Effect of graded levels of wheat flour on the quality, nutritional value and sensory attributes of beef patties

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Abstract

The global consumption of meat and meat products continues to grow, driven by increasing population, urbanization, and rising incomes, particularly in developing countries. However, with this growth comes a demand for healthier and higher-quality meat products that align with evolving consumer preferences and dietary needs. Traditional meat products are often associated with high levels of saturated fat and cholesterol, which are linked to cardiovascular diseases, obesity, and other health concerns. As a result, there is a pressing need to modify meat products to enhance their nutritional profiles without compromising their sensory appeal, such as taste, texture, and overall acceptability. This study was designed to investigate the enhancement of beef 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 samples: A (100% beef - positive control), B (75% beef and 25% wheat flour), C (50% beef and 50% wheat flour), D (25% beef and 75% wheat flour), and E (100% wheat flour - negative control). Each formulation was replicated six times. Results showed significant differences ($p<0.05$) in proximate composition: protein ranged from 31.90% (sample A) to 8.20% (sample E), while carbohydrate content increased with higher wheat flour, reaching 55.30% in sample E. Cooking yield improved with wheat flour incorporation, with sample D recording the highest yield (92.59%). pH values decreased with more wheat flour, from 6.85 in sample A to 6.01 in sample E. Sensory evaluation revealed that sample A and B had the highest scores for tenderness, juiciness, colour and overall acceptability, whereas higher wheat flour levels significantly reduced sensory qualities. In conclusion, integrating wheat flour into beef patties at 25% level enhanced product quality while maintaining nutritional value.

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

Effet de niveaux gradués de farine de blé sur la qualité, la valeur nutritionnelle et les attributs sensoriels des galettes de bœuf

Résumé

La consommation mondiale de viande et de produits carnés continue de croître, portée par l'augmentation de la population, l'urbanisation et la hausse des revenus, en particulier dans les pays en développement. Cependant, cette croissance s'accompagne d'une demande pour des produits carnés plus sains et de meilleure qualité, conformes aux préférences et aux besoins alimentaires changeants des consommateurs. Les produits carnés traditionnels sont souvent associés à des niveaux élevés de graisses saturées et de cholestérol, liés aux maladies cardiovasculaires, à l'obésité et à d'autres problèmes de santé. Par conséquent, il est urgent de modifier les produits carnés pour améliorer leur profil nutritionnel sans compromettre leur attrait sensoriel, tel que le goût, la texture et l'acceptabilité globale. Cette étude a été conçue pour étudier l'amélioration des galettes de bœuf par l'incorporation de farine de blé, en analysant ses effets sur la composition nutritionnelle, les attributs sensoriels et les propriétés physico-chimiques. Un Plan Complètement Aléatoire (PCA) a été utilisé avec cinq échantillons : A (100% bœuf - témoin positif), B (75% bœuf et 25% farine de blé), C (50% bœuf et 50% farine de blé), D (25% bœuf et 75% farine de blé) et E (100% farine de blé - témoin négatif). Chaque formulation a été répliquée six fois. Les résultats ont montré des différences significatives ($p<0,05$) dans la composition globale : les protéines variaient de 31,90% (échantillon A) à 8,20% (échantillon E), tandis que la teneur en glucides augmentait avec plus de farine de blé, atteignant 55,30% dans l'échantillon E.

Le rendement à la cuisson s'est amélioré avec l'incorporation de farine de blé, l'échantillon D enregistrant le rendement le plus élevé (92,59%). Les valeurs de pH diminuaient avec plus de farine de blé, passant de 6,85 dans l'échantillon A à 6,01 dans l'échantillon E. L'évaluation sensorielle a révélé que les échantillons A et B avaient les scores les plus élevés pour la tendreté, la jutosité, la couleur et l'acceptabilité globale, alors que des niveaux plus élevés de farine de blé réduisaient significativement les qualités sensorielles. En conclusion, l'intégration de farine de blé dans les galettes de bœuf à un niveau de 25% a amélioré la qualité du produit tout en maintenant la valeur nutritionnelle.

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

Introduction

The global consumption of meat and meat products continues to grow, driven by increasing population, urbanization, and rising incomes, particularly in developing countries. However, with this growth comes a demand for healthier and higher-quality meat products that align with evolving consumer preferences and dietary needs. Traditional meat products are often associated with high levels of saturated fat and cholesterol, which are linked to cardiovascular diseases, obesity, and other health concerns (WHO, 2018). Meat product modification refers to the incorporation of various ingredients or the application of different processing methods to improve the nutritional value, functional properties, and sensory characteristics of meat products. The primary focus is often on reducing fat content, enhancing protein quality, increasing dietary fiber, and minimizing the formation of harmful compounds during cooking (Pereira & Vicente, 2015). This approach seeks to create healthier meat options that can cater to health-conscious consumers while also meeting industry demands for cost-effective production (Pereira & Vicente, 2015).

As consumers become more health-conscious, the food industry is challenged to create products that are both nutritious and palatable.

Wheat flour is widely used in baked goods and it is valued for its protein, fibre, and carbohydrate content, as well as its ability to act as a binder in meat formulations (Nguyen & Tran, 2017). Several studies have demonstrated that the inclusion of plant-based ingredients, such as wheat flour, in meat products can improve their functional properties while offering economic advantages by reducing overall production costs (Garcia *et al.*, 2019).

Wheat flour acts as a binder and can enhance the moisture retention and structural integrity of beef patties (Alkali *et al*., 2016) However, there is a delicate balance in maintaining the sensory characteristics and nutritional value, as excessive levels of wheat flour may dilute the protein content and modify flavour, texture, and overall acceptability. Additionally, wheat flour contributes carbohydrates and dietary fibre which can improve the nutritional value of beef patties, appealing to health conscious consumers.

This study was aimed to evaluate the effect of graded levels of wheat flour on the quality, nutritional value and sensory attributes of beef patties. Specifically, it investigates how the addition of different concentrations of wheat flour affects parameters such as cooking loss, texture, protein content and sensory attributes in terms of taste, juiciness, and tenderness.

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.

Preparation of patties

Fresh beef (chuck) was purchased from Lapai market and transported to the Laboratory. The fresh beef were thoroughly washed with clean water to remove any surface contaminants, chopped into smaller pieces suitable for mincing. The beef were minced using a blender (Silver crest German industrial SC-1589) to create a uniform paste. Seasoning cube (onion flavour), salt and ground pepper were used for taste enhancement and flavour. Fresh eggs were used as an additional binder to improve the cohesiveness of the patties. Vegetable oil was

used for frying the patties. All purpose commercially available wheat flour was purchased in Lapai market and was used as a binder and extender in the patty formulations.

Formulation of beef patty mixture

Wheat flour of different quantity were weighed and set aside. All seasonings (salt, pepper and seasoning cube) were measured according to the desired flavour profile and mixed together in a small bowl. Eggs were cracked into a separate bowl and lightly beaten. In a large mixing bowl, the minced beef was combined with the wheat flour. The mixture was mixed thoroughly by hand until the flour is evenly distributed throughout the beef paste. The seasonings were added to the mixture and mixed thoroughly to ensure even distribution of flavour. The beaten eggs were added gradually to the mixture, continuing to mix until the mixture became cohesive and could hold its shape.

Table 1: Ingredients composition (g) of the patties in proportions

Ingredient (g)	Sample A	Sample B	Sample C	Sample D	Sample E
Beef	263	198	131.5	65.0	0
Wheat flour	0.0	65.0	131.5	198	263
Egg	25	25	25	25	25
Seasoning cube	6	6	6	6	6
Ground pepper	3	3	3	3	3
Vegetable oil	2	2	2	2	2
Common salt	1	1	1	1	1
Total	300.00	300.00	300.00	300.00	300.00

Recipe modified from Olayinka *et al*,. 2009

Experimental design

A Completely Randomized Design (CRD) was used, consisting of five formulations:
Sample A: 100% beef (positive control)
Sample B: 75% beef, 25% wheat flour
Sample C: 50% beef, 50% wheat flour
Sample D: 25% beef, 75% wheat flour
Sample E: 0% beef, 100% wheat flour (negative control)
Each formulation was replicated six times.

Shaping the patties

The beef mixture was divided into six equal portions, each weighing 45g. 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 min before frying. This helps the patties to set and retain their shape during frying (Olayinka *et al*., 2009).

Frying the patties

A non-stick *masa* pan (*tanda*) was used in frying the patties. The pan was placed on medium heat with a little drop of vegetable oil in the pan. The oil was heated to 100°C as monitored by a thermometer. The patties were gently placed into the pan and fried for 10-12 minutes and flipped halfway through (Fernández-Martín *et al*., 2000)

Data Collection

Physicochemical parameters

Cooking loss

Cooking loss is the weight loss of food due to moisture evaporation and fat or other substances released during cooking. 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

Cooking yield is the percentage of the initial weight retained after cooking. It shows how much of the raw weight remained after cooking. This was determined as the difference between 100% and values of cooking loss of each treatment (AOAC 2005). Thus; Cooking yield = (100 - % cooking loss) or

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

pH

The pH of the samples was measured by a digital pH meter (Knick-Portamess 913 pH, Berlin,

Germany). The sample of 5g was mixed with 20mL of distilled water and the mixture was shaken for 3 minutes before the measurements were taken (AOAC, 2019).

Sensory evaluation

The consumer acceptance and preference were determined using 30 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 as described by Stone and Sidel (2004) with 1 labelled dislike very much, and 5 labelled like very much.

Proximate analysis

Samples from the prepared patties were subjected to proximate analysis to determine the composition of carbohydrate, protein, fat, ash, crude fibre and moisture content using standard laboratory techniques (AOAC, 2019).

Data Analysis

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

Results

Sensory evaluation

Sample A (100% beef) and sample B (75% beef, 25% wheat flour) had the highest scores across all the sensory parameters (tenderness, juiciness, flavour and overall acceptability). However, increasing wheat flour beyond 25% significantly reduced sensory scores, with sample E (100% wheat flour) receiving moderate score for colour ratings.

Table 2: Sensory evaluation of beef patties incorporated with varying levels of wheat flour

Sample	Tenderness	Juiciness	Colour	Flavour	Overall acceptability
A	4.70^{a}	4.37^{a}	4.27^{a}	4.47^{a}	4.77^{a}
B	3.97^{b}	3.87^{a}	4.03^{ab}	3.80^{b}	4.10^{b}
C	3.03^{c}	2.63^{b}	3.50^{c}	2.93^{c}	3.10^{c}
D	3.23^{c}	3.17^{b}	3.57^{c}	3.31^{bc}	3.53^{c}
E	3.03^{c}	2.97^{b}	4.10^{ab}	3.43^{bc}	3.60^{bc}
SEM	0.102	0.103	0.095	0.10	0.092
LSD	0.00	0.00	0.003	0.00	0.00

$^{a, b, c, d}$: Means with different superscripts differ significantly ($p<0.05$).**Sample A**(100% beef - positive control), **Sample B** (75% beef and 25% wheat flour), **Sample C** (50% beef and 50% wheat flour), **Sample D** (25% beef and 75% wheat flour), **Sample E** (100% wheat flour - negative control).

Physicochemical properties

Cooking yield improved with increased wheat flour content, with sample D (25:75) recording the highest yield (92.59%). Cooking loss was highest in sample A (24.44%) and lowest in sample D (7.41%). The pH values decreased as wheat flour increased, ranging from 6.85 (sample A) to 6.01 (sample E).

Table 3: Physicochemical analysis of beef patties incorporated with varying levels of wheat flour

Sample	Cooking yield (%)	Cooking loss (%)	P^H
A	75.55^{d}	24.44^{a}	6.85^{a}
B	83.70^{c}	16.29^{b}	6.76^{b}
C	87.77^{b}	12.22^{c}	6.54^{c}
D	92.59^{a}	7.40^{d}	6.48^{d}
E	90.37^{ab}	9.63^{cd}	6.01^{e}
SEM	0.09	0.95	0.09
LSD	2.77	2.77	0.00

$^{a, b, c, d}$: Means with different superscripts differ significantly ($p<0.05$). **Sample A** (100% beef - positive control), **Sample B** (75% beef and 25% wheat flour), **Sample C** (50% beef and 50% wheat flour), **Sample D** (25% beef and 75% wheat flour), **Sample E** (100% wheat flour - negative control).

Proximate composition

There were significant differences ($p<0.05$) in the proximate composition of beef patties (Table 4). Sample A (100% beef) had the highest protein (31.90%) and fat content (22.30%), while sample E (100% wheat flour) had the lowest protein (8.20%) and fat (3.40%). Carbohydrate content increased with wheat flour incorporation, with sample E having the highest (55.30%).

Table 4: Proximate analysis of beef patties incorporated with varying levels of wheat flour

Sample	Moisture content	Ash	Crude protein	Crude fibre	Fat	Carbohydrate
A	40.57^{b}	1.75^{c}	31.90^{a}	1.19^{e}	22.30^{a}	2.29^{e}
B	37.83^{d}	1.91^{b}	29.03^{b}	1.90^{d}	16.10^{b}	13.23^{d}
C	45.63^{a}	2.10^{a}	17.31^{c}	3.20^{c}	11.77^{c}	19.98^{c}
D	38.41^{c}	1.38^{d}	12.82^{d}	3.50^{b}	8.57^{d}	35.32^{b}
E	27.40^{e}	1.21^{e}	8.20^{e}	4.49^{a}	3.40^{e}	55.30^{a}
SEM	1.98	0.11	3.06	0.39	2.15	6.15
LSD	0.00	0.00	0.00	0.00	0.00	0.00

$^{a, b, c, d}$: Means with different superscripts differ significantly ($p<0.05$). Sample A (100% beef - positive control), Sample B (75% beef and 25% wheat flour), Sample C (50% beef and 50% wheat flour), Sample D (25% beef and 75% wheat flour), Sample E (100% wheat flour - negative control).

Discussion

The high beef content in the patties contributed to the desirable qualities that were observed by the taste panelists, particularly in terms of tenderness, juiciness, and flavour. These findings are consistent with consumer preferences for meat products that are more tender and juicier, which are often attributed to the high meat content (Oni *et al*., 2020). As the level of wheat flour increased, a significant decline in sensory scores was observed, particularly in tenderness and juiciness, which dropped notably in Sample C (50% beef, 50% wheat flour) and Sample D (25% beef, 75% wheat flour). This reduction can be attributed to the lower water-binding capacity and reduced fat content with higher wheat flour inclusion. The addition of wheat flour may have likely altered the texture and mouth feel of the patties, making them less tender and juicy compared to the beef-only patties (Sample A). This result aligns with previous research findings that suggest increasing wheat flour in meat products often leads to a decrease in desirable sensory attributes (Abdulrahman *et al*., 2019) Cooking yield was found to increase with higher wheat flour inclusion, with Sample D showing the highest yield (92.59%).This could be attributed to the high fibre content of wheat flour. This aids the patties to retain water during cooking, which likely enhanced the moisture retention. Wheat flour is known for its high water absorption capacity, which can improve the yield of meat products by reducing moisture loss during cooking (Ghafoor *et al.*, 2021).

Conversely, the cooking loss was found to decrease significantly with higher wheat flour inclusion, supporting the conclusion that wheat flour helps in retaining moisture and nutrients during cooking, thereby improving the overall product yield. The pH of the beef patties decreased as the wheat flour level increased, with Sample A (100% beef) having the highest pH (6.85) and Sample E (100% wheat flour) having the lowest (6.01). This reduction in pH is likely due to the slightly acidic nature of wheat flour compared to beef, which has more neutral or alkaline properties. The lower pH values in the wheat flour-based patty samples could indicate the presence of more acidic ingredients, which might impact the texture and flavour of the patties (Sullivan *et al*., 2020), which may have been caused by the combined water-binding capacities of both beef and wheat flour. The presence of wheat flour, with its ability to absorb water, likely enhanced the water retention of the patties, leading to higher moisture levels. The ash content, an indicator of mineral content, was highest in Sample C (2.10%) and lowest in Sample E (1.21%), suggesting that the combination of beef and wheat flour contributed more minerals compared to meat or wheat flour alone. This is consistent with the motion that animal-based ingredients like beef are richer in essential minerals compared to plant-based ingredients like wheat flour (Zhao *et al*., 2019). A notable trend in the proximate composition was the decrease in crude protein content as the wheat flour content increased. This reflects the naturally higher protein content in beef compared to wheat flour. The reduction in protein content with higher wheat flour inclusion is expected, as wheat flour contains significantly less protein than meat (Zhang *et al*., 2020). Crude fibre content increased significantly with higher wheat flour levels, which expected, as wheat flour is a rich source of dietary fibre. The increased fibre content in the patties may provide additional health benefits, including improved digestion and better bowel movements. However, the addition of high level of wheat flour may also result in a less desirable texture and mouthfeel, as higher fibre content in products have been observed to lower the quality of the product (Duan *et al.*, 2021) The decrease in fat content is consistent with the reduction in beef content of the products, as beef is naturally high in fat. The reduced fat content in the wheat flour-based patty samples may result in a leaner product, which could be considered a positive attribute for health-conscious consumers (Brownsworth *et al.*, 2019). The carbohydrate content which was highest in Sample E (55.30%) and lowest in Sample A (2.29%),is a reflection of the high starch content in wheat flour. As wheat flour inclusion increased, so did the carbohydrate content, which is expected given the nature of wheat flour as a carbohydrate-rich ingredient. This increase in carbohydrates could affect the overall energy value of the patties, potentially making them more filling but possibly less desirable for consumers aiming to limit their carbohydrate intake (Nguyen *et al.*, 2021).

Conclusion

The incorporation of varying levels of wheat flour into beef patties significantly affected their sensory qualities and physicochemical properties. While the 100% beef patties (Sample A) were preferred for attributes such as tenderness, juiciness, and flavour, the addition of wheat flour (particularly in higher concentrations) led to a decline in these desirable qualities. Nutritionally, the addition of wheat flour to beef patties resulted in a decrease in protein and fat content, while crude fibre and carbohydrate content increased. These changes highlight the trade-offs between improving the health profile of the patties (e.g., by increasing fibre and reducing fat) and maintaining desirable sensory attributes (such as tenderness and flavour). The study suggests that an optimal balance between beef and wheat flour (levels up to 25%) is necessary to achieve a product that is both nutritionally enhanced and sensory acceptable.

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