology and Engineering, College of Fisheries, CAU (Imphal), Tripura.

2. Preparation of Fish Skin Papad

About 480 g of freshly collected fish skins were taken and washed them thoroughly under running water. After washing, the skins were soaked in a 20% salt solution for about 30-45 minutes. This helped to remove any leftover meat stuck to the skin and also disinfected them. Then the skins were dried in a solar dryer. Once dried, these were ground into a fine powder, which yielded roughly 180 g of fish skin powder. From that, 15 g of the powder was taken and mixed with 106.8 g of wheat flour, ginger-garlic paste, onion paste, chili flakes, fennel seed powder, dried fenugreek leaves and salt. 150.48 ml of water was added to the mixture to obtain a smooth paste-like consistency of the mixture.

Round-shaped moulds were greased with refined oil and two teaspoons of the paste was placed into each mould. Meanwhile, water was boiled in a steamer and then steamed the moulds with the paste for 2-3 minutes. After steaming, the moulds were taken out and placed the steamed papads onto the greased aluminum foil or trays. These were then dried in a solar dryer (50 ºC for 24 hours). Finally, the raw papads were fried in refined oil until they turned golden brown.

The exact ingredient composition for the fish skin papad is shown in table 1 and the step-by-step preparation process is illustrated in figure 1.

3. Analysis of Physico-chemical Parameters

3.1 Proximate Composition Analysis

Proximate composition analysis including moisture, crude protein, fat and ash content was determined for fresh Rohu fish meat and fish skin papad following standard AOAC methods.

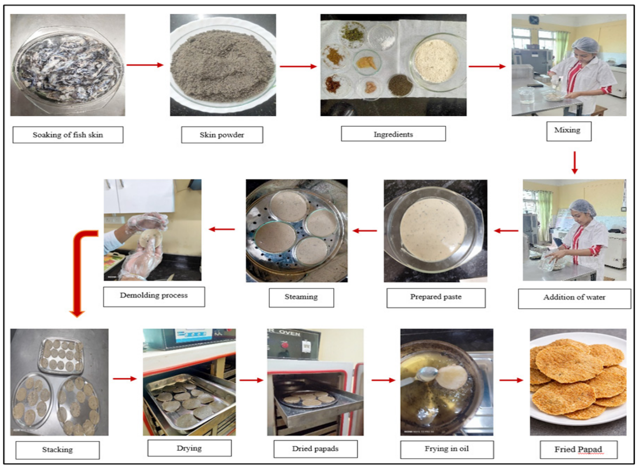

Figure 1: Steps for preparation of fish skin papad

Table 1: Ingredient composition for fish skin papad

Sl. No.	Ingredients	Percentage (%)
1	Fish skin powder	5.00
2	Ginger, garlic paste	3.07
3	Onion paste	2.36
4	Chili flakes	0.76
5	Fennel seed powder	0.76
6	Fenugreek leaves	0.76
7	Salt	1.53
8	wheat flour	35.60
9	Water	50.16

a) Moisture Estimation (AOAC, 2016): About 6 g of homogenized sample was placed in a pre-weighed petri dish and dried in a hot air oven at 100±2 °C for 16-18 hours. After drying, the dish was cooled in a desiccator and weighed again. Moisture percentage was calculated from the weight loss during drying.

b) Crude Protein Content (Kjeldahl Method, AOAC, 2016): Approximately 200 mg of dried sample was digested with concentrated sulfuric acid and a catalyst mixture (copper sulphate and potassium sulphate in a 1:5 ratio). Digestion started at 200 °C and then went up to 410 °C until the solution became clear. The digest was then distilled and the ammonia released was titrated with 0.1 N HCl using boric acid and appropriate indicators. Nitrogen percentage was calculated from the titration values and converted to crude protein using a conversion factor of 6.25.

c) Crude Fat Content (Soxhlet Method, AOAC, 2016): Approximately 3 g of dried sample was placed in a thimble and extracted with anhydrous ether (40-60 °C) for 1.5 hours using a Soxhlet apparatus. After recovering the solvent, the extract was dried and weighed. Fat content was calculated gravimetrically; dry-basis results were converted to wet basis by accounting for the solid content of the sample.

d) Crude Ash Content (AOAC, 2016): A 2 g dried sample was first charred at 100±5 °C using a Bunsen burner, then incinerated in a muffle furnace at 550±5 °C until white ash remained (about 5-6 hours). After cooling, the ash was weighed and ash percentage was calculated relative to the initial sample mass.

e) Carbohydrate Content (AOAC, 2016): Exactly 100 mg of the sample was weighed into a boiling tube and hydrolysed with 5 ml of 2.5 N HCl in a boiling water bath for three hours. After cooling, the mixture was neutralized with solid sodium carbonate until bubbling stopped, then made up to 100 ml with distilled water and centrifuged. Aliquots of 0.5 ml and 1.0 ml of the supernatant were taken for analysis. Standards were prepared by taking 0, 0.2, 0.4, 0.6, 0.8 and 1.0 ml of a working glucose standard; the volume in all tubes (including samples) was adjusted to 1 ml with distilled water. To each tube, 4 ml of anthrone reagent was added and the mixture was heated in a boiling water bath for eight minutes. After rapid cooling, absorbance was read at 630 nm. A standard curve was plotted with absorbance against glucose concentration and the glucose content of the unknown samples was determined from that curve.

4. Analysis of Colour Parameters

Colour of the fish skin papad was measured using a colorimeter (Colourflex EZ, Hunter Associates Laboratory, Inc., Reston, VA). Before each analysis, the instrument was calibrated with black and white reference plates. A small portion of both raw and fried fish skin papad was placed over the light source and the post-processing L^*, a^* and b^* values were recorded for the samples.

5. Cutting Force Analysis

Cutting force of the fish skin papad was measured using a texture analyzer (Dong, 2023). The required blade was attached and the instrument was calibrated with specific settings before starting the analysis. Crispness of the papad was determined from the first force peak in the graph. Cutting force was calculated using the following formula:

Cutting force = Maximum force / Cross-section area

6. Oil Absorption Test

Oil absorption of the fish skin papad was estimated by measuring the fat content before and after frying using a fat estimation machine. The percentage of fat uptake was calculated with the following formula:

Fat uptake (%) = {(Amount of fat after frying - Amount of fat before frying) / weight of sample} × 100

7. Microbial Analysis

7.1 Total Plate Count

The total plate count was carried out following the method described by APHA (1995). For total bacterial enumeration, 10 g of the sample was macerated with 90 ml of sterile physiological saline (0.85% NaCl). Ten-fold serial dilutions were prepared from the mixture and 0.1 ml from each dilution was spread onto triplicate plates containing nutrient agar using a spreader following the standard spread plate technique. The plates were then incubated under aerobic conditions for 24 to 48 hours. Visible colonies were counted and the results were expressed as log CFU (colony forming units) per gram of sample.

8. Sensory Analysis

A panel of 20 trained and experienced assessors from the College of Fisheries, CAU (I), Lembucherra was invited for sensory evaluation of the fish skin papad. All panel members were regular consumers familiar with the sensory attributes of the product. A structured scorecard was prepared and the samples were rated using a 9-point hedonic scale, with scores assigned according to the degree of liking the product as described by Wichchukit and O'Mahony (2015).

9. Statistical Analysis

All experiments were carried out in triplicate and data were expressed as mean ± standard deviation.

Results and Discussion

Fish skin papad represents an innovative value-added snack food that utilizes the fish processing waste and adds nutrition. In some parts of the country, people actually prefer eating fish with the skin on and do not consider it as a waste. The product developed in this study offers a novel approach where nutritional potential of fish skin (high protein) is exploited which supports skin elasticity, joint health, bone strength and mineral availability. The yield of fish skin powder obtained in the present study, along with the initial raw material weight is shown in table 2.

Table 2: Yield of fish skin papad

Total weight of raw skin (g)	Total weight of skin after drying (g)	Total weight of skin powder (g)	Yield (%)
300±0.21	195±0.07	193.74±0.12	64.58±0.55

*The values presented in the table are mean±SE, n=3.

The proximate composition data of fish skin and fish skin papad (both raw and fried) are presented in figure 2. Moisture content was found to be 5.73%, desirable for keeping the crispiness of papad and prevent microbial growth and spoilage. Protein content in the raw fish skin papad was 20.4%, which remained relatively stable (19.85%) even after frying. This finding is comparable to studies that found minimal protein loss during fish frying with skin on for Cod and Salmon fillet (Ansorena *et al.*, 2010). Ash content was found to be 7.46%, pointing to the presence of minerals like calcium and phosphorus naturally abundant in fish skin. This high ash content adds to the papad's nutritional and health benefit properties especially for bone health management. Similar observation was recorded by Hou *et al.* (2022), who highlighted the content of essential minerals in collagen-rich fish derived products.

Table 3 shows the instrumental colour values L^* (lightness), a^* (redness) and b^* (yellowness) for the fish skin papad. The raw papad had a low L^* value, showing a dark or dull colour. However, it turned much lighter and brighter after frying.

L* value increased from 23.25 up to 52.03 after frying of the product. Redness (a*) increased from 2.28 to 4.98 and yellowness (b*) rose from 7.49 to 14.54, which expressed as a nice golden-yellow colour for the papad. These changes are attributed to possible occurrence of Maillard reactions and caramelization during frying. Sidhu *et al.* (2024) saw similar colour changes in chickpea flour papads. When compared to lentil-based papads studied by Emir *et al.* (2023), the fish skin papad had a much bigger jump in yellowness. This is likely because the fish skin powder brings its own natural pigments to the product.

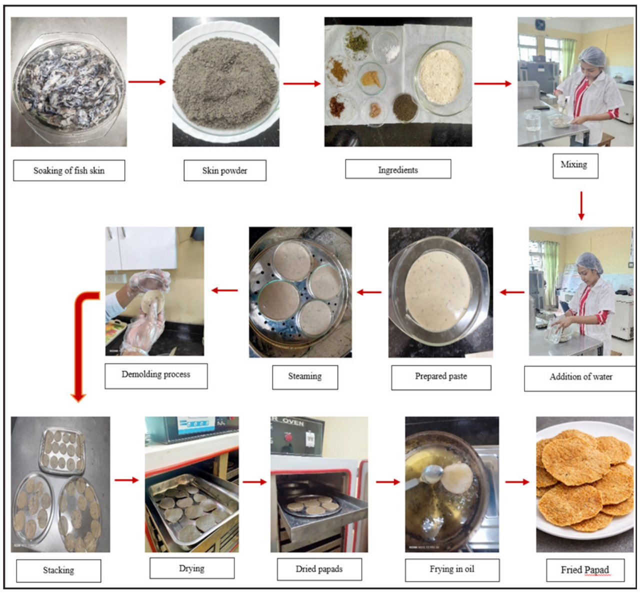

Figure 1: Graphical representation of preparation of fish skin papad

Table 3: Color analysis of fish skin papad

Sample	L*	a*	b*
Fish skin papad (Raw)	23.25±0.04	2.28±0.19	7.49±0.23
Fish skin papad (Fried)	59.03±0.14	4.98±0.23	14.54±0.78

*The values presented in the table are mean±SE, n=3.

Texture profile analysis revealed clear differences in cutting force between raw and fried samples (Table 4). The raw papad required a cutting force of 0.57 kgf, whereas the fried papad needed only 0.28 kgf.

Table 4: Cutting force analysis of fish skin papad

Force (kgf)	Fish skin papad (Raw)	Fish skin papad (Fried)
	0.57±0.01	0.28±0.04

*The values presented in the table are mean±SE, n=3.

Table 5 gives the fat levels of the product before and after frying. The oil uptake of the fried papad was 11.91%. At that absorption rate, the papad contained with a moderate amount of fat but still held onto that nice crispiness of the product which people desire. According to Valle *et al.* (2024), some of the food products soak up over 20% oil. The observed balance between fat and protein makes the fish skin papad nutritionally rich functional snack product. It is consistent with growing consumers' preference towards low-fat, high-protein foods.

Table 5: Oil absorption of fish skin papad

Amount of fat before frying (g)	Amount of fat after frying (g)
0.19±0.21	0.50±0.17

*The values presented in the table are mean±SE, n=3.

The oil uptake by fish skin papad observed in this study is relatively low, especially in comparison to other fried snack products. According to Kita *et al.* (2007), potato chips usually soak up somewhere around 30-40% oil during frying. So, moderate oil absorption by fish skin papad can be considered a desirable quality. Excessive oil uptake makes snacks greasy and packs in extra calories, which is often considered as nutritionally poor-quality product (Saguy and Dana, 2003). The less oil uptake by fish skin papad may be attributed to structural characteristics of fish skin matrix which limits oil absorption during frying (Bouchon, 2009). On the flip side, products like fish chips have a more porous structure thus end up absorbing more oil resulting in higher fat content.

The total plate count (TPC) for the fish skin papad was found to be 1.512 log CFU g^{-1}, indicating low overall microbial load. This low TPC value signifies hygienic handling, processing and storage of the product, with minimal chances for microbial contamination. According to the food safety standards established by the Food Safety and Standards Authority of India (FSSAI, 2011; 2022), the TPC value of 1.512 log CFU g^{-1} falls well within the acceptable limit for fried snack foods. So, the fish skin papad can be considered microbiologically safe for consumption meeting the required food safety standards.

The sensory parameters of fish skin papad are presented in the table 6. The product was well accepted by the panelists with an overall acceptability score averaging 8.03 out of 9.

Table 6: Sensory characteristics of fish skin papad

Sl. No.	Sensory parameter	Score
1	General appearance	8.31
2	Color	7.16
3	Taste	8.48
4	Texture	8.19
5	Overall acceptability	8.03

Conclusion

The high protein coming from collagen-rich fish skin, plus a solid amount of minerals highlights the potential of fish skin papad as a functional food option with good nutrition and nutritional potential. The moderate oil absorption while maintaining crispy texture enhances its appeal and suitability as a healthier alternative to the usual fried snacks. The low microbial load further establishes the product's safety, which backs up its potential as a ready-to-cook product. The satisfactory sensory scores suggest a promising value added product meeting the growing demand of consumers for nutritious, safe and convenient snack food.

Future studies should emphasize the standard packaging system to preserve the quality attributes and enhance shelf life of fish skin papad. Alternative cooking methods may also be explored to reduce oil absorption, maintaining nutrition, functionality and consumer acceptability of the product. Overall, fish skin papad has solid potential as a nutritious, cost-effective and sustainable snack. With proper hygienic processing, standardization and packaging, it would serve as a healthier alternative to conventional papad. In addition, the utilization of fish skin contributes to valorization of fish processing waste and supports sustainable development.

Author's Contribution

Bahni Dhar: Conceptualization, designing of the study, final editing of the article. *Surashree Sarkar*: Experimental analysis data collection, writing original draft. *Sikan Shubhankar Nayak*: Data analysis, editing and formatting the article. All authors have read the final version and given their consent for submission.

Ethical Statement

The authors declare that no generative artificial intelligence tools were used in drafting or preparing this manuscript. The manuscript was written, interpreted and revised solely by the authors, who take full responsibility for its content.

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