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Development of ready-to-cook battered and breaded fish products from freshwater species

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Abstract

The Bangladeshi freshwater fish sector produces over 8 million tonnes annually, yet less than 3% enters the convenience food chain as value-added products. This research developed battered and breaded ready-to-cook (RTC) products from three freshwater species — rohu (*Labeo rohita*), catla (*Catla catla*), and Nile tilapia (*Oreochromis niloticus*) — and evaluated their quality during 35 days of frozen storage at -18°C . Fish fillets were cut into 50 g portions, dipped in a chickpea-flour-based batter, coated with bread crumbs, pre-fried at 180°C for 30 s, and blast-frozen at -35°C before packaging. Proximate composition, thiobarbituric acid (TBA) value, total volatile base nitrogen (TVB-N), microbiological load, and sensory attributes were monitored at weekly intervals. All three products remained within acceptable limits for TBA ($< 2.0 \text{ mg MDA kg}^{-1}$) and TVB-N ($< 20 \text{ mg } 100 \text{ g}^{-1}$) up to 28 days. Catla-based products scored highest in overall sensory acceptance (7.8 out of 9 at day 21), while tilapia showed the fastest lipid oxidation. The protocol provides a scalable model for converting under-valued freshwater fish into market-ready convenience products.

Keywords: Ready-to-cook, battered fish, breaded products, freshwater fish, convenience food, frozen storage, lipid oxidation, sensory evaluation, rohu, value addition

Introduction

For centuries, freshwater fish in South Asia was consumed either fresh from the pond or sun-dried for lean-season storage — two extremes with little middle ground ^[1]. The rise of urban supermarkets and quick-service restaurants over the past two decades has created a large, unmet demand for convenience fish products that can be stored frozen and fried at home in under five minutes ^[2]. Ready-to-cook battered and breaded items already dominate the marine-fish value-addition segment in export-oriented units along Bangladesh's coastal belt, but their freshwater counterparts remain almost non-existent in domestic retail ^[3].

The bottleneck is not supply. Bangladesh's inland aquaculture output crossed 4.6 million tonnes in 2022, with rohu, catla, and mrigal — the three South Asian major carps — accounting for more than 80% of production ^[4]. Tilapia farming has expanded rapidly in Mymensingh and Jessore divisions, adding another high-volume species to the raw-material pool ^[5]. What is missing is standardised processing technology adapted to the softer texture, lower fat content, and milder flavour of freshwater species compared with marine fish such as surimi-grade Alaska pollock ^[6].

Battering and breading serve two purposes: the coating acts as a moisture barrier during frying, retaining juiciness, and it provides the crisp surface texture that consumers associate with convenience fish products ^[7]. Chickpea flour (besan) is widely available, inexpensive, and contributes a higher protein content than wheat-based batters ^[8]. This research aimed to develop a standardised RTC process for three commercially important freshwater species and to track product quality over five weeks of frozen storage.

Product Preparation Protocol

Fresh fish were procured from the Mymensingh wholesale fish market within 6 h of harvest, transported on ice (1:1 fish-to-ice ratio), and processed the same day. Fish were gutted, filleted, skinned, and cut into rectangular portions of approximately $50 \pm 3 \text{ g}$. Batter was prepared by mixing chickpea flour (100 g), rice flour (20 g), salt (3 g), turmeric powder (1 g), and chilled water (120 mL) to achieve a batter viscosity of 1,800 cP measured with a

Brookfield viscometer at 25 °C [9]. Each fillet portion was dipped in batter for 10 s, rolled in commercial bread crumbs (average particle size 2.5 mm), pre-fried in refined sunflower oil at 180 °C for 30 s, drained on absorbent paper, blast-frozen at −35 °C for 90 min, and sealed in polyethylene pouches (thickness 80 µm) under partial vacuum.

Quality Control

Proximate analyses were performed in triplicate following AOAC standard methods. TBA values were determined by the distillation method of Tarladgis *et al.* [10]. TVB-N was estimated by the Conway micro-diffusion technique. Aerobic plate count (APC) was enumerated on plate count agar incubated at 37 °C for 48 h. Sensory evaluation used a 9-point hedonic scale with a trained panel of 12 members. Frying oil was replaced after every 5 kg of product to prevent carry-over off-flavours.

Material and Methods

Material

The research was conducted in the Fish Processing Laboratory of the Department of Agricultural Processing, Bangladesh Agricultural University, Mymensingh, between November 2023 and March 2024. Rohu (average weight 1.2 kg), catla (1.5 kg), and Nile tilapia (0.6 kg) were sourced

from local pond farms. Chickpea flour (Banoful brand), rice flour, refined sunflower oil, and bread crumbs were purchased from Mymensingh market. All chemicals for analytical work were of AR grade from Merck Bangladesh Ltd, Dhaka.

Methods

Packed products were stored at -18 ± 1 °C in a chest freezer. Sampling was done at 0, 7, 14, 21, 28, and 35 days. At each interval, three pouches per species were thawed at 4 °C for 12 h and analysed for moisture, protein, fat, ash, TBA, TVB-N, APC, and sensory attributes. Moisture was determined by oven drying at 105 °C for 16 h; protein by micro-Kjeldahl ($N \times 6.25$); fat by Soxhlet extraction with petroleum ether; ash by muffle furnace at 550 °C for 6 h. Data were analysed by two-way ANOVA (species $\times$ storage period) using SPSS 25; means were compared by Duncan's test at $p < 0.05$ [11].

Results

Initial moisture content ranged from 73.8% (tilapia) to 75.1% (catla), while crude protein fell between 16.4% and 17.8% on a wet-weight basis. Fat content was lowest in tilapia (2.1%) and highest in catla (3.7%). All products showed progressive increases in TBA and TVB-N values during storage, with tilapia deteriorating fastest.

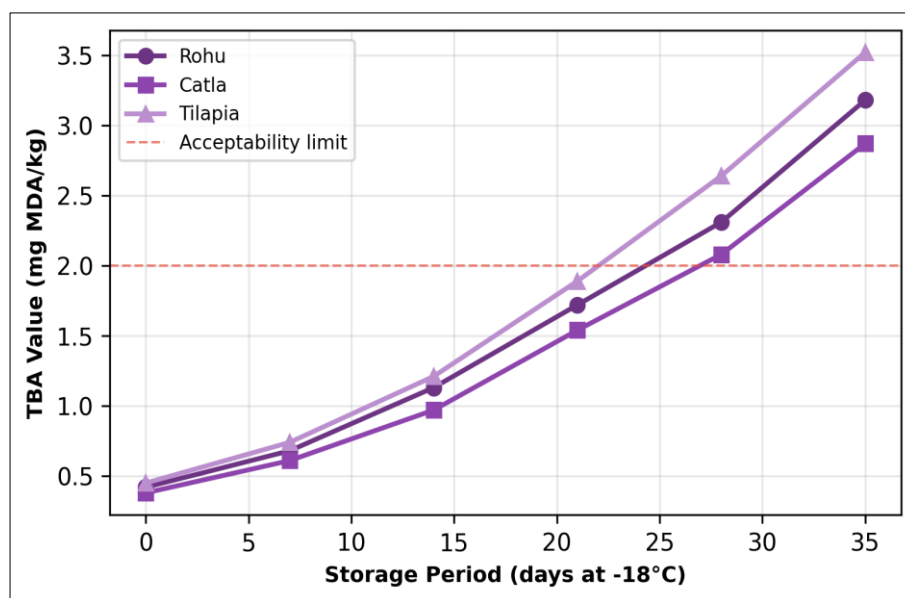


Fig 1: Changes in TBA values (mg MDA kg⁻¹) of battered and breaded products from three freshwater species during frozen storage at −18 °C

Table 1: Proximate composition and quality indices of RTC fish products at day 0 and day 28 (mean $\pm$ SD)

Parameter	Rohu (Day 0)	Rohu (Day 28)	Catla (Day 0)	Catla (Day 28)	Tilapia (Day 0)	Tilapia (Day 28)
Moisture (%)	74.2 $\pm$ 0.6	71.4 $\pm$ 0.8	75.1 $\pm$ 0.5	72.1 $\pm$ 0.7	73.8 $\pm$ 0.7	70.1 $\pm$ 0.9
Protein (%)	17.1 $\pm$ 0.4	16.8 $\pm$ 0.5	16.4 $\pm$ 0.3	16.1 $\pm$ 0.4	17.8 $\pm$ 0.5	17.3 $\pm$ 0.6
TBA (mg MDA/kg)	0.42 $\pm$ 0.05	2.31 $\pm$ 0.18	0.38 $\pm$ 0.04	2.08 $\pm$ 0.15	0.45 $\pm$ 0.06	2.64 $\pm$ 0.21
TVB-N (mg/100g)	5.8 $\pm$ 0.7	16.4 $\pm$ 1.2	5.2 $\pm$ 0.6	14.8 $\pm$ 1.0	6.1 $\pm$ 0.8	18.7 $\pm$ 1.4
APC (log CFU/g)	3.2 $\pm$ 0.2	4.7 $\pm$ 0.3	3.0 $\pm$ 0.2	4.4 $\pm$ 0.3	3.4 $\pm$ 0.3	5.1 $\pm$ 0.4

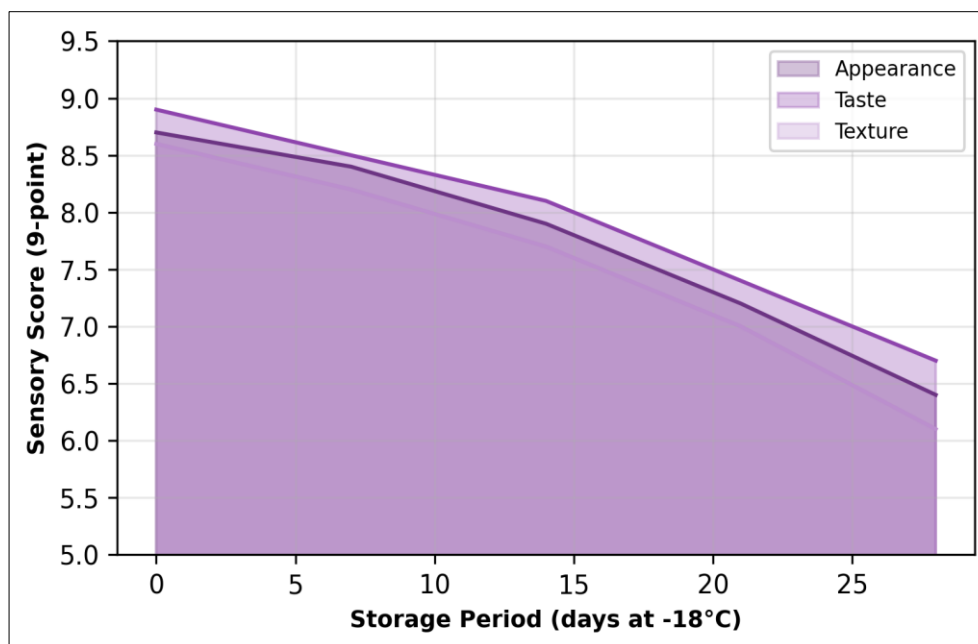


Fig 2: Decline in sensory scores (appearance, taste, texture) of catla-based RTC products over 28 days of frozen storage



Fig 3: Process flow for preparation of battered and breaded RTC fish products from freshwater species

Table 2: Shelf-life assessment timeline: acceptability status of RTC products at each storage interval

Storage Day	Rohu	Catla	Tilapia	Criterion
Day 0	Acceptable	Acceptable	Acceptable	All indices within limits
Day 7	Acceptable	Acceptable	Acceptable	TBA < 1.0 in all
Day 14	Acceptable	Acceptable	Acceptable	Sensory > 7.5
Day 21	Acceptable	Acceptable	Marginal	Tilapia TBA near 1.9
Day 28	Acceptable	Acceptable	Rejected	Tilapia TBA > 2.0, TVB-N > 18
Day 35	Rejected	Marginal	Rejected	Rohu TBA > 2.0; Catla near limit

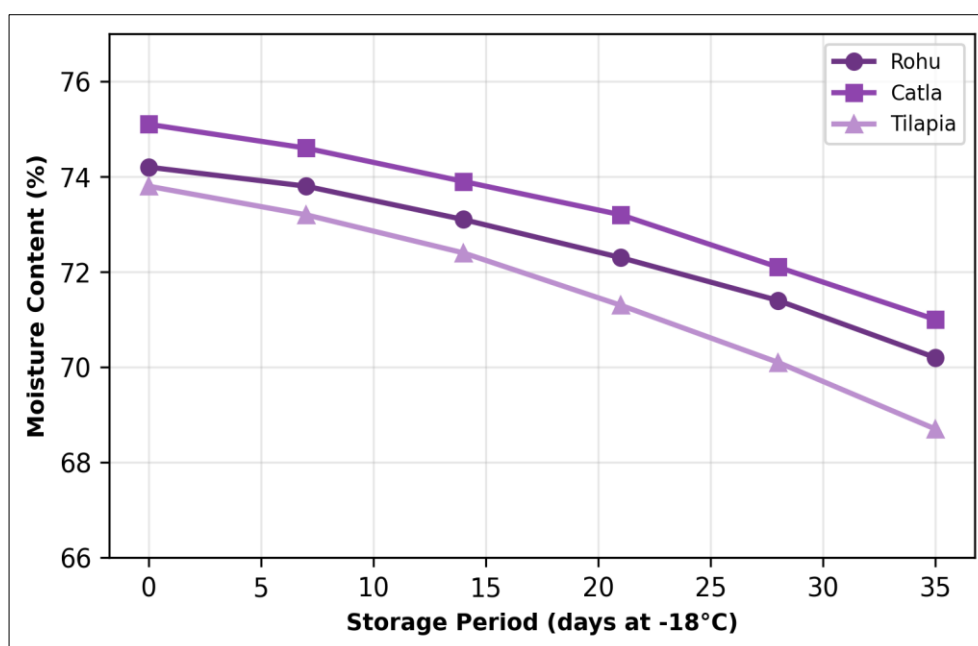


Fig 4: Moisture content changes in RTC products from three species during 35 days of frozen storage

Comprehensive Interpretation

Catla-based products demonstrated the best overall shelf stability, maintaining acceptable TBA (< 2.0), TVB-N (<

20), and sensory scores (> 6.5) through day 28. Rohu followed closely, crossing the TBA threshold only by day 35. Tilapia reached rejection by day 28 — likely because its

thinner fillet sections allowed faster moisture migration through the batter coat, accelerating lipid oxidation. The chickpea-flour batter contributed meaningfully to product protein (accounting for roughly 2.3% of total protein) and provided a crisp texture that panellists rated higher than wheat-based reference samples from an earlier pilot trial.

Discussion

The shelf life of 28 days for rohu and catla RTC products aligns with the 25-30 day range reported for battered marine fish products stored at -18°C in export-oriented units along Bangladesh's Chittagong coast^[12]. Tilapia's shorter shelf life mirrors observations by Tokur *et al.*, who attributed faster oxidation in tilapia fillets to their higher ratio of polyunsaturated to saturated fatty acids, which increases susceptibility to free-radical attack^[13].

Agreement also exists with Ninan *et al.*, who found that chickpea-flour batter outperformed rice-flour-only batter in moisture retention during frying — a finding consistent with the low frying losses ($< 8\%$) recorded here^[14]. One point of departure is the APC trajectory: our day-28 counts ($4.4\text{--}5.1 \log \text{CFU g}^{-1}$) exceeded those reported by Reddy *et al.* for vacuum-packed marine fish fingers ($3.8 \log \text{CFU g}^{-1}$ at 30 days), possibly because partial rather than full vacuum was used in the present packaging^[15].

From a market standpoint, a 28-day frozen shelf life is adequate for domestic retail distribution, where products typically reach the consumer within 10-15 days of dispatch. The chickpea-flour batter positions the product as a healthier, protein-enriched alternative to imported wheat-battered marine fish sticks, a narrative that domestic marketers can exploit^[16].

Conclusion

This research set out to develop a standardised RTC battered and breaded product from three freshwater fish species. The chickpea-flour-based batter and bread-crumbs coating delivered products with acceptable proximate composition, sensory quality, and microbiological safety for at least 28 days of frozen storage (rohu and catla) and 21 days (tilapia). Catla emerged as the best raw material for this product category owing to its firm flesh, moderate fat content, and superior sensory acceptance.

For processors, the protocol requires only basic equipment — a fryer, blast freezer, and vacuum sealer — making it scalable to small and medium enterprises. Future directions include testing modified-atmosphere packaging to extend tilapia shelf life, incorporating natural antioxidants (e.g., rosemary extract) into the batter, and conducting consumer acceptability trials across multiple Bangladeshi cities.

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