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Effect of spice treatment on the proximate composition of fish floss from catfish *(Clarias gariepinus)*

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Abstract
This study investigated the production and proximate composition of fish floss from African catfish (*Clarias gariepinus*), with emphasis on the effects of spice treatments on the nutritional quality and storage stability. Fresh fish samples purchased from were processed into floss using s method describe by Isah, 2018 [6], with three (3) treatments per species: control (no spice), ginger, clove, and a ginger-clove combination. Proximate composition was analyzed following AOAC (2015) [2] methods, and data were subjected to one-way analysis of variance (ANOVA) with significance at $p<0.05$. Results showed that moisture content decreased significantly in the catfish floss without spices but remained more stable in spiced samples, suggesting improved shelf-life. Ash and crude fibre levels were higher in spiced treatments, indicating mineral and dietary fibre contributions from spices. Fat content was more stable in spiced floss, supporting the anti- oxidative role of ginger and clove, while protein values were better preserved in spiced treatments compared to controls. Carbohydrate levels declined over storage periods, likely due to non-enzymatic browning and microbial activity. Overall, spiced fish floss demonstrated superior nutritional retention and stability compared to the un-spiced samples. The findings highlight the potential of spice incorporation to enhance the quality, safety, and shelf-life of value-added fish products.

Keywords: Spice treatment, proximate composition, fish floss, *Clarias gariepinus*

Introduction

African catfish (*Clarias gariepinus*) is among the most important freshwater species in global aquaculture, providing a large share of affordable animal protein for low- and middle-income countries. Its rapid growth rates, adaptability to diverse culture systems, and widespread consumer acceptance have driven increases in production over the past decade (Barría *et al.*, 2023; Liu *et al.*, 2015) [3, 9].

Proximate composition is central to evaluating the nutritional quality and shelf-life behaviour of fish floss. Protein content determines the product's value as a protein supplement, while residual lipid content is a primary determinant of oxidative stability and shelf life: higher fat levels increase susceptibility to lipid oxidation and off-flavours, shortening acceptable storage time at ambient conditions. Moisture content (and resulting water activity) controls microbial growth and textural properties; therefore, proximate analyses provide essential baseline data for formulation, process control, and labelling (Liu *et al.*, 2015; Kusumawati *et al.*, 2024) [9, 7].

"Dambun kifi" (fish floss) is a fish product produced mostly in the northern Nigeria by mainly the Hausas and Fulanis. It is a shredded or mashed fish meat/flesh cooked in spices and then stir fried until the fish flesh is dry and powdery. Fish floss is quite different from other flosses; it has very nice and attracting aroma ahead of them. It is quite easier, though, it also requires time and energy, but fish due to its softness do not need grinding or beating with a wooden stick. It requires less oil than other flosses. (Lisa, 2019) [8].

Materials and Methods

Study Area

The study was carried out in the Fish Processing Unit and the Hospitality Department of the Federal College Freshwater Fisheries Technology (FCFFT), New Bussa, Niger State, Nigeria.

Geographical Location
New Bussa is the headquarters of Borgu Emirate and Borgu Local Government Area in Niger State, Nigeria. It is geographically located on latitude 9°53′N and longitude 4°31′E (NIFFR Archive, 2023) [10].

Source of Experimental Fish
The experimental fish species, African catfish *(Clarias gariepinus)* was purchased fresh from the Monday Market, New Bussa, Borgu Local Government Area, Niger State, Nigeria.

Materials
The materials used in the experiment included fresh fish samples, sodium chloride (NaCl; table salt), ginger *(Zingiber officinale)*, clove *(Syzygium aromaticum)*, seasoning cubes, onion *(Allium cepa)*, pepper *(Capsicum annuum)*, vegetable oil, curry powder, thyme, lime *(Citrus aurantiifolia)*, stainless steel bowls, sharp knife, cutting slab, turning spoon, frying pot, packaging materials, weighing balance *(Diamond and Five Goats' Products)*, and a Smeg electric cooker.

Procedure for Production of Fish Floss
The production of fish floss followed the method described by Isah (2018) [6] with slight modifications. The fish samples were rubbed with lime juice to remove surface slime, washed thoroughly with clean water, descaled, degutted, and de-finned. Each 5 kg portion was weighed using a digital weighing balance. Ten grams (10 g) of table salt, five (5) seasoning cubes, two chopped onion bulbs, and 100 g of fresh pepper were added to each sample. The appropriate spice treatment (ginger, clove, or combination) was incorporated according to the design.
The fish was cooked at 63 °C for 30 minutes using a Smeg electric cooker, following US-FDA/USDA (2021) safe cooking guidelines, until the flesh became tender. After cooking, the fish was strained to reduce moisture (Winarni *et al.*, 2021) [16], deboned, and de-skinned to obtain boneless flesh. The flesh was shredded into fine fibres and shallow-fried with two (2) tablespoons of vegetable oil (2 tablespoon) at 150 °C for 30 minutes, until the moisture content reached a level suitable for shelf-life stability.

Proximate Analysis
Proximate composition of the fish samples was determined following the methods of AOAC (2015) [2].

Moisture Content
Moisture was determined using the oven-drying method. Two grams of fish sample were dried at 100 °C to constant weight and cooled in a desiccator before weighing.

$$\%Moisture = \frac{Loss\ in\ weight}{Sample\ weight} \times 100$$

Crude Protein
Protein content was determined by the Micro-Kjeldahl method. Total nitrogen obtained was multiplied by 6.25 to estimate crude protein.

Ash Content
Samples were ignited in a muffle furnace at 550-600 °C until a whitish-grey ash was obtained, cooled in a desiccator, and weighed.

$$\%Ash = \frac{Weight\ of\ ash}{Sample\ weight} \times 100$$

Crude Fat
Crude fat was determined by Soxhlet extraction using petroleum ether as solvent. The solvent was evaporated, and the flask dried and reweighed.

$$\%Fat = \frac{Weight\ of\ extract}{Sample\ weight} \times 100$$

Crude Fibre
Defatted samples were digested with dilute acid and alkali, filtered, dried, incinerated at 550 °C, and reweighed
.

$$\%Crude\ Fibre = \frac{Residue - Ash}{Sample\ weight} \times 100$$

Nitrogen-Free Extract (NFE)
- NFE was obtained by difference
- %NFE=100−(%Moisture+%Protein+%Fat+%Fibre+%Ash)%

Data Analysis
Data obtained from the proximate composition of fish floss produced from *Catfish* (*Clarias gariepinus*) were subjected to one-way Analysis of Variance (ANOVA) using SPSS (Version 25.0). Treatment means were separated using Duncan's Multiple Range Test (DMRT) at a significance level of $p<0.05$.

Results
Moisture Content of Fish Floss Produced from Catfish
In treatment C0, the initial moisture content was $12.85\pm0.03^{a,A}$, which decreased to $10.87\pm0.03^{a,B}$ in month 1, remained steady at $12.10\pm0.03^{a,A}$ in month 2, then dropped to $9.38\pm0.03^{a,c}$ in month 3. It further declined to $9.70\pm0.03^{b,c}$ in month 4, reached its lowest at $8.52\pm0.03^{b,D}$ in month 5, and slightly increased to $9.55\pm0.03^{a,c}$ by month 6.
For treatment C1, the initial value was $4.80\pm0.03^{c,D}$, slightly decreasing to $4.63\pm0.03^{c,D}$ in month 1, and rising to $5.29\pm0.03^{b,c}$ in month 2. It then increased to $6.13\pm0.03^{b,B}$ in month 3, $7.42\pm0.03^{b,A}$ in month 4, dipped slightly to $7.12\pm0.03^{b,A}$ in month 5, and ended at $7.15\pm0.03^{b,A}$ in month 6.
In C2, the moisture content started at $5.29\pm0.03^{b,B}$, slightly rose to $5.79\pm0.03^{b,B}$ in month 1, followed by $5.91\pm0.03^{b,B}$ in month 2. It continued increasing to $6.22\pm0.04^{b,A}$ in month 3 and peaked at $6.85\pm0.03^{c,A}$ in month 4. The values then slightly declined to $6.65\pm0.03^{c,A}$ and $6.53\pm0.03^{c,A}$ in months 5 and 6, respectively.
Treatment C3 began at $4.92\pm0.03^{c,D}$, increased to $5.19\pm0.03^{b,c}$ in month 1, and $5.82\pm0.03^{b,c}$ in month 2. The moisture continued to rise to $6.15\pm0.03^{b,B}$ in month 3, $7.49\pm0.03^{b,A}$ in month 4, peaked at $7.78\pm0.03^{b,A}$ in month 5, and slightly reduced to $7.19\pm0.03^{b,A}$ by month 6.

The percentage ash content of fish floss produced from catfish: The percentage ash content of fish floss produced from catfish with different spice treatments (C0 to C3) over six months of storage. Initially, the ash content was $4.42 \pm 0.03^{a,A}$ for both C0 and C3, $4.57 \pm 0.03^{a,A}$ for C1, and highest in C2 at $4.87 \pm 0.03^{a,A}$. Across the six-month period, C0 remained relatively stable, ranging from $4.26 \pm 0.03^{a,A}$ to $4.51 \pm 0.03^{a,A}$, while C1 varied between $4.36 \pm 0.03^{a,A}$ and

4.63 ± 0.03^{a,A}. C2, although initially the highest, ranged from 4.33 ± 0.05^{a,A} to 4.62 ± 0.03^{a,A}, and C3 ranged from 4.09±0.03^{a,A} to 4.66 ± 0.03^{a,A}. Throughout the storage period, no significant differences (p>0.05) were observed among treatments or over time, as indicated by the common superscripts (^{a,A}) across all values.

Percentage Fat Content of Fish Floss Produced from Catfish: The fat content of catfish fish floss varied across spice types and storage durations: For C0 (no spice), the fat content increased from 13.07±0.03^{b,B} initially to 14.63±0.03^{b,A} at month 6, with superscript letters indicating significant differences over time (^{B} to ^{A}), but no significant differences across spice types within each month (same lowercase letter ^{b}).

C1 showed the highest and most stable fat content, starting at 15.27±0.03^{a,A} and ending at 15.32±0.03^{a,A}, with consistent superscripts (^{a,A}), meaning no significant difference over time or across spice types.

C2 started at 12.17±0.03^{c,c} and increased to 15.22±0.03^{a,A}, showing significant differences across both spice types and time (from ^{c} to ^{a} and ^{c} to ^{A}).

C3 had the lowest initial fat content at 9.23±0.03^{d,c}, dropped further to 7.85±0.03^{c,e} at month 1, then rose steadily to 14.56±0.03^{b,A} by month 6. The superscripts (^{d,c} to ^{b,A}) reflect highly significant changes over both time and spice type.

Percentage crude protein content of fish floss produced from catfish: For treatment C0, the initial crude protein content was 52.47±0.03%. Over six months, the values fluctuated slightly but generally stayed in the range of about 54.67±0.03% to 55.20±0.03%.

Treatment C1 started with 55.09±0.03% crude protein, and the protein content showed significant increases at months 1 to 4 (ranging from 58.32±0.03% to 58.00±0.03%), with a slight decline at month 5 and then a slight rise again at month 6 (58.34±0.03%).

Treatment C2 began at 57.72±0.03% and showed some fluctuations across the six months, with protein values ranging from 55.47±0.03% to 56.90±0.03%.

Treatment C3 started with a lower initial value of 51.13±0.03%, and showed a consistent decline in protein content over the six months, dropping from 41.29±0.03% at month 1 to 48.35±0.03% at month 6.

Crude fibre content of fish floss produced from catfish

For spice type C0, the crude fibre content started at 1.33±0.03^{a,A} and remained constant at 1.33±0.03^{a,A} in month 1, then slightly increased to 1.38±0.03^{a,A} in months 2 and 3. It peaked at 1.36±0.03^{a,A} in month 4 (significantly different), before decreasing in months 5 and 6 to 1.26±0.03^{ab,A} and 1.24±0.03^{ab,A} respectively.

For spice type C1, crude fibre content began at 1.49±0.03^{a,A} and stayed consistent through months 1 and 2 (1.49±0.03^{a,A} and 1.44±0.03^{a,A}). It slightly dropped through months 3 and 4 to 1.37±0.03^{a,A} and 1.39±0.03^{a,A}, then decreased more in month 5 to 1.28±0.03^{ab,A} and finally increased slightly in month 6 to 1.30±0.03^{ab,A}.

For spice type C2, initial crude fibre content was 1.35±0.03^{a,A} and remained steady for month 1 (1.35±0.03^{a,A}). It increased significantly to 1.49±0.03^{a,A} in month 2, further to 1.51±0.04^{a,A} in month 3, and peaked at 1.72±0.03^{a,A} in month 4. It then slightly decreased in months 5 and 6 to 1.67±0.03^{a,A} and 1.65±0.03^{a,A} respectively.

For spice type C3, crude fibre started at 0.74±0.03^{b,B} remaining the same through months 1 and 2. It increased to 1.13±0.02^{ab,A} in month 3, then further increased to 1.40±0.03^{a,A} in month 4. It continued to increase in months 5 and 6 to 1.54±0.03^{a,A} and 1.55±0.03^{a,A}.

Carbohydrate of Fish Floss Produced from Catfish

For Treatment C0, the initial carbohydrate content was 23.89±0.13^{aA}. It decreased over time, with values between 17.25±0.13^{bf} and 20.79±0.13^{bB}.

For Treatment C1, the initial carbohydrate content was 18.27±0.13^{cdA}. It declined significantly during storage, reaching 13.65±0.46^{dG} at month 6, with notable decreases at months 1 (14.57±0.13^{dD}), 2 (14.05±0.10^{df}), 3 (14.40±0.02^{dE}), and 4 (14.20±0.11^{df}).

For Treatment C2, the initial carbohydrate content was 18.95±0.13^{cB}. There was a peak at month 2 (33.00±0.13^{bA}), but values generally decreased over time.

For Treatment C3, the initial carbohydrate content was 21.61±0.13^{bE}. The carbohydrate content increased significantly, peaking at month 2 (38.74±0.09^{aA}), and then decreased but remained relatively high.

Table 1: Percentage Moisture content of fish floss produced from catfish

Treatment	Months						
	Initial	1	2	3	4	5	6
C0	12.85±0.03^{a,A}	10.87±0.03^{a,B}	12.10±0.03^{a,A}	9.38±0.03^{a,C}	9.70±0.03^{b,C}	8.52±0.03^{b,D}	9.55±0.03^{a,C}
C1	4.80±0.03^{c,D}	4.63±0.03^{c,D}	5.29±0.03^{b,C}	6.13±0.03^{b,B}	7.42±0.03^{b,A}	7.12±0.03^{b,A}	7.15±0.03^{b,A}
C2	5.29±0.03^{b,B}	5.79±0.03^{b,B}	5.91±0.03^{b,B}	6.22±0.04^{b,A}	6.85±0.03^{c,A}	6.65±0.03^{c,A}	6.53±0.03^{c,A}
C3	4.92±0.03^{c,D}	5.19±0.03^{b,C}	5.82±0.03^{b,C}	6.15±0.03^{b,B}	7.49±0.03^{b,A}	7.78±0.03^{b,A}	7.19±0.03^{b,A}

^{abcd} indicate significant difference (p<0.05) among spice type over a storage duration, ^{ABC} indicate significant difference across the storage duration over spice type

Table 2: Percentage ash content of fish floss produced from catfish

Spice type	Months						
	Initial	1	2	3	4	5	6
C0	4.42±0.03^{a,A}	4.26±0.03^{a,A}	4.32±0.03^{a,A}	4.32±0.03^{a,A}	4.28±0.03^{a,A}	4.45±0.03^{a,A}	4.51±0.03^{a,A}
C1	4.57±0.03^{a,A}	4.45±0.03^{a,A}	4.36±0.03^{a,A}	4.41±0.04^{a,A}	4.35±0.03^{a,A}	4.63±0.03^{a,A}	4.58±0.03^{a,A}
C2	4.87±0.03^{a,A}	4.62±0.03^{a,A}	4.49±0.03^{a,A}	4.33±0.05^{a,A}	4.43±0.03^{a,A}	4.38±0.03^{a,A}	4.52±0.03^{a,A}
C3	4.42±0.03^{a,A}	4.64±0.03^{a,A}	4.09±0.03^{a,A}	4.53±0.03^{a,A}	4.49±0.03^{a,A}	4.66±0.03^{a,A}	4.61±0.03^{a,A}

Values with similar lower, or upper-case superscripts indicate no statistical significance.

Table 3: Percentage fat content of fish floss produced from catfish

Spice type	Months						
	Initial	1	2	3	4	5	6
C0	13.07±0.03 $^{b, B}$	14.30±0.03 $^{b, A}$	14.80±0.03 $^{b, A}$	14.23±0.02 $^{b, A}$	14.55±0.03 $^{b, A}$	14.61±0.03 $^{b, A}$	14.63±0.03 $^{b, A}$
C1	15.27±0.03 $^{a, A}$	15.36±0.03 $^{a, A}$	15.52±0.03 $^{a, A}$	14.94±0.04 $^{b, B}$	15.20±0.03 $^{a, A}$	15.04± 0.03 $^{a, A}$	15.32±0.03 $^{a, A}$
C2	12.17±0.03^{c},^{C}	14.25±0.03 $^{b, B}$	15.71±0.03 $^{a, A}$	15.51±0.04 $^{a, A}$	15.18±0.03 $^{a, A}$	15.11±0.03 $^{a, A}$	15.22±0.03 $^{a, A}$
C3	9.23±0.03 $^{d, C}$	7.85±0.03 $^{c,\varepsilon}$	8.05±0.03 $^{c,\delta}$	12.53±0.06$^{c,\beta}$	14.22±0.03 $^{b, A}$	14.55±0.03 $^{b,\alpha}$	14.56±0.03 $^{b, A}$

^{abc} indicate significant difference (p<0.05) among spice type over a storage duration, ^{ABCDE} indicate significant difference across the storage duration over spice type.

Table 4: Percentage crude protein content of fish floss produced from catfish

Treatment	Months						
	Initial	1	2	3	4	5	6
C0	52.47±0.03 $^{c, D}$	54.67±0.03 ^{c,} C	56.87±0.03 $^{b, A}$	54.23±0.06 $^{c, C}$	54.70±0.03 $^{c, C}$	54.92±0.03 $^{b, C}$	55.20±0.03 $^{b, B}$
C1	55.09±0.03 $^{b, C}$	58.32±0.03 ^{a,}A	58.72±0.03 $^{a, A}$	58.66±0.06 ^{a,A}	58.00±0.03 $^{a, A}$	56.48±0.03 $^{a, B}$	58.34±0.03 ^{a,}A
C2	57.72±0.03 $^{a, D}$	56.07±0.03^{b,} B	55.47±0.03 $^{c, C}$	56.32±0.04 $^{b, B}$	55.90±0.03 $^{b, C}$	56.90±0.03 $^{a, B}$	55.52±0.03 $^{b, C}$
C3	51.13±0.03 $^{d,\alpha}$	41.29±0.03 $^{d, E}$	36.25±0.03 $^{d,\rho}$	44.30±0.27 $^{d,\delta}$	45.10±0.03 $^{d, D}$	49.75±0.03 $^{c, B}$	48.35±0.03 ^{c,C}

^{abcd} indicate significant difference (p<0.05) among spice type over a storage duration, ^{ABCDEF} indicate significant difference across the storage duration over spice type

Table 5: Percentage crude fibre content of fish floss produced from catfish

Spice type	Months						
	Initial	1	2	3	4	5	6
C0	1.33±0.03^{a,A}	1.33±0.03 ^{a,A}	1.38±0.03 ^{a,A}	1.38±0.03 ^{a,A}	1.36±0.03 ^{a,A}	1.26±0.03 ^{ab,A}	1.24±0.03 ^{ab,A}
C1	1.49±0.03 ^{a,A}	1.49±0.03 ^{a,A}	1.44±0.03 ^{a,A}	1.37±0.03 ^{a,A}	1.39±0.03 ^{a,A}	1.28±0.03 ^{ab,A}	1.30±0.03 ^{ab,A}
C2	1.35±0.03 ^{a,A}	1.35±0.03 ^{a,A}	1.49±0.03 ^{a,A}	1.51±0.04 ^{a,A}	1.72±0.03 ^{a,A}	1.67±0.03 ^{a,A}	1.65±0.03 ^{a,A}
C3	0.74±0.03 ^{b,B}	0.74±0.03 ^{b,B}	0.72±0.03 ^{b,B}	1.13±0.02 ^{ab,A}	1.40±0.03 ^{a,A}	1.54±0.03 ^{a,A}	1.55±0.03 ^{a,A}

^{ab} indicates significant difference (p<0.05) among spice type over a storage duration, ^{AB} indicate significant difference across the storage duration over spice type

Table 6: Percentage Carbohydrate of fish floss produced from catfish

	Storage duration (months)						
Treatment	Initial	1	2	3	4	5	6
C0	23.89±0.13$^{a, A}$	20.79±0.13^{b,B}	17.32±0.13 $^{c, E}$	19.71±0.07^{b,C}	17.34±0.58 ^{b,E}	17.62±0.13 ^{b,D}	17.25±0.13 $^{b, F}$
C1	18.27±0.13 $^{cd, A}$	14.57±0.13^{d,D}	14.05±0.10 $^{d, F}$	14.40±0.02^{d,E}	14.20±0.11 ^{d,F}	15.90±0.13 $^{c, B}$	13.65±0.46 $^{d, G}$
C2	18.95±0.13 $^{c, B}$	18.50±0.13 ^{c,C}	33.00±0.13 $^{b, A}$	17.19±1.75 $^{c.D}$	15.26±0.13 ^{c,F}	14.14±0.13 $^{d, G}$	15.88±0.13 $^{c, E}$
C3	21.61±0.13 $^{b, E}$	34.59±0.13^{a,B}	38.74±0.09 $^{a, A}$	28.12±0.26^{a,C}	25.07±0.12^{a,D}	20.96±0.13^{a,F}	21.36±0.13 $^{a, E}$

^{abcd} indicate significant difference among the treatment ^{ABCDEF} indicate significant difference across the storage duration, at p<0.05

Discussion

The proximate composition of fish floss produced from catfish varied significantly with respect to spice treatments and storage duration.

The moisture content of catfish fish floss decreased significantly in the un spiced treatment (C0) from 12.85±0.03^{a,A} to 8.52±0.03^{b,D} over six months, while spiced treatments (C1-C3) generally showed lower initial values with gradual increases during storage. The overall lower moisture contents in spiced samples suggest that spices may possess hygroscopic or antimicrobial properties that help retard water absorption during storage. Similar trends were reported by Adebowale *et al.* (2016) [1], who observed that spice incorporation reduced moisture levels in fish products, thereby enhancing shelf stability. Conversely, the gradual increase in some treatments is consistent with findings by Ola and Afolabi (2018) [11], who attributed it to moisture migration from packaging material or environmental humidity.

Ash content in catfish floss remained statistically unchanged (p>0.05) across treatments and storage, indicating mineral stability. This agrees with earlier reports by Olayemi *et al.* (2019) [13], who noted that spices can contribute to mineral composition and stability in stored fish products.

Fat levels in catfish floss varied significantly, with C1 remaining the most stable, while C3 exhibited the lowest initial values but rose steadily to match other treatments. The stability of fat content in spiced treatments supports observations by Oparaku and Mgbenka (2012) [14], who reported that spices may act as antioxidants, thereby retarding lipid oxidation during storage. However, the sharp decline in un-spiced samples aligns with the findings of Clucas and Ward (2019) [4], which highlighted the susceptibility of unprotected fish lipids to oxidative rancidity.

Protein content remained relatively stable in most treatments, although C3 in catfish showed a marked decline (from 51.13±0.03^{d,A} to 48.35±^{c,C}). Crude fibre was relatively low but showed some variability, especially in C3, which recorded progressive increases during storage. This may be attributed to the fibre contribution of added spices. A similar observation was made by Olaoye *et al.* (2017) [12], who reported that spice incorporation enhances crude fibre levels in fish products.

Carbohydrate levels decreased over storage in most catfish treatments except for C2 and C3, which peaked significantly at month 2 before declining. This reduction in carbohydrate content over storage is consistent with the findings of FAO (2003) [5], which linked it to the utilization of carbohydrates during non-enzymatic browning and microbial activities in stored fish products.

Conclusion

The study revealed that both spice incorporation and storage duration had significant effects on the proximate composition of fish floss produced from catfish and tilapia. Moisture content generally decreased in un-spiced samples but fluctuated in spiced treatments, suggesting that spices play a role in moisture regulation and shelf stability. Ash content remained largely stable in catfish floss but varied in tilapia, indicating that spices may enhance mineral retention. Fat and protein contents were better preserved in spiced treatments, supporting the anti-oxidative and antimicrobial benefits of spices, while un-spiced samples were more prone to lipid oxidation and protein degradation. The observed increases in crude fibre further emphasized the contributory role of spices, while the gradual decline in carbohydrate levels reflected storage-induced biochemical changes.

References

1. Adebowale ARA, Dongo LN, Jayeola CO, Orisajo SB. Comparative quality evaluation of biscuits prepared from sweet potato and wheat flour blends. African J Food Sci. 2016;6(9):232-239. https://doi.org/10.5897/AJFSX11.011
2. Association of Official Analytical Chemists (AOAC). Official methods of analysis of AOAC International. 20th ed. Gaithersburg (MD): AOAC International; 2015.
3. Barría A, Joshi R, Sawayama E, Yoshida G. Genomic tools and selective breeding in aquaculture: Advances and future prospects for sustainable production. Aquacult Rep. 2023;31:101644.
4. https://doi.org/10.1016/j.aqrep.2023.101644
5. Clucas IJ, Ward AR. Post-harvest fisheries development: A guide to handling, preservation, processing and quality. Rev ed. Chatham (UK): Natural Resources Institute; 2019.
6. Food and Agriculture Organization of the United Nations (FAO). Food energy: methods of analysis and conversion factors. FAO Food and Nutrition Paper 77. Rome: FAO; 2003.
7. Isah Z. Production of dambun kifi (fish floss). 2018. Available from: http://zubaidaisa.wordpress.com
8. Kusumawati E, Sulistiyati TD, Dewi RS, Puspitasari R. Effect of frying methods and antioxidants on quality and shelf-life of shredded fish floss (abon ikan). Food Res. 2024;8(2):125-134. https://doi.org/10.26656/fr.2017.8(2).356
9. Lisa. Production of fish floss. 2019. Available from: http://www.mykeuken.com/fish-floss.Html?m=1
10. Liu R, Zhao SM, Xie J, Xiong SB. Comparative study on quality characteristics of surimi and fish floss products. J Food Process Preserv. 2015;39(6):1195-203. https://doi.org/10.1111/jfpp.12336
11. National Institute for Freshwater Fisheries Research (NIFFR). Archives with researcher’s modification. 2023.
12. Ola FA, Afolabi OO. Influence of packaging materials and storage conditions on the quality of dried catfish (*Clarias gariepinus*). J Food Sci Nutr. 2018;4(2):45-52. https://doi.org/10.11648/j.jfsn.20180402.12
13. Olaoye OA, Onilude AA, Idowu OA. Quality characteristics of catfish (*Clarias gariepinus*) dried using different methods and spice treatments. Afr J Biotechnol. 2017;16(19):1100-1107. https://doi.org/10.5897/AJB2016.15816
14. Olayemi FF, Adedayo MR, Bamishaiye EI, Awagu EF. Proximate composition of catfish (*Clarias gariepinus*) smoked in Nigerian traditional clay oven. Adv Appl Sci Res. 2019;2(6):246-250.
15. Oparaku NF, Mgbenka BO. Effects of processing on the nutritional qualities of fish and fish products. Int J Biol Biol Sci. 2012;1(3):38-46.
16. United States Food and Drug Administration (USFDA), United States Department of Agriculture (USDA). Food safety. 2021. Available from: http://www.foodsafety-charts/safe-minimum-cooking-temperature
17. Winarni D, Susilo B, Suryanto E. Effect of different cooking techniques on proximate, fatty acid profile and sensory quality of catfish (*Clarias gariepinus*). IOP Conf Ser Earth Environ Sci. 2021;759(1):012045. https://doi.org/10.1088/1755-1315/759/1/012