Impact of varying wheat flour levels on the quality, nutritional composition and sensory properties of fish patties

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Abstract

*As fish consumption continues to grow due to its high protein content and essential fatty acids, developing value-added products like fish patties can improve dietary intake and marketability. This study was designed to investigate the enhancement of mackerel fish patties through the incorporation of wheat flour, analyzing its effects on nutritional composition, sensory attributes, and physicochemical properties. A Completely Randomized Design (CRD) was employed with five treatments: **A** (100% fish - positive control), **B** (75% fish and 25% wheat flour), **C**(50% fish and 50% wheat flour), **D** (25% fish and 75% wheat flour), and **E** (100% wheat flour - negative control). Each treatment was replicated six times. Results showed significant differences ($p<0.05$) in proximate composition: protein ranged from 34.00% (Treatment A) to 8.20% (Treatment E), while carbohydrate content increased with higher wheat flour, reaching 55.30% in Treatment E. Cooking yield improved with wheat flour incorporation, with Treatment C recording the highest yield (92.59%). pH values decreased with more wheat flour, from 6.47 in treatment A to 6.01 in treatment E. Sensory evaluation revealed that treatments A and B had the highest scores for tenderness, juiciness, and overall acceptability, whereas higher wheat flour levels significantly reduced sensory qualities. In conclusion, integrating wheat flour at levels up to 25% enhanced product quality, nutritional balance, and acceptability, indicating its potential for developing nutritious and cost-effective seafood alternatives.*

Keywords: Mackerel fish patties, Wheat flour, Nutritional composition, Physicochemical, Sensory evaluation.
Running title: Wheat flour and fish patties quality

Impact de différents niveaux de farine de blé sur la qualité, la composition nutritionnelle et les propriétés sensorielles des galettes de poisson

Résumé

*Alors que la consommation de poisson continue de croître en raison de sa teneur élevée en protéines et en acides gras essentiels, le développement de produits à valeur ajoutée comme les galettes de poisson peut améliorer l'apport alimentaire et la commercialisation. Cette étude a été conçue pour étudier l'amélioration des galettes de maquereau grâce à l'incorporation de farine de blé, en analysant ses effets sur la composition nutritionnelle, les attributs sensoriels et les propriétés physico-chimiques. Un dispositif complètement aléatoire (CRD) a été utilisé avec cinq traitements : **A** (100 % poisson - témoin positif), **B** (75 % poisson et 25 % farine de blé), **C** (50 % poisson et 50 % farine de blé), **D** (25 % poisson et 75 % farine de blé) et **E** (100 % farine de blé - témoin négatif). Chaque traitement a été répliqué six fois. Les résultats ont montré des différences significatives ($p<0,05$) dans la composition proximale : les protéines variaient de 34,00 % (Traitement A) à 8,20 % (Traitement E), tandis que la teneur en glucides augmentait avec une teneur plus élevée en farine de blé, atteignant 55,30 % dans le Traitement E. Le rendement à la cuisson s'est amélioré avec l'incorporation de farine de blé, le Traitement C enregistrant le rendement le plus élevé (92,59 %). Les valeurs de pH diminuaient avec plus de farine de blé, de 6,47 dans le traitement A à 6,01 dans le traitement E. L'évaluation sensorielle a révélé que les traitements A et B avaient les scores les plus élevés pour la tendreté, la jutosité et l'acceptabilité globale, tandis que des niveaux plus élevés de farine de blé réduisaient significativement les qualités sensorielles. En conclusion, l'intégration de farine*

de blé à des niveaux allant jusqu'à 25 % a amélioré la qualité du produit, l'équilibre nutritionnel et l'acceptabilité, indiquant son potentiel pour développer des alternatives aux fruits de mer nutritives et rentables.

Mots-clés : Galettes de maquereau, Farine de blé, Composition nutritionnelle, Physico-chimique, Évaluation sensorielle.

Introduction

Fish patties are becoming increasingly popular in the seafood industry, providing consumers with a simple, nutritious, and diverse eating option (Li *et al.*, 2016; Llorente and Sobral, 2017). As worldwide dietary trends shift toward healthy eating habits and sustainable food sources, products such as fish patties are becoming more popular due to their high protein content, essential fatty acids, and other necessary nutrients (Kris-Etherton *et al.*, 2003). Fish patties, which are normally formed from minced or ground fish, are frequently combined with a variety of binders, extenders, and seasonings to give a product that is both delectable and simple to make. Mackerel, a nutrient-dense fish abundant in omega-3 fatty acids, protein, and critical vitamins, is well known for its health advantages. Mackerel, a mainstay in many coastal communities and an increasingly popular choice in health-conscious diets, has several nutritional benefits, including cardiovascular benefits, anti-inflammatory characteristics, and brain health support (Kris-Etherton *et al.* 2003). Despite its nutritional significance, mackerel is frequently underutilized in processed food products, notably in the production of value-added items like fish patties. Enhancing mackerel's attractiveness through new product development is critical for increasing consumption and guaranteeing a more diverse fish diet.

Wheat flour, a popular binder and extender in the production of a variety of processed foods, has been shown to increase texture, flavour, and structural integrity in food products (Miskelly, 2014). Incorporating wheat flour into protein based diet has the potential to improve their sensory quality and consumer acceptance. Each formulation was replicated six times.

Furthermore, the carbohydrate content of wheat flour can complement mackerel's high protein and fat content, resulting in a well-balanced nutritional profile ideal for a variety of diets.

The development of mackerel fish patties integrated with wheat flour has the potential to create a nutritious, cost effective, convenient, and appealing food product that could meet the varied consumer tastes. This integration would not only take advantage of mackerel's health benefits, but it would also resolve concerns about the sensory and textural aspects of fish-based goods. However, there is still a void in the research about the specific effects of wheat flour on the quality and nutritional profile of mackerel fish patties.

This research aims to explore the enhancement of mackerel fish patties through the incorporation of wheat flour, focusing on the effects of this combination on the product's nutritional value, sensory characteristics, and overall consumer acceptance.

Materials and Methods

Experimental location

The study was conducted at the Animal Production Laboratory,Department of Animal Production, Faculty of Agriculture, Ibrahim Badamasi Babangida University, Lapai, Niger State, Nigeria.

Experimental design

A Completely Randomized Design (CRD) was used, consisting of five formulations:

Treatment A: 100% fish (positive control)
Treatment B: 75% fish, 25% wheat flour
Treatment C: 50% fish, 50% wheat flour
Treatment D: 25% fish, 75% wheat flour
Treatment E: 0% fish, 100% wheat flour (negative control)

Table 1: Recipe for the patties (%)

Ingredients	Composition (%)
Mackerel fish - flour mixture	87.67
Whole chicken egg	8.33
Seasoning	2.00
Pepper	1.00
Vegetable oil (groundnut oil)	0.67
Table salt	0.33
Total	**100**

Recipe modified from Olayinka *et al*,. 2009

Table 2: Ingredients composition (g) of the patties in proportions

Ingredient (g)	Treatment A	Treatment B	Treatment C	Treatment D	Treatment E
Mackerel fish	263	198	131.5	65	0
Wheat flour	0	65	131.5	198	263
Whole chicken egg	25	25	25	25	25
Seasoning	6	6	6	6	6
Ground pepper	3	3	3	3	3
Vegetable oil	2	2	2	2	2
Table salt	1	1	1	1	1
Total	300	300	300	300	300

Materials

Fresh mackerel fish and commercially available wheat flour were purchased from Lapai market in Niger State and transported to the laboratory. The fish were cleaned, filleted, and minced to obtain a homogenous fish paste.

Mixture and formulation of fish patty

Mixing of the fish patties was done in 300g lots such that 0g, 65g, 131.5g, 198g and 263g of wheat flour was incorporated into 263g, 198g, 131.5g, 65g and 0gof the minced mackerel fish. All seasonings (salt, pepper and seasoning cube) were measured according to the desired flavour profile and eggs were cracked into a separate bowl and lightly beaten and were added to each treatment as shown in Table 2. The mixture was mixed thoroughly until the ingredients were evenly distributed throughout the fish paste.

Shaping the patties

The fish mixture was divided into six equal portions, each weighing 45 grams. Each portion was shaped into round patties of uniform thickness. The shaped patties were placed on parchment paper and allowed to rest for 10-15 minutes before frying. This helps the patties to set and retain their shape during frying.

Frying the patties

The patties were fried in a non-stick pan with vegetable oil (groundnut oil) at 100°C for 10–12 minutes, flipping halfway.

Data collection

Proximate composition analysis

Proximate analysis was conducted using AOAC (2019) methods to determine moisture, crude protein, crude fibre, fats, ash, and carbohydrate contents.

Cooking loss

This was determined using the equation thus:

$$\text{Cooking loss (\%)} = \frac{\text{weight of raw patties (g)} - \text{weight of cooked patties (g)}}{\text{weight of raw patties (g)}} \times 100$$

Cooking yield

This was determined as the difference between 100% and values of cooking loss of each treatment thus; Cooking yield = (100 - % cooking loss) or

$$\text{Cooking yield (\%)} = \frac{\text{weight of cooked patties (g)}}{\text{weight of raw patties (g)}} \times 100$$

pH

The pH of the treatments was measured by a digital pH meter (Knick-Portamess 913 pH, Berlin, Germany). The treatment of 5g was mixed with 20mL of distilled water and the mixture was shaken for 3 minutes before measurements.

Sensory evaluation

The consumer acceptance and preference were determined using 30 untrained taste panelists who were selected randomly among students and staff of Ibrahim Badamasi Babangida University Lapai, Faculty of Agriculture. The sensory evaluation parameters used include; tenderness, juiciness flavour, colour and overall acceptability based on a 5- point hedonic scale with 1 labeled dislike very much and 5 labeled like very much.

Statistical analysis

The data obtained were subjected to one-way analysis of variance (ANOVA) and data were reported as the means ±standard deviations. Comparison of means was done using Duncan's multiple-range test ($p<0.05$), Statistical Package for Social Sciences (SPSS) software version 17.0 was used to analyze the results of the sensory evaluation.

Results

Proximate composition

There were significant differences ($p<0.05$) in the proximate composition of fish patties (Table 3). Treatment A (100% fish) had the highest protein (34.00±0.07%) and fat content (18.75±0.001%), while treatment E (100% wheat flour) had the lowest protein (8.20±0.007%) and fat (3.40±0.007%). Carbohydrate content increased with wheat flour incorporation, with treatment E having the highest (55.30±0.007%).

Table 3: Proximate analysis of fish patties incorporated with varying levels of wheat flour

Treatment	Moisture content	Ash	Crude protein	Crude fibre	Fat	Carbohydrate
A	49.03±0.001^{a}	3.08±0.001^{a}	34.00±0.071^{a}	1.10±0.001^{e}	18.75±0.001^{a}	2.10±0.007^{e}
B	40.43±0.001^{b}	2.51±0.001^{b}	25.00±0.071^{b}	1.37±0.001^{d}	18.08±0.001^{b}	12.68±0.001^{d}
C	40.60±0.007^{b}	1.90±0.007^{c}	19.18±0.001^{c}	2.62±0.001^{c}	12.50±0.014^{c}	23.20±0.014^{c}
D	37.04±0.007^{d}	1.21±0.001^{d}	16.61±0.001^{d}	3.98±0.001^{b}	10.16±0.001^{d}	31.00±0.064^{b}
E	27.46±0.014^{e}	1.15±0.001^{e}	8.20±0.007^{e}	4.49±0.001^{a}	3.40±0.007^{e}	55.30±0.007^{a}
SEM ±	2.32	0.25	2.88	0.45	1.87	6.03
LSD	0.00	0.00	0.00	0.00	0.00	0.00

$^{a, b, c, d}$: Means with different superscripts differ significantly ($p<0.05$). **Treatment A** (100% fish - positive control), **treatment B** (75% fish and 25% wheat flour), **treatment C** (50% fish and 50% wheat flour), **treatment D** (25% fish and 75% wheat flour), **treatment E** (100% wheat flour - negative control). SEM = Standard Error of Means, LSD = Least of significance different

Physicochemical properties

Cooking yield improved with increased wheat flour content, with treatment C (50:50) recording the highest yield (92.59±1.81%). Cooking loss was highest in treatment A (10.37±1.81%) and lowest in treatment C

(7.40±1.81%). The pH values decreased as wheat flour increased, ranging from 6.47 (treatment A) to 6.01 (treatment E).

Table 4: Physicochemical analysis of fish patties incorporated with varying levels of wheat flour

Treatment	Cooking yield (%)	Cooking loss (%)	Ph
A	89.63 ± 1.813^{b}	10.370 ± 1.813^{a}	6.47 ± 0.001^{a}
B	89.26 ± 3.827^{b}	10.742 ± 3.827^{a}	6.45 ± 0.001^{b}
C	92.59 ± 1.816^{a}	7.402 ± 1.816^{b}	6.33 ± 0.001^{c}
D	91.11 ± 1.986^{ab}	8.890 ± 1.986^{ab}	6.21 ± 0.001^{d}
E	90.37 ± 1.146^{ab}	9.630 ± 1.146^{ab}	6.01 ± 0.179^{e}
SEM ±	5.30	5.30	0.06
LSD	2.74	2.74	0.00

[a, b, c, d:] Means with different superscripts differ significantly ($p<0.05$). **Treatment A** (100% fish - positive control), **treatment B** (75% fish and 25% wheat flour), **treatment C** (50% fish and 50% wheat flour), **treatment D** (25% fish and 75% wheat flour), **treatment E** (100% wheat flour - negative control). SEM = Standard Error of Means, LSD = Least of significance different

Sensory evaluation

Treatment A (100% fish) and treatment B (75% fish, 25% wheat flour) had the highest scores for tenderness, juiciness, and overall acceptability. However, increasing wheat flour beyond 25% significantly reduced sensory scores, with treatment E (100% wheat flour) receiving the lowest ratings.

Table 5: Sensory evaluation of fish fatties incorporated with varying levels of wheat flour

Treatments	Tenderness	Juiciness	Colour	Flavour	Overall acceptability
A	4.73 ± 0.521^{a}	4.47 ± 0.900^{a}	3.93 ± 0.980^{ab}	4.43 ± 0.728^{a}	4.57 ± 0.626^{a}
B	4.47 ± 0.681^{a}	4.20 ± 0.664^{a}	4.07 ± 1.081^{a}	3.87 ± 0.900^{b}	4.43 ± 0.728^{a}
C	3.23 ± 1.223^{b}	3.03 ± 1.066^{b}	3.37 ± 1.299^{b}	3.37 ± 0.964^{c}	3.43 ± 1.006^{b}
D	2.93 ± 1.230^{b}	3.00 ± 1.083^{b}	3.40 ± 1.163^{b}	3.33 ± 0.922^{c}	3.40 ± 1.003^{b}
E	2.80 ± 1.064^{b}	2.67 ± 1.155^{b}	3.83 ± 1.053^{ab}	3.03 ± 1.189^{c}	3.17 ± 1.147^{b}
SEM ±	0.103	0.099	0.093	0.087	0.088
LSD	0.00	0.00	0.051	0.00	0.00

[a, b, c, d]: Means with different superscripts differ significantly ($p<0.05$). **Treatment A** (100% fish - positive control), **treatment B** (75% fish and 25% wheat flour), **treatment C** (50% fish and 50% wheat flour), **treatment D** (25% fish and 75% wheat flour), **treatment E** (100% wheat flour - negative control). SEM = Standard Error of Means, LSD = Least of significance different

Discussion

The proximate analysis of the mackerel fish patties highlights the significant impact of wheat flour incorporation on the nutritional profile of the product. Patties with higher fish content (treatment A) had higher moisture and fat levels, which are essential for sensory properties like tenderness and juiciness. As wheat flour content increases, these levels decrease, leading to potentially drier and less succulent patties. Fish is a superior source of protein, and incorporating higher levels of wheat flour significantly reduces the protein content of the patties. Treatment A (100% fish) had the highest protein content, making it the best option for consumers seeking a protein-rich product. As wheat flour content increased, carbohydrate and fibre levels rose. This could be advantageous for consumers interested in a fiber-rich product, but the higher carbohydrate content may not appeal to those

prioritizing a high-protein, low-carb diet. Higher fish content provides more minerals, as seen in the ash content. Reducing fish content by incorporating more wheat flour leads to a lower mineral composition, potentially affecting the overall nutritional value of the product. The incorporation of wheat flour into mackerel fish patties alters their nutritional profile significantly. While moderate levels of wheat flour (up to 25%) can provide some benefits (e.g., increased fibre), higher levels (50% or more) lead to a decrease in key nutrients like protein and fat, which are critical to the sensory and nutritional appeal of fish patties. The result is in line with the findings of Jin *et al.* (2020), who demonstrated that the protein and fat content of the patties decreased slightly with the addition of wheat flour. In another study by Adeola (2021) who assessed the changes in nutritional, texture, rancidity, and microbiological properties of composite biscuits made from breadfruit and wheat flours enriched with edible fish meal over a 12-week storage period revealed that higher levels of fish meal increased protein and fat content. Therefore, the level of wheat flour should be carefully balanced to achieve both nutritional and sensory goals.

The results on cooking yield and cooking loss indicate that incorporating wheat flour into mackerel fish patties increases cooking yield and reduces cooking loss. This is attributed to flour's water-binding capacity, which enhances moisture retention during frying (Ikhlas *et al.*, 2011; Nurul *et al.*, 2018). Treatments with higher wheat flour content (Treatments C, D, and E) showed better moisture retention during cooking, which is reflected in their higher cooking yields and lower cooking losses. Wheat flour's ability to absorb and retain moisture during cooking makes it an effective binder, contributing to improved cooking performance. In contrast, treatments with higher fish content (treatments A and B) lost more moisture during cooking due to lower carbohydrate content, resulting in higher cooking losses and lower cooking yields.

The pH values of the patties showed a decreasing trend as wheat flour content increased. The higher pH in fish-based treatments is due to the presence of fish proteins, which are more alkaline. The gradual decrease in pH with increasing wheat flour content is expected, as wheat flour is less alkaline. While these pH values are still within a range that supports good product quality, the lower pH in treatments with more wheat flour may have a slight impact on flavour and microbial stability.

Incorporating wheat flour into mackerel fish patties at varying levels had clear effects on their cooking properties and pH. Moderate levels of wheat flour (up to 50%) appear to strike a balance between maintaining high cooking yield and minimizing cooking loss, without drastically lowering the pH. However, as wheat flour content increases further, the sensory and cooking properties start to deviate from traditional fish patties. This result is in line with findings of Nurul *et al.* (2018), who investigated the physicochemical properties and consumer preferences of fish burgers made from black tilapia surimi paste and varying levels of potato flour. The study found that increasing potato flour content resulted in higher hardness and lower springiness in both raw and cooked fish burgers. This finding also agrees with result of Ikhlas *et al.* (2011), who studied the chemical composition and physicochemical properties of meatballs prepared from mechanically deboned quail meat using various types of flour, including wheat flour. The research indicated that the type and level of flour incorporation significantly affected the cooking yield, texture, and overall acceptability of the meatballs. Therefore, using up to 50% wheat flour may offer a good compromise between enhancing moisture retention and maintaining acceptable fish-based qualities.

From the sensory evaluation, it is clear that the incorporation of wheat flour into mackerel fish patties affects their sensory properties in a dose-

dependent manner. Treatment A (100% fish) was rated highest across all sensory attributes, confirming that pure fish patties offer superior tenderness, juiciness, flavour, and overall acceptability. Treatment B (75% fish, 25% wheat flour) received comparable scores to treatment A, suggesting that a moderate level of wheat flour incorporation (up to 25%) does not significantly diminish the sensory quality of the patties.

However, as the proportion of wheat flour increased in treatments C, D, and E, there was a noticeable decline in sensory scores, particularly in tenderness, juiciness, and flavour. Treatment E, which contained only wheat flour, had the lowest scores across most attributes, indicating that fish is a critical component in achieving the desirable sensory qualities of fish patties. This study agrees with the findings of Ahmed *et al.* (2020), who observed that patties with more than 20% wheat flour had lower sensory scores, suggesting that there is an optimal range for flour incorporation to balance sensory attributes. These findings also agrees with the result of Fan *et al.* (2016), who found that fish patties with moderate levels of wheat flour (10-15%) were the most acceptable to consumers, while higher levels of flour led to lower acceptability due to changes in flavour and texture.

Conclusion

This study demonstrated that incorporating wheat flour into mackerel fish patties influences their nutritional, physicochemical, and sensory properties. While levels up to 25% maintain desirable characteristics, higher levels negatively impact taste, texture, and nutritional value. This research supports the potential for wheat flour-enhanced fish patties as a nutritious alternative in the seafood industry.

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