Effects of Different Fermentation Periods on the Nutritional and Anti-Nutritional Properties of "Tuwo" Produced from Maize and Bambara Groundnut

Daramola, A. S[1], Dr, Adebayo, T. K[2], Abdulraheem, I. A[3], Ibrahim, M.C[4]

Federal polytechnic Offa, Kwara state, Nigeria

DOI: https://dx.doi.org/10.47772/IJRISS.2025.90500079

Received: 08 April 2025; Revised: 22 April 2025; Accepted: 25 April 2025; Published: 30 May 2025

ABSTRACT

This study aimed to evaluate the effects of fermentation period on nutritional and anti-nutritional properties of tuwo made from maize and bambara groundnut. The bambara groundnuts were subjected to fermentation at 24 h, 48 h and 72 h prior to pulverizing into flour. Maize flour was composited with the fermented bambara groundnut flour and coded as sample A (100% maize flour), sample B (90% maize flour + 10% fermented bambara groundnut at 24 h), sample C (90% maize flour + 10% fermented bambara groundnut at 48 h) and sample D (90% maize flour + 10% fermented bambara groundnut at 72 h). The tuwo samples were subjected to proximate, anti-nutritional and sensory analysis using standard analytical methods. The sensory properties of the tuwo samples were assessed using standard 9-point hedonic scale with 9 representing like extremely and 1 representing dislike extremely. The proximate composition of the dumpling samples showed that moisture varied from 48.00 to 55.10%, ash from 0.47 to 1.95%, crude fibre from 4.11 to 6.44%, crude lipid from 1.06 to 3.39%, crude protein from 0.37 to 0.90%, carbohydrate from 88.83 to 93.08% and dry matter from 44.90 to 52.01%. The antinutritional properties result showed that phytate varied from 9.70 to 13.16 mg/100 g, oxalate from 53.13 to 92.50 mg/100 g, tannin from 0.000212 to 0.000274 mg/100 g. The sensory properties of the tuwo samples showed that tuwo from sample A was the most preferred by the sensory assessors; however, other tuwo samples supplemented with bambara groundnut samples had comparable sensory ratings. The tuwo samples were of high moisture contents. Supplementation of fermented bambara groundnut flour at 24 h, 48 h and 72 h improved the total ash, crude fibre, crude lipid and crude protein. However, reduction in carbohydrate and dry matter were observed. Antinutritional properties of the tuwo samples including phytate, oxalate and tannin reduced at varying periods (24 h, 48 h and 72 h) of fermented bambara groundnut flour inclusion.

INTRODUCTION

Maize-based dumplings, commonly referred to as "tuwo" in Nigeria, are staple foods consumed across various regions. However, their nutritional value is limited due to their high carbohydrate and low protein content. This dietary imbalance contributes to widespread protein-energy malnutrition (PEM) in many parts of sub-Saharan Africa. To improve the nutritional profile of maize-based products, supplementation with protein-rich legumes such as Bambara groundnut has been proposed (Elham *et al.*, 2019).

Bambara groundnut (*Vigna subterranea*) is a nutrient-dense legume known for its high protein, lipid, and mineral content. Despite its rich nutritional properties, Bambara groundnut remains underutilized due to factors such as hard-to-cook characteristics and the presence of antinutritional factors like phytate, tannins, and oxalate. Fermentation is a widely recognized processing method that enhances food quality by increasing protein bioavailability, reducing antinutritional compounds, and improving sensory attributes (Olanipekun *et al.*, 2018).

The objective of this study was to evaluate the effects of different fermentation periods on the proximate, nutritional and sensory characteristics of maize-Bambara groundnut composite tuwo. The study aims to establish the optimal fermentation duration that enhances both the nutritional value and acceptability of these dumplings.

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume IX Issue V May 2025

MATERIALS AND METHODS

Materials

Maize grains were purchased from Owode Market in Offa Local Government area of Kwara state while bambara groundnut were procured from a local market in Zaria, Kaduna State. Equipment required for the successful conduct of this study was made available for usage by the Food Processing Laboratory of Food Technology Department in Federal Polytechnic Offa, Kwara State.

Methods

Preparation of maize flour

Maize flour was prepared according to the method described by Ezekiel (2022), with modification. The maize grains were sorted to remove stones, damaged kernels and other extraneous materials. The sorted maize grains were then washed in clean water, drained, oven dried at 70 ^oC for 2 h. The dried grains were decorticated on a Grantex decorticating machine to aid the removal of the maize bran and the germ to obtain the grits. Thereafter, the decorticated maize grit was milled using a disc attrition mill (PUC, Germany) to obtain the flour followed by sieving using a sieve with 300-µm aperture and then kept in airtight polythene bags until needed.

Maize grains

Sorting

Pre-cleaning in water

Draining

Oven drying (70 ^oC for 5 h)

Decortication

Dry milling

Sieving (300 µm)

Maize flour

Packaging

Figure 1: Flow chart for the preparation of maize flour

Source: Ezekiel (2022) (modified)

Fermented bambara groundnut flour preparation

Bambara groundnut flour was prepared as described by Ola and Opaleye (2019), with modification. Known weight of bambara nut were cleaned and washed with tap water. It was steeped in water for 24 h and dehulled.

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume IX Issue V May 2025

The steeped beans were boiled at 100 ºC in the steeped water for 15 mins, drained and spread out to dry a little at room temperature. Known weight of dehulled bambara nut were poured into the perforated polythene bag, tightly sealed and incubated at 32 ºC for periods of 24 h, 48 h and 72 h respectively. At regular intervals of 12 h, samples were taken out for appropriate analysis. At the end of each fermentation period, samples were washed, drained and oven dried at 55ºC for 24 h, cooled, milled using hammer mill and then sieved with 180 µm sieves to fine particles. The flour was packed in a polythene bags, sealed and kept in a deep freezer until required for analyses.

Bambara groundnut

↓

Cleaning (removal of stones, damaged kernels, extraneous materials)

↓

Washing (using running water)

↓

Steeping (24 h)

↓

Boiling (100 ºC for 15 min)

↓

Fermenting (incubating in perforated polythene bags at 24 h, 48 h and 72 h)

↓

Milling (hammer mill)

↓

Sieving (using 250 µm mesh)

↓

Fermented bambara groundnut flour

Figure 2: Flow chart for the preparation of bambara groundnut flour

Source: Ola and Opaleye (2019) (modified)

Production of tuwo

Tuwo was produced from maize-fermented bambara groundnut flour as described by Arise *et al.* (2022), with modification. The overall ratio of flour to water was 1:3 (w/v). Cold slurry of the flour was first prepared by mixing 40 % of the desired quantity of flour (500 g) with 60 % of the desired quantity of water (3 L). This was followed by bringing it into boiling and the cold slurry initially prepared was added to this boiling water coupled with vigorous stirring, using a wooden flat spoon to form a pap-like consistency. The remaining quantity of the flour (60 % of the desired total) was then added gradually to the boiling pap-like paste with continuous stirring so as to facilitate non-formation of lumps and to ensure a homogenous gel formation. The remaining quantity of water (40 % of the desired total) was finally added to the formed gel and stirred vigorously to ensure smoothness of the gel desired. The final product so obtained is called “tuwo”

Maize-fermented bambara groundnut flour

↓

Preparing small quantity of slurry from the flour

↓

Addition of slurry to appropriate quantity of boiling water (with stirring)

↓

Vigorous stirring (using wooden spatula)

↓

Addition of appropriate amount of flour (with continuous stirring)

↓

Adding small quantity of water to cook (5 – 7 min)

↓

Final stirring (using wooden spatula)

↓

Hot Maize-fermented bambara groundnut tuwo

↓

Molding/Cooling

↓

Tuwo

Figure 3: Flow chart for the production of *tuwo*

Source: Arise *et al.* (2022) (modified)

Table 1: Formulation of blends for production of tuwo from maize-fermented bambara groundnut flour blends

Samples	**Maize flour (%)**	**Fermented bambara groundnut at 24 h (%)**	**Fermented bambara groundnut at 48 h (%)**	**Fermented bambara groundnut at 72h (%)**
A	100	-	-	-

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume IX Issue V May 2025

B	90	10	-	-
C	90	-	10	-
D	90	-	-	10

Where:

Sample A = control

Source: Ajayi *et al.* (2019) (modified)

Analytical Methods

- **Proximate Composition:** Moisture, crude protein, crude lipid, crude fiber, ash, and carbohydrate content were determined using standard AOAC (2019) methods.
- **Antinutritional Factors:** Phytate, oxalate, tannins, and saponins were analyzed to determine their reduction during fermentation.
- **Sensory Evaluation:** A 9-point hedonic scale was used, with 1 representing "dislike extremely" and 9 representing "like extremely."

RESULTS AND DISCUSSION

Proximate composition of tuwo samples from maize and fermented bambara groundnut flour blends

Table 2: Proximate composition of tuwo samples from maize and fermented bambara groundnut flour blends

Proximate Composition (%)	Sample A	Sample B	Sample C	Sample D
Moisture	48.00 ± 0.00^{d}	50.80 ± 0.00^{c}	54.35 ± 0.00^{b}	55.10 ± 0.00^{a}
Total Ash	1.38 ± 0.00^{c}	1.37 ± 0.00^{c}	1.95 ± 0.00^{a}	0.47 ± 0.00^{b}
Crude Fibre	4.11 ± 0.00^{d}	4.95 ± 0.00^{b}	4.44 ± 0.00^{c}	6.44 ± 0.00^{a}
Crude Lipid	1.06 ± 0.00^{d}	1.86 ± 0.00^{c}	2.07 ± 0.00^{b}	3.39 ± 0.00^{a}
Crude Protein	0.37 ± 0.00^{d}	0.51 ± 0.00^{c}	0.57 ± 0.00^{b}	0.90 ± 0.00^{a}
Carbohydrate	93.08 ± 0.00^{a}	91.32 ± 0.00^{b}	91.00 ± 0.00^{b}	88.83 ± 0.00^{c}
Dry matter	52.01 ± 0.00^{a}	49.02 ± 0.00^{b}	45.66 ± 0.00^{c}	44.90 ± 0.00^{d}

Values are mean ± standard deviation of duplicate determinations. Data with different superscripts along the same row are significantly different at $p < 0.05$

Key:

Sample A = 100% maize flour

Sample B = 90% maize flour + 10% fermented bambara groundnut at 24 h

Sample C = 90% maize flour + 10% fermented bambara groundnut at 48 h

Sample D = 90% maize flour + 10% fermented bambara groundnut at 72 h

Moisture content of food is indicative of dry matter of foods and has impact on shelf-life and nutritive value; thus, the lower the moisture content, the longer the shelf-life (Onimawo and Akubor, 2012). The moisture contents of the tuwo samples varied significantly ($p < .05$) from 48.00 to 55.10% with tuwo from sample D (90% maize flour + 10% fermented bambara groundnut at 72 h) having the highest moisture content (55.10%) while the least moisture content (48.00%) was observed in tuwo from sample A (100% maize flour). Varying in fermentation periods may have significantly ($p < .05$) increased the moisture contents of the dumpling samples. The moisture contents of the tuwo samples are higher than the acceptable level 10 – 14% for moisture contents of foods which assures long shelf stability (Okechukwu-Ezike and Oly-Alawuba, 2019; Chinma *et al.*, 2012); high moisture creates an ideal environment for microorganisms. Also, moisture can activate enzymes causing food degradation hence, a pointer to high microbial proliferation in the dumpling samples which could further lead to spoilage. The findings of the current study are lower than 76.22 – 78.72% reported for moisture contents of *amala* from yam flour fortified with moringa leaf powder studied by Ramota *et al.* (2013), 70.92 – 73.26% for moisture contents of *amala* from yam-distiller's spent grain blends Awoyale *et al.* (2010) and 76.87 – 79.01% for moisture contents of plantain-soy *amala* researched by Adekunle and Mayowa (2018).

The ash contents of the dumpling samples varied from 0.47 to 1.95% with dumpling from sample C (90% maize flour + 10% fermented bambara groundnut at 48 h) significantly ($p < .05$) having the highest ash content (1.95%) while the lowest ash content (0.47%) was observed in dumpling from sample D (90% maize flour + 10% fermented bambara groundnut at 72 h). No significant difference ($p > .05$) was observed between the ash contents of the dumpling from sample A (100% maize flour) and B (90% maize flour + 10% fermented bambara groundnut at 24 h) while other dumpling samples varied significantly ($p < .05$). Ash content is an indication of minerals in foods; hence, sample C could contain more minerals than other dumpling samples. The highest ash contents in sample C could be attributed to loss of organic matter and accumulation of inorganic matter caused by the activities of enzymes and microorganism during fermentation (Terefe *et al.*, 2021; Uvere *et al.*, 2010). Similar findings have been reported for fermented maize flour by Terefe *et al.* (2021). The results obtained in the current study are slightly in line with 1.74 – 2.78% for ash contents of *Moringa oleifera* fortified *amala* studied by Ramota *et al.* (2013), lower than 3.20 – 3.44% reported for ash contents of cocoyam-cowpea flour blends *Amala* studied by Idowu and Adeola (2013) but higher than 0.30 – 0.37% for ash contents of plantain-soy *amala* researched by Adekunle and Mayowa (2018).

The crude fibre contents of the dumpling samples ranged from 4.11 to 6.44% with the highest crude fibre content (6.44%) observed in sample D (90% maize flour + 10% fermented bambara groundnut at 72 h) while the least crude fibre content (4.11%) was observed in dumpling from 100% maize flour (sample A). Significantly ($p < .05$), supplementation of the differently fermented bambara groundnut resulted in increase in crude fibre contents of the dumpling samples. Increase in crude fibre contents of the dumpling samples owing to increase in fermentation periods are not in line with the findings of other literatures; Anasiru *et al.* (2019) reported decrease in crude fibre contents 2.32 – 3.97% for crude fibre contents of fermented sweet corn flour and Olanipekun *et al.* (2012) also reported decrease 4.93 – 6.49% in crude fibre contents of bambara groundnut flour. Oboh (2006) contributed that, fermented foods, such as legume has lower fibre contents. The results obtained in the current study are higher than 1.11 – 1.47% reported for fibre contents of unripe plantain-African yam bean flour blends researched by Salome *et al.* (2021) and 0.60 – 2.18% for fibre contents of *lafun*-pigeon pea flour blends studied by Bolaji *et al.* (2021) but lower than 9.38 – 13.41% for fibre contents of *okara* fortified stiff dough (*amala*) studied by Ilelaboye and Ogunsina (2018). Dietary fibre (DF) describes a number of different substances, such as cellulose, pectin, lignin and guar, all of which are naturally found only in plants and are resistant to digestion in, and absorption by, the human small intestine (Bauer and Turler-Ibdderbitzin, 2008).

Fats are saturated lipids at room temperature which are known to play protective roles in the body system (Olusanya, 2008; Duru *et al.*, 2012). The mean results for the crude lipid samples of the dumpling samples varied significantly at 95% confidence level from 1.06 to 3.39% with dumpling from sample D (90% maize flour + 10% fermented bambara groundnut at 72 h) having the highest crude lipid content (3.39%) while the lowest crude lipid content (1.06%) was observed in dumpling from sample A (100% maize flour). Significant ($p < .05$) increase in crude lipid contents of the dumpling samples were observed with increased periods of fermentation. This negates the claim of Olanipekun *et al.* (2012) that fermentation resulted in decrease in fat contents of bambara groundnut 5.11 – 6.52% which is attributed to the utilization of oxidized lipids to generate energy for the growth and cellular activities. The values reported in this study are comparable to 0.72 – 1.76%

reported for fat contents of cocoyam-cowpea flour blends *amala* studied by Idowu and Adeola (2017) but lower than 3.38 – 3.78% for fat contents of Maize-Kidney bean flour blends by Ohini *et al.* (2019) and 8.00 – 10.89% for fat contents of unripe plantain-African yam bean flour blends *Amala* by Salome *et al.* (2021). The low-fat contents of other dumpling samples could be beneficial as they would not be prone to oxidative rancidity; hence, ensuring prolonged shelf stability.

The crude protein contents of the dumpling samples varied from differed significantly ($p < .05$) from 0.37 to 0.90%. Dumpling from sample D (90% maize flour + 10% fermented bambara groundnut at 72 h) had the highest crude protein content (0.90%) while the least crude protein content (0.37%) was observed in sample A (100% maize flour). The result showed Significantly ($p < .05$) increase in crude protein contents of the dumpling samples with increase in fermentation periods of the bambara groundnut flour. This is attributed to the logarithmic growth of different strains of microorganisms during fermentation, which produces proteolytic enzymes, increasing the protein content (Ojokoh *et al.*, 2020). Moreover, the increase in protein content of the dumpling samples after fermentation of bambara groundnut could also be attributed to a decrease in carbon ratio in the total mass and an increase in cell biomass and productions of non-protein nitrogen compounds like ammonia, amines, amino acids, and peptides as these all are included in the crude protein content (Onyango *et al*., 2013). Similar findings have been reported for increase in protein contents of fermented maize by Li *et al.* (2012). The results are slightly in line with 0.55 – 1.30% reported for *amala* from plantain-soy flour blends researched by Folorunso and Ayodele (2018) but lower than 2.17 – 2.87% reported for protein contents of unripe plantain flour *amala* studied by Karim *et al.* (2020) and 1.86 – 2.45% reported for crude fibre contents of cocoyam-cowpea *amala* flour blends from Idowu and Adeola (2017).

The carbohydrate contents of the dumpling samples were of range 88.83 to 93.08%. Dumpling from sample A (100% maize flour) significantly ($p < .05$) had the highest carbohydrate content (93.08%) while the least carbohydrate content (88.83%) was observed in dumpling from sample D (90% maize flour + 10% fermented bambara groundnut at 72 h). No significant variation ($p > .05$) was observed between the carbohydrate contents of dumplings supplemented with bambara groundnut fermented at 24 h and 48 h respectively (sample B and C). However, significant ($p < .05$) decrease in carbohydrate contents of the fermented bambara groundnut-supplemented dumpling samples B, C and D were observed. During fermentation, microorganisms utilize carbohydrates as an energy source and produce carbon dioxide as a by-product and this causes the nitrogen in the fermented product to be concentrated, and thus, the proportion of protein in the total mass increases (Nasseri *et al*., 2011); hence, a pointer to the decrease in carbohydrate contents of the fermented-bambara groundnut flour supplemented dumplings in the current study. The findings of the current study are in line with the report of Fetuga *et al.* (2014) whose study reported 76.90 – 87.68% for carbohydrate contents of sweet potato flour *amala*, 28.52 – 74.42% for carbohydrate contents of maize tuwo-cirina forda blends by Adeoti *et al.* (2013) and 70.3 – 77.7% reported for cocoyam-cowpea flour blends *amala* studied by Idowu and Adeola (2017). Carbohydrate supplies energy to cells such as brains, muscles and blood, contributes to fat mechanism, acts as mild natural laxative, and spares proteins as an energy source (Idowu and Adeola, 2017).

Table 3: Antinutritional properties and fatty acid composition of dumpling samples from maize and fermented bambara groundnut flour blends

Antinutritional Properties (mg/100 g)	Sample A	Sample B	Sample C	Sample D
Phytate	9.70±0.00^{d}	13.16±0.00^{a}	12.89±0.00^{b}	11.92±0.00^{c}
Oxalate	92.50±0.00^{a}	53.13±0.00^{d}	55.63±0.00^{b}	54.38±0.00^{c}
Tannin	0.000226±0.00^{a}	0.000274±0.00^{a}	0.000212±0.00^{a}	0.000252±0.00^{a}

The antinutritional properties of dumpling samples from maize and fermented bambara groundnut flour blends are shown in table 4.2.

The phytate contents of the dumpling samples varied significantly ($p < .05$) from 9.70 to 13.16 mg/100 g with dumpling from sample B (90% maize flour + 10% fermented bambara groundnut at 24 h) having the highest phytate content (13.16 mg/100 g) while the least phytate content (9.70 mg/100 g) was observed in dumpling from sample A (100% maize flour). Significant ($p < .05$) reduction in phytate contents of the dumpling samples supplemented with fermented bambara groundnut (sample B, C and D) were observed with increase in fermentation periods. Processing, especially fermentation, has been reported to reduce phytic acid content of cereals, legumes and tubers as a result of the activity of the endogenous phytases from both raw ingredient and inherent microorganisms which hydrolyse phytic acid in many fermented food product preparation inisitol and orthophosphate (Sandberg and Andlid, 2002; Ola and Opaleye, 2019); The results obtained in the current study are lower than 105.52 - 311.35 mg/100 g reported for phytate contents of fermented maize flour by Terefe *et al.* (2021) but higher than 0.15 – 3.64 mg/100 g for phytate contents of fermented bambara groundnut flour by Ola and Opaleye (2019) and 0.17 – 0.87 mg/100 g for phytate contents maize-bambara nut composite flours by Adejuyitan *et al.* (2022).

The oxalate contents of the dumpling samples differed significantly at 95% confidence level from 53.13 to 92.50 mg/100 g with dumpling from sample A (100% maize flour) having the highest oxalate content (92.50 mg/100 g) while the least oxalate (53.13 mg/100 g) was observed in dumpling from sample B (90% maize flour + 10% fermented bambara groundnut at 24 h). The study showed significant ($p < .05$) reduction in oxalate contents of the dumpling samples supplemented with fermented bambara groundnut (sample B, C and D) at varying fermentation periods. Similar decreasing trends in oxalate contents 0.72 – 1.49 mg/100 g of fermented bambara nut flour studied by Ola and Opaleye (2019). Fermentation reduces anti-nutrients through enzymatic activity, microbial metabolism such as lactic acid bacteria that produces enzymes that break down anti-nutrients. Similar trend also agrees with the findings of Abiodun and Adepeju (2011) and Oke and Bolarinwa (2012) for cocoyam flour and dehulled bambara nut flour, respectively. The results obtained in the current work are higher than 0.15 – 0.26 mg/100 g for oxalate contents of maize-bambara nut composite flour by Adejuyitan *et al.* (2022).

The tannin contents of the dumpling samples varied insignificantly ($p > .05$) from 0.000212 to 0.000274 mg/100 g with dumpling from sample B (90% maize flour + 10% fermented bambara groundnut at 24 h) having the highest tannin content (0.000274 mg/100 g) while the least tannin content (0.000212 mg/100 g) was observed in dumpling from sample C (90% maize flour + 10% fermented bambara groundnut at 48 h). Reduction in tannin due to fermentation might have been caused by the activity of polyphenol oxidase or fermented microflora on tannins (Abiodun and Adepeju, 2011). The observed decrease in tannin with increase in fermentation time agrees with the report of Onweluzo and Nwabgwu (2009). The results obtained in the current study are lower than 0.02 – 0.03 mg/100 g reported for tannin contents of fermented bambara nut flour by Ola and Opaleye (2019) and 3.84 – 4.80 mg/100 g for tannin contents of maize-kidney beans composite flours by Ohini *et al.* (2019).

Table 4: Sensory properties of dumpling samples from maize and fermented bambara groundnut flour blends

Sensory Properties	**Sample A**	**Sample B**	**Sample C**	**Sample D**
Colour	$8.50±0.61^a$	$8.15±0.75^c$	$8.20±0.77^b$	$7.95±0.83^d$
Texture	$8.10±0.97^a$	$7.75±0.72^c$	$8.05±0.61^b$	$7.60±1.35^d$
Taste	$8.45±0.69^a$	$7.90±0.72^c$	$8.00±0.61^b$	$7.95±1.10^b$
Aroma	$8.30±0.66^a$	$7.75±0.55^b$	$7.75±0.79^b$	$7.45±1.23^c$
Overall Acceptability	$8.50±0.51^b$	$8.10±0.79^c$	$8.55±0.69^a$	$8.00±1.08^d$

Key:

Sample A = 100% maize flour

Sample B = 90% maize flour + 10% fermented bambara groundnut at 24 h

Sample C = 90% maize flour + 10% fermented bambara groundnut at 48 h

Sample D = 90% maize flour + 10% fermented bambara groundnut at 72 h

The sensory properties of tuwo samples from maize and fermented bambara groundnut flour blends are presented in table 4. Sensory properties, such as flavours, aroma, taste, texture, and mouthfeel, are among the most important attributes of food products in ensuring their acceptability to the consumers. The colour attribute ratings of the dumpling samples varied significantly ($p < .05$) from 7.95 to 8.50 with dumpling from sample A (100% maize flour) having the highest rating for colour (8.50) while the least value (7.95) was observed in dumpling from sample D (90% maize flour + 10% fermented bambara groundnut at 72 h).

The texture attribute ratings of the dumpling samples ranged from 7.60 to 8.10 with dumpling from 100% maize flour (sample A) having the highest texture attribute rating (8.10) while the lowest value (7.60) was observed in dumpling from sample D (90% maize flour + 10% fermented bambara groundnut at 72 h). Significant variations at 95% confidence level were observed between the texture attribute ratings of the dumpling samples.

The aroma attribute ratings of the dumpling samples ranged from 7.45 to 8.30 with dumpling from sample A (100% maize flour) having the highest value for aroma rating (8.30) while the lowest value (7.45) was observed in dumpling from sample D (90% maize flour + 10% fermented bambara groundnut at 72 h). No significant variation ($p > .05$) was observed between dumpling from sample B (90% maize flour + 10% fermented bambara groundnut at 24 h) and C (90% maize flour + 10% fermented bambara groundnut at 48 h) while other dumpling samples differed significantly ($p < .05$).

The overall acceptability ratings of the dumpling samples differed significantly ($p < .05$) from 8.00 to 8.55 with dumpling from sample C (90% maize flour + 10% fermented bambara groundnut at 48 h) having the most rating for overall acceptability (8.50) while the least overall acceptability rating (8.00) was observed in dumpling from sample D (90% maize flour + 10% fermented bambara groundnut at 72 h).

CONCLUSION AND RECOMMENDATION

Conclusion

The proximate, anti-nutritional and sensory properties of tuwo from maize and fermented bambara groundnut flour blends were studied. The dumpling samples were of high moisture contents. Supplementation of fermented bambara groundnut flour at 24 h, 48 h and 72 h improved the total ash, crude fibre, crude lipid and crude protein. However, reduction in carbohydrate and dry matter were observed. Antinutritional properties of the dumpling samples including phytate, oxalate, tannin and saponin reduced at varying periods (24 h, 48 h and 72 h) of fermented bambara groundnut flour inclusion. Organoleptically, dumpling from 100% maize flour (sample A) was the most acceptable of all the dumpling samples; however, other dumpling samples supplemented with bambara groundnut samples had comparable sensory ratings, thus, indicating that acceptable dumpling could be produced maize and differently fermented bambara groundnut flour.

Recommendation

Further studies are hereby recommended on the functional, pasting, and storage stability of the dumpling samples produced in this study.

REFERENCES

1. Abiodun, A.O., and Adepeju, A.B. (2011). Effect of processing on the chemical, pasting, and anti-nutritional composition of Bambara Nut (Vigna subterranea L. Verdc) Flour. Advance Journal of Food Science and Technology, 3(4): 224-227.
2. Adejuyitan, J.A., Alabi, B.E., and Salaam, S.B. (2022). Quality attributes of abari (maize pudding) produced from maize and Bambara groundnut flour blends. Ceylon Journal of Science, 51(3): 269-276.

3. Ajayi, O.O., Abegunde, B.A., and Olajide, O.J. (2019). Formulation and Quality Assessment of Dumpling Made from Maize-Bambara Groundnut Composite Flour. International Journal of Food Science and Nutrition Engineering, 9(2): 30–35
4. AOAC (2019). Official Methods of Analysis of AOAC International
5. Ayo, J.A., and Gidado, F.E. (2017). Physicochemical, Phytochemical, and Sensory Evaluation of Acha-Carrot Flour Blend Biscuit. Current Journal of Applied Science and Technology, 25(5): 1 – 15.
6. Ayo, J.A., Ojo, M., and Obike, J. (2018). Proximate composition, functional and phytochemical properties of pre-heated aerial yam flour. Research Journal of Food Science and Nutrition, 3(1): 1 – 8.
7. Elham, G.K., Atia, S., Haq, N., Rafia, R., and Shafaq, N. (2019). Maize (Corn) - A Useful Source of Human Nutrition and Health: A Critical Review. International Journal of Chemical and Biochemical Sciences
8. Ikegwu, O., Nwobasi, V., Odoh, M., and Oledinma, N. (2009). Evaluation of the pasting and some functional properties of starch isolated from some improved cassava varieties in Nigeria. African Journal of Biotechnology, 8, 2310–2315.
9. James, S., Akosu, N.I., Maina, Y.C., Baba, A.I., Nwokocha, L., Amuga, S.J., Audu, Y., and Omeiza, M.Y.M. (2018). Effect of addition of processed Bambara nut on the functional and sensory acceptability of millet-based infant formula. Food Science and Nutrition, 6: 783 – 790.
10. James, S., and Nwabueze, T.U. (2014). Influence of condition and defatted soybean inclusion on the functional and pasting characteristics of African Breadfruit flour blend. Food Science and Quality Management, 34, 26–33.
11. Ogundele, G.F., Ojubanire, B.F., and Bamidele, O.P. (2015). Determination of the pasting and functional properties of cowpea (Vigna unguiculata) and soybean (Glycine max) blends. British Journal of Applied Science and Technology, 6(3), 304–309.
12. Ohini, O. P., Ferdinand, O. M., and Betsy, O. O. (2019). Chemical, Anti-Nutritional Factors and Sensory Properties of Maize-Kidney Bean Flours. Food Science and Nutrition Technology, 4(6): 1 – 9.
13. Oke, M.O., and Bolarinwa, I.F. (2012). Effect of fermentation on physicochemical and oxalate content of cocoyam (Colocasia esculenta) Flour. ISRN Agronomy, 1-4.
14. Ola, O.I., and Opaleye, S.O. (2019). Effect of Fermentation on Antinutritional Factors and Functional Properties of Fermented Bambara Nut Flour. Asian Food Science Journal, 11(1): 1 – 5.
15. Olaleye, H.T., Oresanya, T.O., and Temituro, E.O. (2020). Quality assessment of weaning food from blends of sorghum, mung beans, and orange-fleshed sweet potato. European Journal of Nutrition and Food Safety, 12(6): 42–52.
16. Olanrewaju, B.J., Jesufunmi, O.E., Oyedunni, E.O., Micheal, A.O., and Ademola, A.D. (2021). Effect of processing methods on functional, pasting properties of flours and sensory evaluation of "Amala" made from different yam cultivars. GSC Advanced Research and Reviews, 7(1): 123 – 132.
17. Olanipekun, B.F., Otunola, E.T., Adejuyitan, J.A., and Adeyanju, J.A. (2012). Proximate and Fatty Acid Composition of Bambara Groundnut (Voandzeia subterranean L. Thouars) as Influenced by Fermentation with a Combination of Rhizopus oligosporus and R. nigricans. Transnational Journal of Science and Technology, 2(9): 77 – 87
18. Olatunde, S.J., Adetola, R.O., Oyeyinka, A.T., and Oyeyinka, S.A. (2015). Production and quality evaluation of tapioca substituted with fermented Bambara flour. Food Technologies, 5(6): 36 – 43
19. Onweluzo, J.C., and Nwabgwu, C.C. (2009). Fermentation of Millet (Pennisetum americana) and Pigeon Pea (Cajanus cajan) Seeds for Flour Production: Effects on Composition and Selected Functional Properties. Pakistan Journal of Nutrition, 8(6): 737-744.
20. Pobee, R.A., Nkrumah, B.O., Oduro, I., and Tortoe, C. (2017). Effect of fortification of rice flour with soybean and mango fruit powders on the nutritional and sensory properties of rice-based infant food. Journal of Food and Nutrition Research, 5(5): 304-311.
21. Samuel, F.O., Ishola, O.R., and Otegbayo, B.O. (2015). Nutritional and Sensory Evaluation of Rice-Based Masa Enriched with Soybean and Crayfish. Food and Nutrition Sciences, 6, 234-241.
22. Sandberg, A.S., and Andlid, T. (2002). Phytogenic and microbial phytases in human nutrition. International Journal of Food Science and Technology, 37: 823-833.
23. Siddhuraju, P., and Becker, D. (2001). Effect of various domestic processing methods on anti-nutrients and in-vitro protein and starch digestibility of two indigenous varieties of Indian tribal pulse (Mucuna pruriens varutilis). Journal of Agricultural and Food Chemistry, 49: 3058-3067.

24. Terefe, Z.K., Omwambe, M.M., and Nduko, J.M. (2021). Effect of solid-state fermentation on proximate composition, antinutritional factors, and in-vitro protein digestibility of maize flour. Food Science and Nutrition, 9: 6343–6352.
25. Tharise, N., Yuwono, S.S., and Herawati, T. (2014). Modification of Cassava Flour Using Composite Flour Blends and Its Effect on Nutritional, Physical and Sensory Properties. International Journal of Food Science and Nutrition Engineering, 4(5): 118-126.
26. Zaidul, I.S., Nor, A.A., and Omar, S. (2007). Starch granule properties and breakdown viscosity of some native starches. Food Chemistry, 106(4): 1356-1362

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume IX Issue V May 2025

APPENDIX

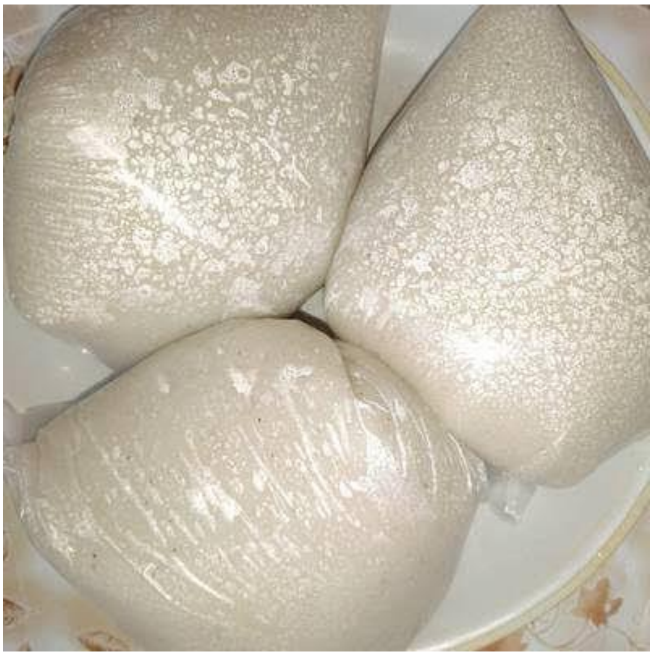

Plate 5.1: Dumpling from sample A

Plate 5.2: Dumpling from sample B

Plate 5.3: Dumpling from sample C

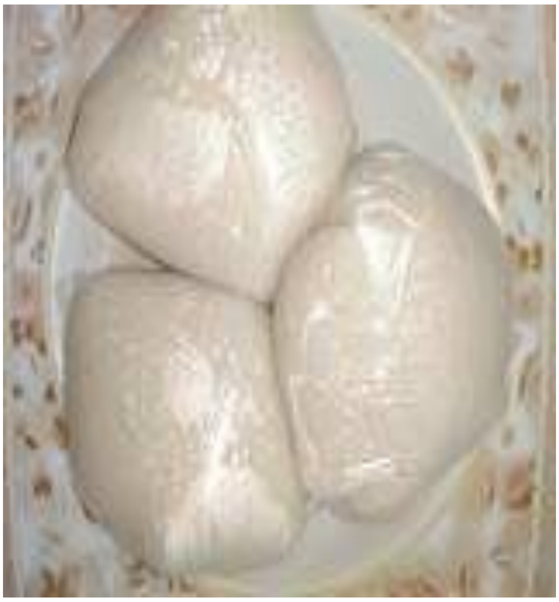

Plate 5.4: Dumpling from sample D