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Quality Evaluation of Noodles Produced From Blends of Wheat, Unripe Banana and Cowpea Flours

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Abstract
The work determined the quality of noodles produced from wheat, unripe banana and cowpea flour blends. Flour blends were produced from wheat, cowpea and unripe banana flour at the ratios of 100:0:0, 80:10:10, 70:10:20, 60:10:30, 50:10:40 (wheat: unripe banana: cowpea). Noodles were prepared from the flour blends and evaluated for the chemical composition, color, cooking characteristics and sensory properties. Noodles from 100% wheat flour served as control. The cowpea flour contained higher amount of protein while the unripe banana flour and wheat flour had higher levels of carbohydrate than the cowpea flour. The wheat flour had higher sodium, calcium, magnesium and phosphorous contents than the other flours, which were closely followed by those of the unripe banana flour. The moisture contents of the noodles varied from 9.15-11.25%. The ash contents of the noodles ranged between 1.03 and 1.80%.The crude fiber, fat and carbohydrate contents of the noodles increased with the level of cowpea flour in the noodles. The energy contents of the noodles ranged from 383.39-422.31Kcal/100g. The cooking time decreased from 10.50 min in wheat flour noodles to 7.50 min in the noodle containing 40% cowpea flour. However, the cooking loss and weight increased as the amount of cowpea flour in the noodles increased. The wheat flour noodles were rated higher for color, taste and overall acceptability but not for flavor and mouthfeel. The score for overall acceptability of the wheat flour noodle was 8.60 while those of the composite flour noodles containing 10 and 20% cowpea flour were 8.15 respectively on 9-point Hedonic scale. It is concluded that noodles could be produced from 70% wheat, 20% cowpea and 10% unripe banana flour blends without affecting the qualities of the noodles.

Keywords : Unripe banana, cowpea, wheat, flour, noodles, cooking characteristics, nutritional and sensory properties.

Introduction

Noodles are quick-cooking foods that have become popular across the globe due to their convenience, easiness in preparation, fast-yielding income, status symbol, job demands (among urban dwellers), affordable cost, versatility, sensory appeal, storage ability, satiety, good eating and nutritional qualities (Okafor and Usman, 2015).They are important staple foods worldwide, with a steady annual production increase of 3% since 2010 (World's Instant Noodles Association, 2019). For instance, about 20-50% of wheat consumed in Asian countries are in the form of noodles (Ojure and Quadri, 2012; Niu and Hou 2020) and the popularity has continued to extend beyond Asia (Niu and Hou, 2020). In Nigeria, they are fast replacing the traditional diets, serving as breakfasts and snacks where they are consumed wet, boiled, steamed or fried. They are often eaten with sauce or in soup and stew.

Typically, noodles are made from unleavened dough of wheat and are stretched, extruded or rolled into variety of shapes such as waves, helices, tubes, strings, shells etc (Wikipedia, 2022; Niu and Hou, 2020). Though, there are many types of noodles, differentiated in their ingredients, type of processing, size and shape, cooking properties, and end-use quality, they all share common processing steps of mixing ingredients, kneading, rolling or sheeting the dough and cutting into pieces (Wieser et al., 2020).

However, production of noodles like other wheat flour based products is confronted with spiking import bills for wheat, and nutrient deficiency. For instance, Nigeria only produces about 1% of the 5-6 million metric tons of the wheat consumed annually in Nigeria (Oyekanmi, 2022; Damak et al., 2022). This has continued to tremendously deplete the nation's foreign exchange reserve and also outrageously hiked the cost of wheat flour based products like noodles and bread. Besides, an increasing consumer health-consciousness is a key factor in expansion of research towards the deployment of composite flour technology for formulation of noodles. Malnutrition and some health concerns are traced to consumption of 100% wheat flour products for wheat flour is refined and debased of essential nutrients like protein, dietary fibre, minerals and vitamins (Okereke *et al.*, 2021; Damak *et al*., 2022). Weight gain/obesity, diabetes, cardiovascular disease, inflammation, allergy, digestion problems and celiac disease are implicated in excessive consumption of wheat flour based products which are becoming staple foods in developed and developing countries like Nigeria (Okereke et al., 2021). For instance, the deficiency of lysine and threonine (essential amino acids) in wheat flour makes it difficult for the body to synthesize protein, hormone, enzyme and antibodies, which are needed for growth and other functions. Therefore, to mitigate these highlighted problems, Nigerian scientists have continued to investigate the potentials of flours from local food crops such as soybean, breadfruit, cassava, arrowroots, yams, sweet potatoes, plantains, maize, banana, cowpea among others in production of wheat flour based products such as biscuit, bread, cakes, pasta, cookies, noodles etc. (Akubor & Ishiwu, 2013; Akubor & Obiegbuna, 2014; Iwe et al., 2014; Okereke et al., 2021; Damak et al., 2022).

Nigeria is among the largest banana producing countries in Africa, and the leading producing nation of cowpeas in the world (Olumba & Onunka, 2020; FAO 2021). However, these two profitable food crops are under-utilized in Nigeria due to limited nutritional information on them and poor industrial exploitation. In addition, huge post-harvest losses due to poor storage stability and preservation techniques are recorded against these crops annually. These weaken the Nigeria's fragile food security system. However, studies have revealed that unripe bananas (*Musa sapientum*) are rich sources of bioactive compounds, pectin, carbohydrates, resistant starch, dietary fibre, and their consumption has been reported to exert huge beneficial effects on human health (Axe, 2018; Falcomer et al., 2019; Adrija, 2022). In this regard, banana has been processed into flour for utilization in various foods. Cowpea (*Vignaunguiculata L. Walp.*), on the other hand, is a leguminous crop that is rich in protein, B-vitamins, minerals and carbohydrate (Okereke & Banigo, 2021). High protein (18% – 35%) and carbohydrate (50% – 60%) contents of cowpeas, together with amino acid profile make them complementary to cereal grains in food formulations (Prinyawiwatkul et al., 1996; Jayathilake et al., 2018). Cowpea is one potential source of nutritious flour for snack foods, and provides alternative source of protein for people that cannot afford fish and meat. It has wider pattern of utilization more than other legumes.

Therefore, formulation of noodles with composite flour of wheat, unripe banana and cowpea s would greatly enhance the nutritional quality and phytochemical status of the noodles. Therefore, the objective of this study to evaluate the quality of noodles produced from blends of wheat, unripe banana and cowpea flours.

Materials and Methods

Materials

Fresh unripe banana (*Musa spp*.) fruits and cowpea grains were purchased from Ayingba Market, Dekina LGA, Kogi State. Commercial wheat flour was purchased from Ayingba New Market, Lokoja, Kogi State. These raw materials were packed in polyethylene bags and stored (under dry condition and ambient room temperature of 27^{o}C) in the Laboratory of Food Nutrition and Home Science Department, Prince Audu Abubakar University, Kogi State, Nigeria.

Methods

Preparation of Wheat flour: The commercial wheat flour was sieved through a 0.20mm mesh screen, packaged in high density polythene bags and stored in airy clean dry place at ambient room temperature (27^{o}C) prior to use.

Production of Unripe banana flour: Unripe banana flour was produced using the method described by Anggraeni and Saputra (2018) with slight modification as shown in figure 1. Green banana fruits were individually plucked from banana hands, washed in clean water, blanched in hot water (100^{o}C) for 10 minutes, cooled and peeled using a stainless knife. The peeled bananas were sliced (5mm thickness) and soaked in 0.20% solution of sodium metabisulfite for 5 min. The solution was drained off and the slices dried at 50^{o}C in a hot air oven (Model PP, 22 US, Genlab, England) to constant weight. The dried slices were milled using hammer mill, sieved to pass through 0.20 mm aperture screen and packaged in air tight plastic container for subsequent use.

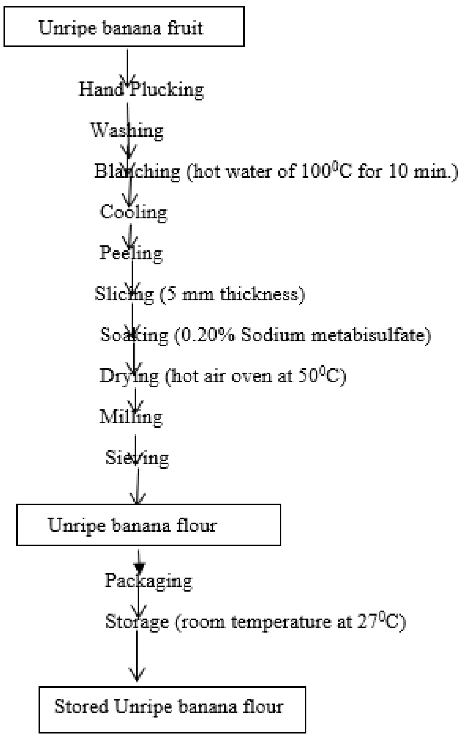

Figure 1: Flow chart for production of unripe banana flour
Source: Modified Anggraeni and Saputra (2018)

Production of Cowpea flour: Cowpea flour was prepared using the method described by Akosua et al. (2014) as shown in figure 2. The cowpea beans were manually sorted to remove unwholesome ones and foreign materials. The sorted beans were soaked in water (bean seed: water, 1: 5) for 12 hours, blanched in hot water (1:3 w/v) at 100°C for 5minutes, cooled and dehulled manually by rubbing between the palms. The dehulled beans were dried in hot air oven at 50°C to constant weight, milled, sieved through 0.20 mm aperture screen and packaged in air tight plastic container for subsequent use.

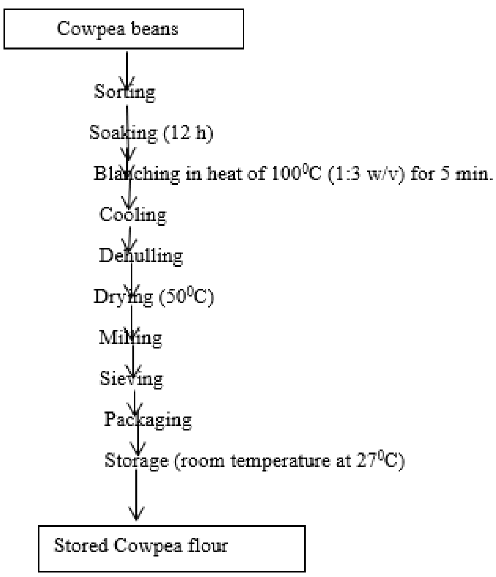

Figure 2: Flow chart for production of cowpea flour
Source: Akosua et al. (2014)

Formulation of the Flour Blends: Flour blends were produced from wheat, cowpea and unripe banana flour at the ratios of 100:0:0, 80:10:10, 70:10:20, 60:10:30, 50:10:40 (wheat: unripe banana: cowpea) using Philip blender (HR2811 model) operated at full speed for 10 min. The five (5) flour blends were packaged in high density polyethylene bags prior to use.

Production of the noodles

The recipe used for the production of the noodles samples is shown in Table 1. The method as described by Omeire et al. (2014) and, Dhull and Sandhu (2018) with slight modifications was used to produce the five noodles samples labeled N_1, N_2, N_3, N_4 and N_5. All the ingredients (flour blend, salt, $NaHCO_3$, oil, egg, garlic powder, cumin and water) were weighed and measured as shown in Table 1. The flour blend was mixed with warm water (40⁰C) and other ingredients; then kneaded for 10 minutes to form dough sheets of about 3 mm thickness. The dough was allowed to rest for 20 min. The dough sheets were extruded using a cold extruder (Eurosonic, Globe 150 Model). The prepared raw noodles were then steamed at 100°C for 3 minutes, and then dried in a cabinet dryer at 68°C for 2 h. The noodles were cooled at room temperature (27⁰C) and packaged in polythene bags for analyses. The procedure is shown in Figure 3.

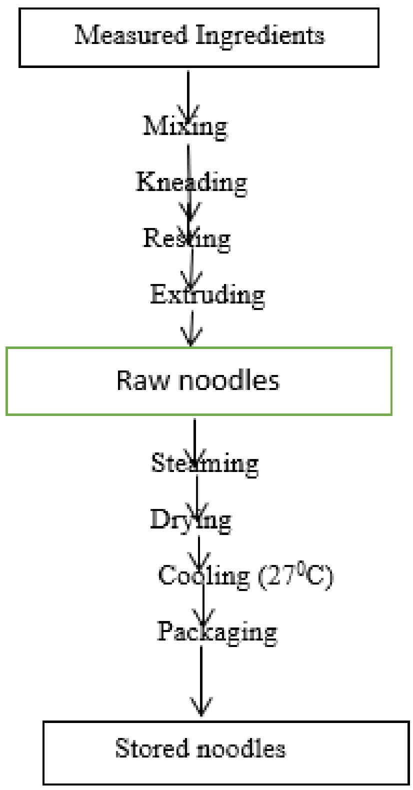

Figure 3: Flow chart for production of noodles
Source: Modified Taneya et al. (2014)

Table 1: Recipe for production of noodles from the various flour blends of wheat flour (WHF), cowpea flour (CPF) and unripe banana flour (UBF)

Noodles sample	Flour Blend (WHF: CPF: UBF) (g)	Water (mL)	Salt (g)	Sodium bicarbonate ($NACO_3$) (g)	Oil (mL)	Egg (mL)	Garlic powder (g)	Cumin powder (g)
N_1	100	31	1	1	5	10	0.1	0.5
N_2	80:10:10	31	1	1	5	10	0.1	0.5
N_3	70:20:10	31	1	1	5	10	0.1	0.5
N_4	60:30:10	31	1	1	5	10	0.1	0.5
N_5	50:40:10	31	1	1	5	10	0.1	0.5

N_1= Noodles of 100% wheat flour (Control)
N_2 = Noodles of flour blend (80% Wheat flour: 10% Cowpea flour: 10% Unripe banana flour)
N_3 = Noodles of flour blend (70% wheat flour: 20% Cowpea flour: 10% Unripe banana flour)
N_4= Noodles of flour blend (60% Wheat flour: 30% Cowpea flour: 10% Unripe banana flour)
N_5 = Noodles of flour blend (50% Wheat flour: 40% Cowpea flour: 10% Unripe banana flour)
Source: Modified Taneya *et al.* (2014)

Determination of the Proximate Composition of the Flours (Wheat flour, Unripe banana and Cowpea flour) and Noodles Samples

Proximate analyses were carried out on the samples of the flours (wheat flour, unripe banana flour and cowpea flour) and noodles to determine the moisture, ash, crude fibre, fat, protein and carbohydrate contents using the method outlined by the Association of Official Analytical Chemists (2010).

Moisture Content

The moisture contents of the flours (wheat flour, unripe banana flour and cowpea flour) and noodles were determined by hot air oven method as described by AOAC (2010). The sample (2 g) was weighed into an empty dish. This was placed into the hot air oven to dry for 24 hours at 100^{0}C. The dish and its contents were cooled in the desicator and their weights taken. The loss in weight was recorded as moisture content and expressed as percentage of the original weight of the sample. This experiment was carried out in triplicates.

$$\%\ \text{Moisture Content} = \left(\frac{W_2 - W_3}{W_2 - W_1}\right) X\ 100$$

W_1 = weight of cooled empty dish
W_2 = weight of empty dish + undried sample
W_3 = weight of dish + dried sample

Ash Content

The Ash contents of the flours/noodles samples were determined using the method of AOAC (2010). The sample (5 g) was weighed into empty crucible and then the sample was incinerated in a muffle furnace at 550°C until a light grey ash was observed and a constant weight obtained. The sample was cooled in the desiccator to avoid absorption of moisture and weighed to obtain ash content. The percentage ash content was expressed as percentage of the original weight of the sample on dry basis. The experiment was done in triplicates.

$$\%\ \text{Ash Content} = \left(\frac{W_3 - W_1}{W_2 - W_1}\right) X\ 100$$

W_1 = weight of cooled empty crucible
W_2 = weight of empty crucible + undried sample
W_3 = weight of crucible + dried sample

Crude Fibre Content

Crude fibre of the flours/noodles sample were determined using the method of AOAC (2010). The sample (5 g) was weighed into a 500 ml Erlenmeyer flask and 100 ml of TCA digestion reagent was added. It was then brought to boiling and refluxed for exactly 40 minutes counting from the start of boiling. The flask was removed from the heater, cooled a little then filtered through a 15.0 cm number 4 Whatman paper. The residue was washed with hot water, stirred once with a spatula and transferred to a porcelain dish. The sample was dried overnight at 105°C. After drying, it was transferred to a desiccator and weighed as W_1. It was then burnt in a muffle furnace at 500°C for 6 hours, allowed to cool, and reweighed as W_2.

$$\%\ \text{Crude fibre Content} = \left(\frac{W_2 - W_1}{W_0}\right) X\ 100$$

W_1 = Weight of crucible + fiber + ash
W_2 = Weight of crucible + ash
W_0 = Dry weight of food sample

Crude Fat Content

The soxhlet extraction method described by AOAC (2010) was used in determining fat contents of the flours and noodles. Two grams (2 g) of the flour/noodles sample were weighed into a weighed flat bottom flask, with the extractor mounted on it. The thimble was held half way into the extractor and the weighed sample. Extraction was carried out using boiling point of hexane (40 - 60°C). The thimble was plugged with cotton wool. At completion of extraction which lasted for 8 hours, the solvent was removed by evaporation on a water bath and the remaining part in the flask was dried= at 80°C for 30 minutes in the air oven to dry the fat and then cooled in a desiccator. The flask was reweighed and percentage fat content calculated as follows.

$$\%\ \text{Crude fat Content} = \left(\frac{\text{weight of fat}}{\text{weight of sample}}\right) X\ 100$$

Protein Content

The micro Kjeldahl method as described by AOAC (2010) was used to determine crude protein. The flour/noodles sample (2 g) was weighed into the digestion flask. Ten grams (10 g) of copper sulphate and sodium sulphate (catalyst) in the ratio of 5:1 respectively and 25 ml concentrated sulphuric acid were added to the digestion flask. The flask was placed into the digestion block in the fume cupboard and heated until frothing ceased giving clear and light blue green coloration. The mixture was then allowed to cool and dilute with distilled water until it reached 250 ml of volumetric flask. Distillation apparatus was connected and 10 ml of the mixture was poured into the receiver of the distillation apparatus. Also 10 ml of 40% sodium hydroxide was added. The released ammonia by boric acid was then treated with 0.02 N of hydrochloric acid until the green color changed to purple. Percentage of nitrogen in the sample was calculated using the formula below.

$$\text{Nitrogen (\%)} = \left(\frac{(\text{Titre} - \text{blank})\text{X}14.008\text{XNormalityX}100}{\text{Weight of Sample}}\right)\text{X}100$$

$$\%\ \text{Protein Content} = \%\ \text{N X } 6.25$$

Carbohydrate Content

The carbohydrate content was calculated by difference method according to Ihekoronye and Ngoddy (1985). This was done by summing up the moisture, crude protein, crude fat, crude fibre and ash contents and then subtracting from 100.

$$\%\ \text{Carbohydrate Content} = 100 - (\%\ \text{MC} + \%\text{CP} + \%\text{CF} + \%\text{CFb} + \%\text{A})$$

Where MC = Moisture content
CP = Crude Protein
CF = Crude fat
CFb = Crude fibre
A = Ash

Energy Content

The energy value of the noodles sample was calculated in Kcal/100g, using the Atwater Factor Method, as described by Ojo et al. (2017). It was calculated using the equation:

$$E.V = (4CP + 9CF + 4\ C)$$

Where E.V = Energy value or Energy content of the noodles measured in kilocalories (Kcal)
CP = Crude protein content
CF = Crude Fat content
C = Carbohydrate content

Determination of minerals (sodium, calcium, magnesium, and phosphorous) contents of the Flours (Wheat flour, Unripe banana and Cowpea flour) and Noodles Samples

Sodium contents

The method as described by Onwuka (2005) was followed to determine the sodium contents. Sample (1.0 g) was digested with 20.0 ml of acid mixture (650 ml of concentrated HNO_3; 80 ml PCA; 20 ml concentrated H_2SO_4). The aliquots of the diluted clear digest were taken for photometry using flame analyzer. Absorbance for sodium was read at 767nm.

Calcium content

The calcium content of the sample was determined using the method described by AOAC (2010). The ash (2 g) obtained from the ash analysis earlier was boiled in in a beaker with 10 ml of 20% HCl and then filtered into 100 ml standard flask. This was made up to the mark with de-ionized water. The calcium content was determined by using the Unicam Solar Spectrophotometer (Model 969 Mk 11, Unicam Ltd, Cambridge, UK) to measure the absorbance at 422.7 nm wavelength.

Magnesium content

The magnesium content of the sample was determined using the method described by AOAC (2010). The ash (2 g) obtained from the ash analysis earlier was boiled in a beaker with 10 ml of 20% HCl and then filtered into 100 ml standard flask. This was made up to the mark with de-ionized water. The magnesium content was determined by using the Unicam Solar Spectrophotometer (Model 969 Mk 11, Unicam Ltd, Cambridge, UK) to measure the absorbance at 285.2 nm wavelength.

Phosphorus content

The phosphorus content of the sample was determined using the method described by AOAC (2010). The ash (2 g) obtained from the ash analyses earlier was boiled in a beaker with 10 ml of 20% HCl and then filtered into 100 ml standard flask. This was made up to the mark with de-ionized water. The total phosphorus content was obtained using ascorbic blue colour procedure of Okalebo et al. (2002) by reading the absorbance at a wavelength of 880 nm on a Helia Gamma Spectrophotometer (Helios Gamma UV-vis Spectrophotometer, thermo Spectronic, Cambridge, UK).

Evaluation of the cooking characteristics of the noodles: Cooking time

Noodles (10 g) were cooked in 200 ml of boiling distilled water in a 250 ml beaker. Noodles were cooked until disappearance of white core, as judged by squeezing between two glass slides (Yadav et al., 2014). Cooking time was determined by the removal of a piece of noodle every 2 minutes and pressing the noodle between two pieces of watch glasses. Optimum cooking was achieved when the center of the noodles became transparent or when the noodle was fully hydrated. Cooking was stopped by rinsing briefly in deionized water (AACC, 1995).

Cooking loss

Noodles (10 g) were cooked in 300mL of distilled water in a 500mL beaker until the central opaque core in the noodle strand disappeared. Cooking loss (%) was measured by transferring the cooked water to a pre-weighed beaker and evaporating the water in a conventional oven over night at 100°C, then reweighing the beaker with left over solids. Cooking quality analysis was performed in duplicate (AACC, 2015).

$$Cooking\ loss\ (\%) = \left(\frac{Dried\ residue\ in\ cooking\ water}{Weight\ of\ noodle\ before\ cooking}\right) X\ 100$$

Cooked weight

The cooked weight of noodles was determined as described by Galvez and Resurreccion (1992) with minor modifications. Noodles (10 g) were soaked in 300 ml water for 5 min and then cooked in water bath for 5 min. The beaker was covered with aluminum foil to minimize the loss of water due to evaporation. The cooked noodles were drained for about 2 min, rinsed with distilled water in a Buchner funnel, and cooked weight was determined by weighing wet mass of noodles.

Weight and Volume increase

Weight and Volume (%) increase is the difference in weight and volume of cooked noodles and uncooked noodles, expressed as the percentage of the weight of uncooked noodles. Cooked noodles were rinsed with water and drained for 30 seconds, then weighed to determine the gain in weight and volume. This analysis indicates the amount of water absorbed by the noodles during cooking process (AACC, 2015).

Color measurement

Color of noodle samples was evaluated by measuring the L (100=white; 0=black), a (+, red; -, green), and b (+, yellow; blue) values using a Minolta CR-400 (Konica Minolta, Inc., Osaka, Japen). Means for color values were based on triplicate analyses.

Sensory evaluation of the noodles

The noodles samples were assessed by 20 panelists randomly selected from the students of the Department of Food, Nutrition and Home science, Prince Abubakar Audu University, Anyigba, Kogi State , Nigeria, who were familiar with the quality attributes of noodles. The samples were evaluated for appearance, flavor, taste, mouthfeel and overall acceptability on a 9- point Hedonic scale (1=dislike extremely and 9=like extremely) as described by Ihekoronye and Ngoddy (1985). The samples were presented to the panelists in clean glass tumblers. The order of presentation of the samples to the panelists were randomized. The evaluation was carried out in a sensory evaluation laboratory under controlled conditions of lighting and illumination.

Experimental design

The experiments were fit into a one way Analysis of variance (ANOVA). Five (5) samples were generated in triplicates for each experiment on the nutritional, cooking characteristics and sensory properties of the noodles, yielding a total of fifteen (15) samples per experiment analyzed.

Statistical analysis

Data obtained were expressed as means of triplicate values and then subjected to statistical analysis. Analysis of variance (ANOVA) were determined using SPSS Version 21.0 and the differences between the mean values were evaluated at p<0.05 using Duncan's multiple range test.

Table 2: Proximate composition (%) of cowpea, unripe banana and wheat flours

Flours	Moisture	Ash	Crude fibre	Fat	Protein	Carbohydrate
CPF	7.00^{c}±0.00	1.63^{a}±0.04	0.76^{a}±0.03	8.35^{b}±0.07	35.15^{a}±0.04	46.99^{c}±0.01
UBF	7.19^{b}±0.01	1.58^{a}±0.04	0.70^{b}±0.00	11.06^{a}±0.08	20.09^{b}±0.11	59.39^{b}±0.22
WHF	8.85^{a}±0.07	1.38^{b}±0.04	0.75^{a}±0.01	1.77^{c}±0.04	16.63^{c}±0.00	71.09^{a}±0.59

Values are mean ± standard deviation (n=3). Means with same superscript within a column are not significantly different (p>0.05). CPF =cowpea flour, UBF= unripe banana flour, WHF= wheat flour

Proximate composition of flours

The proximate composition of wheat, cowpea and unripe banana flours are shown in Table 2. There was significant difference in the moisture contents of the flours (p <0.05). The moisture contents of the flours were 7.00%, 7.19% and 8.85% for cowpea, unripe banana and wheat flours, respectively. The wheat flour had the highest moisture content, followed by unripe banana and then cowpea. These results were similar to the results reported by Oppong et al. (2015) for soft wheat flour. The moisture contents of all the samples were within the acceptable limit of not more than 10% for long term storage of flour. Moisture content of a food is influenced by type of food, food variety, and the storage conditions (Oppong et al., 2015). The low moisture contents of the flours would enhance storage stability by preventing the growth of mold and reducing biochemical reactions (Okereke et al., 2021). Consequently, the low moisture contents of the flours will extend the shelf life of the final products made from them.

The ash contents of cowpea, unripe banana and wheat flour were significantly (p<0.05) different, the values being 1.63%, 1.58% and 1.38%, respectively. The cowpea and unripe banana flours showed no significant (p<0.05) difference in the ash content. The results were similar to the range of 1.00 to 3.00% reported by Oppong et al. (2015). Ash content is an indication of the mineral content of a food. This suggests that cowpea and unripe banana flour blends could be more important sources of minerals than wheat flour. The ash content of wheat flour could be improved by incorporation of cowpea or unripe banana flour. Ash content indicates the level of minerals, and is also used as quality parameter for contamination in a given food sample (Kavitha & Parimalavalli, 2014). The crude fibre contents of the flours from cowpea, unripe banana and wheat were 0.76%, 0.70% and 0.75%, respectively. Cowpea and wheat flour showed no significant (p>0.05) difference in crude fibre contents. These values were relatively higher than the average value of 0.51% reported by Oppong et al. (2015) for refined wheat flour. Chinma and Gernah (2007) reported crude fiber contents of 8.19% for pigeon pea, 9.58% for cowpea, 4.61% for mung bean and 6.83% for peas flour. These values were higher than the values obtained in this study .Crude fibre helps to prevent heart diseases, diabetes, colon cancer etc. (Oppong et al., 2015). According to Norman and Joseph (2015), fiber has an important function in providing roughage or bulk that aids in digestion, softens stool and lowers plasma cholesterol level in the body.

The fat content of the flours were 8.35%, 11.06% and 1.77%for cowpea, unripe banana and wheat flour, respectively. Cowpea and wheat flours were lower in fat contents than the unripe banana flour. This is because legumes and cereals store energy as starch rather than lipids (Iwe et al., 2016). The low fat levels would be beneficial as they will ensure longer shelf life and stability for the products (Okereke et al., 2021). All fats and fat containing foods contain some unsaturated fatty acids and hence, are potentially susceptible to oxidative rancidity (Okereke *et al*., 2021).

The crude protein contents of the flour samples were 35.15%, 20.09% and 16.63% for cowpea, unripe banana and wheat flours, respectively. The protein content of cowpea flour was higher than those of the other flours. This is because cowpea is a leguminous crop. The protein quality of wheat and unripe banana flours can be improved by blending the flours with cowpea flour and used as composite flours. Proteins act as carriers for other nutrients such as lipids, vitamin A, iron, sodium, and potassium (Mahan & Escott-Stump, 2008).It also acts as enzymes and hormones and maintains fluid electrolyte and acid–base balance, and strong immune system (Mahan & Escott-Stump, 2008). The carbohydrate contents of the flours were 46.99%, 59.39% and 71.09 % for cowpea, unripe banana and wheat flour, respectively. There was significant difference in the carbohydrate contents of the flours (p <0.05). The high carbohydrate content of wheat flour suggested that it can be used in combating protein-energy malnutrition in which the carbohydrates provide energy to the body in order to spare protein. Protein can then be used for its primary function of building the body and repairing worn out tissues, rather than being used as energy source. Carbohydrates are good sources of energy (Okereke et al., 2021). A high concentration of carbohydrates is desirable in weaning formulas and breakfast meals. The high carbohydrate content of wheat flour would make it a good source of energy in product formulations (Butt & Batool, 2010).

Table 3: Mineral composition (mg/100g) of cowpea, unripe banana and wheat flours

Sample	Sodium	Calcium	Magnesium	Phosphorus
CPF	$18.40^c \pm 0.07$	$84.40^c \pm 0.28$	$35.63^c \pm 0.04$	$41.25^b \pm 1.06$
UBF	$20.00^b \pm 0.00$	$95.20^b \pm 0.28$	$39.00^b \pm 1.41$	$35.75^c \pm 0.07$
WF	$27.70^a \pm 0.00$	$126.90^a \pm 2.19$	$53.20^a \pm 0.07$	$148.75^a \pm 0.00$

Values are mean ± standard deviation (n=3). Means with same superscript along a column are not significantly different (p>0.05).CPF= cowpea flour, UBF= unripe banana flour, WHF= wheat flour.

Mineral composition of Wheat flour, unripe banana flour and cowpea flour

The mineral composition of the flour is presented in Table 3.There were significant (p<0.05) differences among flours in the mineral composition. Wheat flour had the highest in sodium (27.70 mg/100g), calcium (126.90 mg/100g), magnesium (53.20 mg/100g) and phosphorus (148.75 mg/kg) contents, while cowpea flour had the least values for sodium, calcium and magnesium. The unripe banana flour had the lowest phosphorus content. The results of this study were similar to those reported by Sunmonu et al. (2018) for cowpea and wheat flours.

Table 4: Proximate composition and energy content of noodles produced from wheat, cowpea and unripe banana flour blends

Noodle	Moisture (%)	Ash (%)	Crude fibre (%)	Fat (%)	Protein (%)	Carbohydrate (%)	Energy (kcal/100g)
N_1	$9.15^e \pm 0.07$	$1.70^b \pm 0.00$	$0.89^e \pm 0.01$	$13.19^c \pm 0.01$	$23.49^e \pm 0.06$	$51.60^a \pm 0.06$	$419.07^b \pm 0.31$
N_2	$8.77^d \pm 0.04$	$1.73^b \pm 0.04$	$0.98^d \pm 0.00$	$13.65^b \pm 0.07$	$24.58^d \pm 0.06$	$50.29^b \pm 0.07$	$422.33^a \pm 0.75$
N_3	$11.05^b \pm 0.07$	$1.80^a \pm 0.00$	$1.05^c \pm 0.01$	$13.92^a \pm 0.03$	$26.12^c \pm 0.00$	$46.06^d \pm 0.06$	$414.00^c \pm 0.33$
N_4	$10.08^c \pm 0.11$	$1.03^c \pm 0.03$	$1.11^b \pm 0.01$	$14.05^a \pm 0.07$	$26.71^b \pm 0.03$	$46.95^c \pm 0.00$	$421.00^a \pm 0.12$
N_5	$11.25^a \pm 0.07$	$1.07^c \pm 0.04$	$1.17^a \pm 0.01$	$7.47^d \pm 0.09$	$28.97^a \pm 0.06$	$50.07^b \pm 0.18$	$383.39^d \pm 0.12$

Values are mean± standard deviation of triplicate determinations. Means with same superscript within a column are not significantly (p<0.05) different. N_1 = 100% wheat flour noodle; N_2 = 80% wheat flour + 10% cowpea flour + 10% unripe banana flour noodle; N_3 = 70% wheat flour + 20% cowpea flour + 10% unripe banana flour noodle; N_4 = 60% wheat flour + 30% cowpea flour + 10% unripe banana flour noodle; N_5 = 50% wheat flour + 40% cowpea flour + 10% unripe banana flour noodle.

Proximate composition of the noodles

Table 4 shows the proximate composition of noodles produced from wheat, cowpea and unripe banana flour blends. The moisture contents of the noodles ranged from 8.77% in sample N_2 (containing 10 % cowpea flour) to 11.25% in sample N_5 (containing 40% cowpea flour). Moisture content of noodles showed significant (p<0.05) differences. Moisture contents of the noodles (except for sample N_5) were below the 10 -11% moisture level recommended for safe keeping of dried pasta and macaroni (USDA, 2012). The moisture contents of noodles were within the range of 8.03 -10.10% reported for wheat/ orange fleshed sweet potato (Sunmonu et al., 2018), but lower than 11.53-12.40% for wheat/orange fleshed sweet potato/ African bean yam flour noodles reported by Effiong et al. (2018). The low moisture content of the noodles is preferable as it will extend the shelf life of the products. Generally, the shelf life of noodle is dependent on its moisture content because of microbial activities in the product which result in spoilage (Sunmonu et al., 2018; Okereke *et al.,* 2022).

The ash contents of the noodles ranged from 1.03% to 1.80%. The sample N_3 containing 30% cowpea flour had the highest value (1.80%), while sample N_4 containing 40% cowpea flour had the least value (1.03%) but showed no significant (p>0.05) difference from sample N_5 containing 50 % cowpea flour. The ash content increased with the level of cowpea flour in N_2 and N_3 noodles; but decreased in N_4 and N_5 noodles. Ash content of a food sample is an index of the mineral elements of such food (Okereke et al., 2021). This indicates that the noodles formulated from composite flours would contribute more mineral elements to the product than 100% wheat flour noodle (N_1). This result was in agreement with that of Chude et al. (2018) who reported an increase in ash content of wheat noodles on substitution with fermented Bambara groundnut flour (1.80-3.08%).

The crude fibre contents of the noodles ranged from 0.89 to 1.17%. Noodles produced from 100% wheat flour had the least value while sample N_5 had the highest fibre content. The crude fibre contents of the noodles increased with the level of addition of cowpea flour. Crude fibre contents of the noodles were lower than 8.94 - 9.46% reported for noodles fortified with cowpea and pomegranate peel powder (Thorat et al., 2018). However, the values were comparable with the 0.08 - 2.65% for wheat noodles supplemented with nettle leave flour reported by Dagem et al. (2016). Increased dietary fibre consumption could lead to significantly lower risks for obesity, constipation, cardiovascular diseases and colon cancer (Kranz *et al.,* 2012; Okereke et al., 2021). Food products high in dietary fiber are known as low glycemic index foods and have been shown to reduce postprandial blood glucose and insulin response and improve blood glucose and insulin concentration in subjects with diabetes mellitus (Okereke *et al.,* 2021).

The fat contents of the noodles ranged from 7.47 to 14.05 %. The sample N_4 had the highest fat content while sample N_5 had the least. Fat content of sample N_4 was significantly higher ($p < 0.05$) than those of the other samples but was not significantly ($p > 0.05$) different from with sample N_3 containing 30% cowpea flour. There was fat contents increase as the level of cowpea addition increased in the noodles. This could be due to the higher content of fat in cowpea and unripe banana compared to wheat flour. These results were higher than the range of 1.39-3.00% for wheat/cassava noodles reported by Omeire (2014). Chude et al. (2018) also reported increase in fat content with addition of Bambara groundnut to wheat (1.69-6.28%) for noodle production. Fat is essential component of tissues and a veritable source of fat soluble vitamins (A, D, E and K) (Wardlaw, 2004).

Protein content of the noodles ranged from 23.49 % in control sample to 28.97% in sample N_5. The protein content of sample N_5 was significantly higher ($p < 0.05$) than the other noodles. There was increase in protein contents of the noodles on addition of cowpea flour. Comparable results were reported for noodles produced from wheat/orange fleshed sweet potato/African bean yam flour noodles which ranged from 11.67-13.04% (Effiong *et al.,* 2018). Protein content of the noodles in the present study was higher than 5.88-7.79% for trifoliate yam-wheat noodles as reported by Akinoso *et al*. (2016) and 2.63-4.47% for yellow noodles substituted with mango stem pericarp powder (Maridana *et al.,* 2015). This result therefore, indicated that noodles of improved protein content could be produced from substitution of wheat flour with cowpea flour and unripe banana flour. Proteins are important in the body for the production of hormones, enzymes and blood plasma. They are immune boosters and can help in cell division as well as in growth.

The carbohydrate contents of the noodles ranged from 46.06 to 51.60 %. There was significant ($p < 0.05$) difference in the carbohydrate contents of the noodles. The carbohydrate contents of noodles decreased as the supplementation of cowpea flour increased. Wheat is a high carbohydrate food and as the proportions of cowpea flour increased, the carbohydrate content decreased. Similar results were reported by Chude *et al*. (2018) for wheat/Bambara groundnut flour noodles (72.45-53.60%). The carbohydrate contents of the noodles in the present study were lower than 67.90-70.90% reported for wheat/orange-fleshed sweet potato/African yam bean flour noodles (Effiong *et al.*, 2018) and 75.10-77.32% for wheat/Bambara nut/cassava composite flour noodles (James *et al.,* 2017). The low carbohydrate of the composite flour noodles has several benefits, as it aids digestion in the colon and reduces constipation often associated with products from refined wheat flour (Eleuch *et al.*, 2011). The decreased carbohydrate contents of the noodles would also be useful to people who need low carbohydrate foods leading to enhanced health for overweight and obese persons.

The energy contents of the noodles were in the range of 383.39 to 422.33 kcal/100g.The sample N_5 had the lowest energy value compared to the control sample. This could be due to lower amount of carbohydrate in cowpea flour and unripe banana flour relative to wheat flour. This observation was in agreement with the reports by Dagem *et al.* (2016) who reported decrease in energy content of noodles made from nettle leaves and wheat flour blends (351.45-367.38 kcal) as the substitution with nettle leaves increased.

Table 5: Mineral composition (mg/100g) of noodles produced from wheat, cowpea and unripe banana flour blends

Sample	Sodium	Calcium	Magnesium	Phosphorus
N_1	$26.80^d \pm 0.02$	$103.00^a \pm 0.71$	$42.80^a \pm 0.07$	$155.25^b \pm 14.49$
N_2	$33.50^c \pm 0.71$	$89.60^a \pm 0.00$	$37.60^e \pm 0.07$	$110.00^c \pm 0.00$
N_3	$34.80^b \pm 0.11$	$98.40^b \pm 0.14$	$41.20^b \pm 0.07$	$177.50^a \pm 3.54$
N_4	$36.40^a \pm 0.00$	$97.20^c \pm 0.07$	$40.80^c \pm 0.14$	$187.50^a \pm 1.41$
N_5	$25.55^e \pm 0.64$	$92.80^d \pm 0.14$	$38.80^d \pm 0.07$	$58.75^d \pm 0.00$

Values are mean± standard deviation of triplicate determinations. Means with same superscript within a column are not significantly ($p<0.05$) different. N_1 = 100% wheat flour noodle; N_2 = 80% wheat flour + 10% cowpea flour + 10% unripe banana flour noodle; N_3 = 70% wheat flour + 20% cowpea flour + 10% unripe banana flour noodle; N_4 = 60% wheat flour + 30% cowpea flour + 10% unripe banana flour noodle; N_5 = 50% wheat flour + 40% cowpea flour + 10% unripe banana flour noodle.

Mineral composition of the noodles

The mineral contents of the noodles produced from composite flours of wheat, cowpea and unripe banana flours are shown in Table 5. There were significant differences ($p < 0.05$) in the mineral contents of the noodles. This could be attributed to the differences in mineral composition of the different flours used in the composite flour formulation. In the present study, phosphorus and calcium were the most abundant elements in all the noodles produced. Sodium contents varied from 25.55 mg/100g (N_5 noodles) to 36.47 mg/100g (N_4 noodles). There was significant difference ($p < 0.05$) in the sodium contents of all the noodles. Sodium regulates blood pressure and blood volume. The low sodium contents of the noodles produced in the present study make them suitable for use by hypertensive individuals (Inyang et al., 2018). Effiong *et al*. (2018) reported similar values for sodium in noodles produced from wheat and orange flesh sweet potatoes. Calcium contents also varied significantly ($p < 0.05$) among the noodles and ranged from 92.80 to 103.00 mg/100g. Calcium intake is important in blood clotting, muscle contraction, enzyme activation, development and maintenance of bones and teeth (Okereke *et al.*, 2021). Phosphorus contents ranged from 58.75 to 187.50 mg/100g. This value differed significantly ($p < 0.05$) from the values for the other noodles. Phosphorus is a component of nucleic acids which plays an important function in the cellular metabolism of other nutrients such as carbohydrate, fat etc. (Okereke *et al.,* 2021).

Table 6: Colour attributes of noodles produced from wheat, cowpea and unripe banana flour blends

Sample	L^*	a^*	b^*
N_1	$50.66^a±1.12$	$5.63^d±0.37$	$20.49^c±1.44$
N_2	$46.91^b±0.58$	$5.82^d±0.14$	$22.21^b±1.90$
N_3	$46.11^b±0.54$	$6.39^c±0.28$	$22.51^b±0.14$
N_4	$47.48^b±0.27$	$6.53^b±0.42$	$24.39^a±0.98$
N_5	$47.56^b±0.30$	$7.48^a±0.05$	$24.41^a±0.54$

Values are mean± standard deviation of triplicate determinations. Means with same superscript within a column are not significantly ($p<0.05$) different. N_1 = 100% wheat flour noodle; N_2 = 80% wheat flour + 10% cowpea flour + 10% unripe banana flour noodle; N_3 = 70% wheat flour + 20% cowpea flour + 10% unripe banana flour noodle; N_4 = 60% wheat flour + 30% cowpea flour + 10% unripe banana flour noodle; N_5 = 50% wheat flour + 40% cowpea flour + 10% unripe banana flour noodle.

Color attributes of the noodles

The color attributes of noodles produced from wheat, cowpea and unripe banana flour blends are shown in Table 6.There was decrease in whiteness (L*) and increase in redness (a*) and yellowness (b*) of the noodles samples with increased addition of the level of cowpea flour. The color became darker as the level of cowpea flour increased because of the Maillard browning and caramelization reactions between proteins and sugar present, which are influenced by the distribution of water (Makinde and Akinoso, 2014). Color of products is one of the factors that determine the acceptability of products. Previous work by Makinde and Akinoso (2014) had shown that surface color depends both on the physicochemical characteristics of the raw dough (i.e., water content, pH, reducing sugars, and amino acid content) and on the operating conditions applied during baking (i.e., temperature, air speed, relative humidity, and modes of heat transfer). The Maillard or caramelized browns are also found to be a good source of antioxidants (phenols), which have been attributed with good physiological needs in managing diverse chronic diseases. This result was similar to that of Eissa *et al.* (2007), who produced biscuit and bread from wheat flour, un-germinated and germinated mushroom. In the same vein, Makinde and Akinoso (2014) also reported similar result when bread was produced from wheat flour and black sesame flours.

Table 7: Cooking characteristics of noodles produced from wheat, cowpea and unripe banana flour blends

Sample	Cooking time (min)	Cooking loss (%)	Weight increase (%)	Volume increase (%)
N_1	$10.50^a±0.03$	$4.25^e±0.00$	$11.14^e±0.01$	$9.49^a±0.03$
N_2	$8.75^b±0.02$	$4.36^d±0.02$	$18.25^a±0.03$	$8.86^b±0.05$
N_3	$8.25^c±0.03$	$4.77^c±0.03$	$16.82^d±0.03$	$8.54^c±0.00$
N_4	$7.75^d±0.06$	$5.01^b±0.03$	$17.24^c±0.01$	$7.91^e±0.03$
N_5	$7.50^e±0.00$	$5.22^a±0.03$	$18.12^b±0.02$	$8.07^d±0.03$

Values are mean± standard deviation of triplicate determinations. Means with same superscript within a column are not significantly ($p<0.05$) different. N_1 = 100% wheat flour noodle; N_2 = 80% wheat flour + 10% cowpea flour + 10% unripe banana flour noodle; N_3 = 70% wheat flour + 20% cowpea flour + 10% unripe banana flour noodle; N_4 = 60% wheat flour + 30% cowpea flour + 10% unripe banana flour noodle; N_5 = 50% wheat flour + 40% cowpea flour + 10% unripe banana flour noodle.

Cooking characteristics of the noodles

The cooking characteristics of noodles are presented in Table 7. Noodles quality could be estimated from cooking attributes such as cooking time, cooking loss, weight and volume increase. The cooking times of the noodles prepared from various blends were lower than that of control sample. A good quality noodle should have short cooking time with little loss of solids in the cooking water. The noodles prepared from 100% wheat flour (N_1) had highest cooking time (10.50 min) whereas the noodles prepared from 40% cowpea flour (N_5) had the lowest cooking time (7.50 min). Ingredients other than wheat flour such as cowpea and unripe banana flour causes discontinuity in gluten network (Inyang *et al.,* 2018) resulting in faster moisture penetration and therefore leading to lower optimum cooking time. Difference in cooking time of noodles can be attributed to the difference in the gelatinization temperature of the respective flours.

The cooking loss ranged from 4.25 to 5.22%, being the highest for noodles prepared with 40% cowpea flour whereas it was the lowest for noodles prepared with 100% wheat flour. An increase in the cooking loss with the noodle from composite flour might be due to weakening of the protein network in the flour. Cooking loss is an indicator of noodles' resistance to cooking (Yadav *et al.,* 2014), so low levels are preferable. High cooking loss is undesirable because it represents high solubility of starch, resulting in turbid cooking water, low cooking tolerance and sticky mouthfeel (Jin *et al.*, 2014).

The weight increase of noodles sample ranged from 11.14 to 18.25 %. Sample N_2 had the highest weight increase (18.25%), while sample N_1 had the least value (11.14 %). There were significant ($p<0.05$) differences among all noodles samples. The variations in weight increase could be due to the heaviness of each flour making up the noodles and also their affinity for moisture. This result was in accordance to that of Inyang et al. (2018).The volume increase showed highest value in the control noodles sample (N_1) compared to other composite noodles. The values ranged from 7.91 to 9.49%. There were significant ($p<0.05$) difference between all the samples. The volume increase gives an indication of high swelling power of wheat flour compared to other composite flours. Akanbi *et al.* (2011), reported higher volume increase in noodles produced from wheat and bread fruit flour blends.

Table 8: Mean sensory scores of noodles produced from wheat, cowpea and unripe banana flour blends

Noodles	appearance	Flavour	Taste	Mouthfeel	Overall acceptability
N_1	8.35^a±1.14	7.80^b±0.83	8.35^a±0.59	7.75^b±.1.16	8.60^a±0.50
N_2	8.00^b±0.65	8.35^a±0.88	7.90^c±0.72	7.85^b±0.98	8.15^b±1.04
N_3	7.55^c±0.94	7.85^b±0.75	8.10^b±0.91	7.85^b±0.98	8.15^b±0.49
N_4	7.55^c±1.09	7.60^c±0.94	7.40^d±1.05	8.05^a±0.94	7.90^c±0.72
N_5	7.35^c±0.88	7.55^c±0.94	7.80^c±0.77	7.60^b±0.88	7.80^c±0.69

Values are mean± standard deviation of triplicate determinations. Means with same superscript within a column are not significantly ($p<0.05$) different. N_1 = 100% wheat flour noodle; N_2 = 80% wheat flour + 10% cowpea flour + 10% unripe banana flour noodle; N_3 = 70% wheat flour + 20% cowpea flour + 10% unripe banana flour noodle; N_4 = 60% wheat flour + 30% cowpea flour + 10% unripe banana flour noodle; N_5 = 50% wheat flour + 40% cowpea flour + 10% unripe banana flour noodle.

Sensory properties of the noodles

Table 8 shows the mean sensory scores of noodles produced from wheat flour, cowpea flour, and unripe banana flour blends. The score for flavour of the noodles ranged from 7.55 in noodles containing 40% cowpea flour (N_5) to 8.35 in the noodle containing 10% cowpea flour (N_2). Noodles produced from 100% wheat flour (N_1) were highly preferred by the panelists to the other noodles with reference to colour, taste and overall acceptability. This could be as a result of it being produced from whole wheat flour, which consumers are already accustomed to. The noodles that contained high levels of cowpea had low scores for flavour, taste and overall acceptability probably due to the beany flavour, which must have overshadowed the normal flavour and taste of the noodles. However, noodles produced from 100% wheat flour (N_1) were not significantly different ($p < 0.05$) from the noodles from N_2, N_3 and N_5 in terms of mouthfeel but differed significantly ($p<0.05$) from noodles containing 30% cowpea flour (N_4). This result therefore, suggests that acceptable noodles can be produced from the blends of wheat flour, cowpea and unripe banana flours.

Conclusion

Acceptable and highly nutritious noodles were produced from blends of wheat flour, unripe banana flour and cowpea flour. The study showed that the wheat, cowpea and unripe banana flour blends possessed desirable chemical composition for the production of noodles. Cowpea flour could substitute up to 20% of wheat in noodles without affecting the chemical composition and sensory attributes of noodles. The noodles from the flour blends had lower cooking and higher weight increase than the 100% wheat flour noodles. However, the whiteness of the noodles decreased with increase in the amount of cowpea flour in the noodles.

Conflict of interest

Authors have declared that no competing interests exist. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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