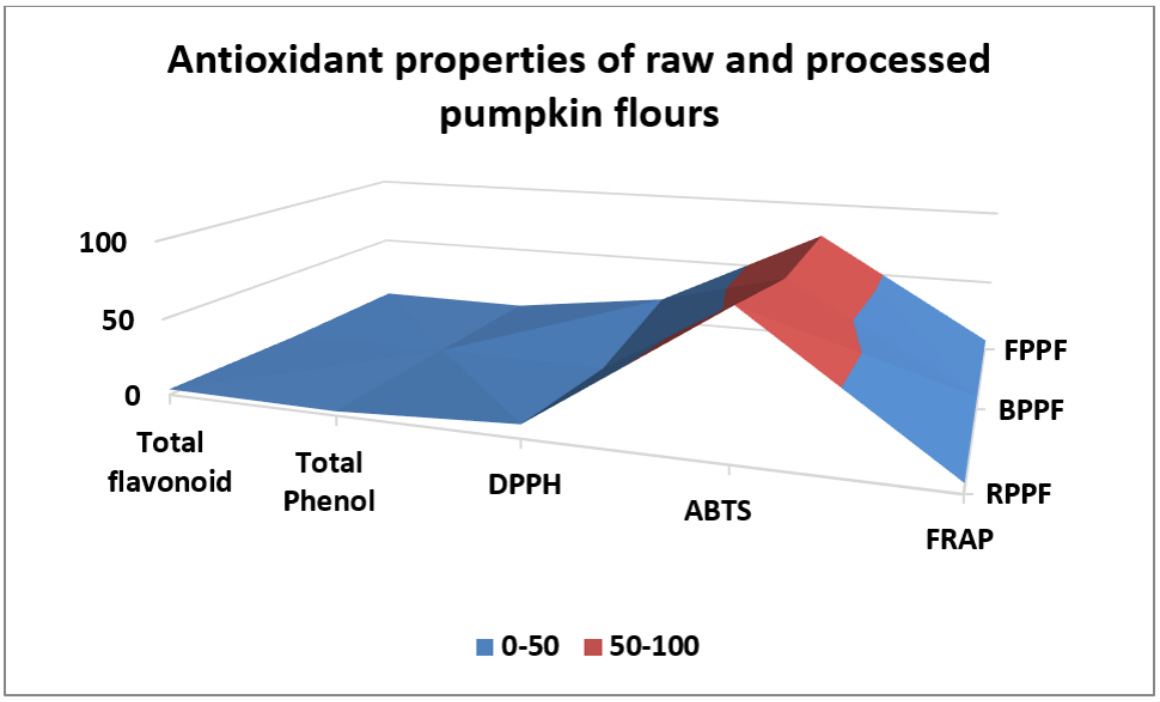
RESEARCH ARTICLE

Physicochemical, nutritional, phytoconstituents, and antioxidant properties of three different processing techniques of pumpkin (*Cucurbita pepo*) pulp flour

R.O. Adelerin, B.O. Ifesan and O.O. Awolu*



Highlights

- Pumpkin (*Cucurbita pepo*) pulp flour subjected to fermentation and boiling for use as gluten-free flours.
- Fermentation and boiling promote the antioxidant properties of the flour.
- Fermentation resulted in flour samples with the least phytonutrients.
- Fermentation improves flour protein contents.

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Physicochemical, nutritional, phytoconstituents, and antioxidant properties of three different processing techniques of pumpkin (*Cucurbita pepo*) pulp flour

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Abstract: This study investigated the effect of boiling and fermentation on the physicochemical, functional, phytoconstituents, and antioxidant properties of pumpkin (*Cucurbita pepo*) pulp flour. The fresh pumpkin pulp obtained was divided into three equal portions for making pumpkin flour and subjected to boiling and fermentation, while the third portion was used as uncooked sample. Fermentation was carried out naturally by soaking the pumpkin pulp in 1:3 (w/v) ratio of water at 25 ℃ for 48 h using a traditional method, while boiling was at 100 ℃ for 20 min. The samples were thereafter oven-dried at 60 ℃ and milled into flour. The fermented sample had the lowest pH and the highest protein content, while the boiled sample had the highest fibre content. Boiled and fermented samples had higher Ca, K, and P contents. The total phenol and FRAP increased by boiling and fermentation. However, the fresh pumpkin sample had the highest total flavonoid content and ABTS ability. The fermented sample recorded the highest DPPH radical scavenging ability and the least phytoconstituents. All the flour samples (uncooked, boiled, and fermented) showed reasonable physicochemical and antioxidant properties while fermented samples had the highest nutritional content, antioxidant properties, and the least phytoconstituents.

***Keywords*:** Antioxidants; *Cucurbita pepo*; fermentation; protein content; pumpkin flour; total phenol.

INTRODUCTION

Food processing techniques such as boiling improve the palatability and nutritional value of food (Nzewi and Egbuonu, 2011), while fermentation improves the biological availability of mineral elements, enhance the amino acid and vitamin contents, and reduces anti-nutrients (McGovern *et al*., 2004). Fermentation has been greatly embraced in the production of many foods and has been considered to be beneficial to human health and nutrition (Kim *et al*., 2012). Pumpkin belongs to the family *Cucurbitaceae* with about 180 genera. The common species are *Cucurbita maxima*, *Cucurbita moschata*, and *Cucurbita pepo* which are annual plants characterized by large and bristle leaves. Pumpkins are readily available in Nigeria. They are locally consumed freshly, cooked, or dried. The seeds are consumed cooked or roasted while the leaves and shoot are made into soups. The pulp can be eaten alone or made into a palatable stew often consumed with yam and potatoes (Zanish *et al*., 2013). Pumpkin fruits pulps are either thick orange or yellow coloured and contained about 90% moisture content (McGinley, 2011). Pumpkins are rich in ß-carotene (a precursor of vitamin A) and acts as an antioxidant that helps prevent oxidative stress, eye disorders, and cancer (Adebayo *et al*., 2013).

Though pumpkin has been appreciated for high yield and good nutritive value yet like most vegetables, it is a perishable crop, and its characteristics change with time. Moreover, the large size and weight cause transportation problems (Mittal *et al*., 2019). Fruits and vegetables, when converted into flour have many benefits and economic potential which include reduction of volume, weight, transportation cost, easier package handling, and longer shelf life (Phisut, 2012). The proximate and organoleptic assessment of pumpkin pulp has been reported (Adebayo *et al*., 2013; Obiakor-Okeke *et al*., 2014). Fermentation has been reported to imoroving the nutritional composition of pumpkin-sorghum flour blends (Ojokoh, 2014).

This evaluates the physicochemical properties, antioxidant activities, and the phytoconstituent of three different preparations of pumpkin flour.

MATERIALS AND METHODS

Sample collection

Mature pumpkins (10 kg) were harvested at 5 months' after germination at Ijero-Ekiti, Nigeria. The fruits were cleaned with tap water to remove dirts and cut into two halves latitudinally. The seeds and the rind were removed and the pulps were sliced into 1-1.5 mm, and divided into three portions for processing, as uncooked, boiled, and fermented samples. A UV-Visible spectrophotometer (Model 6305, Barloworld Scientific) was used for the sphectrophotometric analyses

Preparation of uncooked pumpkin pulp flour

One portion of the sliced pulp (the uncooked samples – 500 g) were manually crushed, oven-dried in a laboratory oven (Gallenkamp) at 60 ℃, milled using a laboratory blender (Century, model: CB-8231-K, AC220-240V50/60Hz800W)

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into a fine flour and sieved through 200 mm mesh sieve (British Standard). It was subsequently stored in an airtight container at 25 ℃ for further studies.

Preparation of boiled pumpkin pulp flour

Five hundred grams of pumpkin pulp was boiled in 500 mL boiling water at 100 ℃ for 20 min. The boiled pulp was strained using a 200 mm mesh sieve (British Standard), allowed to cool, and oven-dried at 60 ℃. The dried sample was milled in a blender (Century, model: CB-8231-K, AC 220-240 V 50/60 Hz 800 W), passed through a sieve with 250 µm to obtain uniform-sized flour, and were packed stored in an airtight container at 25 ℃ for subsequent studies.

Preparation of fermented pumpkin pulp flour

Sliced pulp samples of about 500 g were fermented naturally in a chamber by dispersing the pumpkin pulps into 1500 mL distilled water for 48 h and allowing natural fermenters to act on the samples which were kept in a dark place at 27 ℃. The fermented pulps were strained dried and sieved using a 250 µm mesh sieve. The flour samples later stored in a polythene bag at 25 ℃ for future use.

Analyses of the uncooked, boiled, and fermented pumpkin pulp flour

Determination of physicochemical properties

Total titratable acidity was evaluated by titration of the uncooked, boiled, and fermented pumpkin pulp flour with 0.1 N sodium hydroxide solution using phenolphthalein as an indicator. The pH of the flours was measured using a digital meter calibrated with buffer solution pH 4.0 and 7.0 (AOAC, 2010).

Pasting properties were determined with a Rapid Visco Analyser (Model RVA series 4, Newport Scientific). Flour samples were dissolved in 25 mL water thoroughly mixed in a canister and fitted to the RVA. The analyses was carried out according to the method used by Awolu and Olofinlae (2016).

The water absorption capacity, oil absorption capacity, and bulk density were determined by AOAC (2005) methods, while the foaming capacity and solubility were determined by the method of Coffman and Gracia (1977).

Proximate composition

The moisture content, crude fibre, crude fat, crude protein, and total ash were evaluated using the method of AOAC (2000), protein content was determined using Kjeldahl method while carbohydrate content was calculated by difference.

Determination of mineral composition

Dried samples (2.0 g) were ashed in a crucible, digested using 6 mol dm^{-3} HCl, and filtered in a through a No. 1 Whatman filter paper. Iron and calcium were determined using atomic absorption spectrometer while Na and K were determined using a flame photometer (AOAC, 2005).

Determination of antioxidant properties

Total phenol content determination: Excatly 0.2 mL of the extract was mixed with 0.5 mL of 10% Folin-Ciocalteu reagent and 2.0 mL of 7.5% sodium carbonate. The reaction mixture was subsequently incubated at 45 ℃ for 40 min and the absorbance was measured at 700 nm using a UV-Visible spectrophotometer (Model 6305, Barloworld Scientific). Gallic acid (Sigma Aldrich) was used as the standard phenol (Singleton *et al*., 1999).

The DPPH (1,1- diphenyl-2-picryhydrazyl) was determined using the method of Gyamfi *et al*. (1999). The extract (1.0 mL) was mixed with 1.0 mL of the 0.4 mmol dm^{-3} methanolic (0.006 g in 50 mL of methanol) solution of the DPPH. The mixture was left in the dark for 30 min for colour change and the absorbance measured spectrophotometrically at 516 nm.

The ferric reducing antioxidant property of the sample was determined by the method of Pulido *et al*. (2000). A 0.25 mL of the extract was mixed with 0.25 mL of 200 mmol dm^{-3} of sodium phosphate buffer pH 6.6 and 0.25 mL of 1% KFC. The mixture was incubated at 50 ℃ for 20 min, while 0.25 mL of 10% TCA was subsequently added and centrifuged at 2000 rpm for 10 min. One millilitre of the supernatant was mixed with 1.0 mL of distilled water and 0.1% of $FeCl_3$ and the absorbance was read at 700 nm.

The 2, 2'-azino-bis (3-ethylbenthiazoline-6-sulphonic acid) (ABTS) scavenging ability of the sample extract was determined by reacting 7 mmol dm^{-3} ABTS aqueous solution with $K_2S_2O_8$ (2.45 mmol dm^{-3}, final conc.) in the dark for 16 h. Excatly 0.2 mL of the extract dilution was then added to 2.0 mL of ABTS solution and the absorbance was read at 732 nm after 15 min (Re *et al*., 1999).

Vitamin C and carotenoid determination

The vitamin C (mg/100g) content was estimated titrimetrically using 2, 6- dichlorophenol dye as described by Ranganna (2010). Total carotenoids were extracted with a hexane-acetone mixture, and the optical density was read with the spectrophotometer between 430 and 450 nm (Blasi *et al*., 2018).

Determination of phytoconstituents

Tannin content was determined photometrically by the method of Harbone (1973). Exactly 0.2 g of finely ground sample was weighed into a 50.0 mL sample bottle and 10.0 mL of 70% aqueous acetone was added and tightly covered. The samples were shaken for 2 h at 30 ℃ in a bath shaker. Each solution was then centrifuged using Lisa refrigerated centrifuge (reference number: AFI-C200R-E, SN:19C200RE1490) at 10,000 rpm for 10 min, and the supernatant stored in ice. Exactly 0.2 mL of each solution was pipetted into the test tube and 0.8 mL of distilled water was added. Exactly 0.5 mL of Folin-ciocateau reagent was added to both the samples and the standard tannin solution followed by 2.5 mL of 20% Na_2CO_3 solution. The mixture was vortexed and incubated for 40 min at 25 ℃.

Its absorbance was read at 760 nm against a reagent blank concentration.

Saponin was spectrophotometric determined (Brunner, 1994) by weighing a finely ground (2.0 g) sample into a 250 mL beaker and 100.0 mL of isobutyl alcohol was added. The mixture was thoroughly mixed for 5 h. The mixture was filtered through a No 1 Whatman filter paper into a 100 mL beaker containing 20.0 mL of 40% saturated solution of magnesium carbonate ($MgCO_3$). The resultant mixture was again filtered through No 1 Whatman filter paper to obtain a clean colourless solution. Exactly 1.0 mL of the solution added to 2.0 mL of 5% Iron (III) chloride ($FeCl_3$) solution and then made up to 50 mL mark with distilled water. It was allowed to stand for 30 min for the colour to develop. The absorbance was read against the blank at 380 nm.

Phytate was determined according to the method of Wheeler and Ferrel (1971), while alkaloid content was determined using the method of Harbone, (1973).

Statistical analysis

The results were presented as means (± SD), and statistical difference between the means was determined using one-way analysis of variance (ANOVA). Duncan's Multiple Range Test (DMRT) was used to separate the means at $p < 0.05$ significant difference (Steel *et al*., 1997). Values were carried out in triplicate. Statistical Package for Social Science (SPSS) version 21 for windows was used for the statistical analyses.

RESULTS AND DISCUSSION

Physicochemical Properties of uncooked, boiled, and fermented pumpkin pulp flour

The effect of processing on the titratable acidity and pH of the samples are presented in Table 1. The boiling and fermentation processes decreased the pH values of fresh pumpkin flour. The pH value affects microbial presence, chemical interactions, and food tastes because food samples with pH ≤ 4.6 do not encourage the growth and formation of toxins from the bacteria. The result shows that fermented flour will have a longer shelf life than boiled and uncooked flour since the pH is lesser than 4.6. pH was lesser than 4.6 has been reported to extend the shelf of food. The titratable acidity of the flours increases significantly ($p \leq 0.05$), fermented flour has the highest TTA of 0.68 g/L, followed by boiled flour, 0.45 g/L. These values can be classified as high-acid food and are less susceptible to yeast or mould spoilage. The changes in pH and TTA can be attributed to organic acid production by fermenting macros (Ojokoh, 2015). Mensah *et al*. (1990) has revealed that High titratable acidity reduces the incidences of diarrhea in infants consuming fermented legumes.

The mean WAC for fermented samples was (3.76 g/g) compared to that of the boiled and uncooked pumpkin pulp flour samples which are 4.22 g/g and 8.26 g/g respectively. Oladipupo and Nwokocha (2011), have reported that protein structure affects flour-water association ability under partial supply of water and these depend on the variation of water absorption capacity. Also, low WAC in the result may be a result of the compactness in the structure of the flour samples and low WAC will require a low quantity of water to form a dough. The result of OAC follows a similar trend as WAC, the oil absorption capacity of the pumpkin flour samples is between 2.27 g/g to 2.48g/g. The reduction in the OAC of the boiled flour may be associated with the high density and large particle size of the flour as reported by Fawale *et al*. (2017).

The swelling capacity also showed significant ($p \leq 0.05$) differences in the uncooked, boiled, and fermented flours. Swelling capacity is proportional to the water absorption capacity of the starch or flour products (Agbemafle, 2019).

The foaming capacity of the fermented flour significant ($p \leq 0.05$) (about a 30% increase), while there was a 66.6% decrease in that of the boiled sample. Native proteins result in high foaming capacity (Akubor *et al*., 1999). Boiling reduces the foaming capacity of pumpkin flour because protein structure is denatured irreversibly by heat treatment.

Table 1: Physicochemical Properties of uncooked, boiled, and fermented pumpkin pulp flour.

Parameters	RPPF	BPPF	FPPF
pH	5.54±0.01^a	5.42±0.01^b	3.28±0.03^c
Titratable acidity (g/L)	0.34±0.03^c	0.45±0.03^b	0.62±0.02^a
Oil Absoption Capacity (g/g)	2.48±0.01^a	2.27±0.02^b	2.28±0.02^b
WaterAbsorption Capacity (g/g)	8.26±7.01^a	4.22±3.03^b	3.76±1.02^c
Foaming Capacity (%)	6.00±0.02^b	2.00±0.02^c	8.00±0.01^a
Bulk Density (g/cm^3)	0.72±0.01^b	0.88±0.02^a	0.75±0.01^b
Swelling Capacity (%)	88.00±5.03^a	52.83±2.03^b	42.62±2.01^c
Solubility Index (%)	11.44±0.03^c	21.88±0.09^a	15.44±0.04^b

Mean ± (SD). Values with the same superscript along the same column are not significantly different ($p < 0.05$).
Key: RPPF: Uncooked Pumpkin pulp Flour; BPPF: Boiled Pumpkin pulp Flour; FPPF: Fermented Pumpkin pulp Flour.

The solubility index of uncooked, boiled, and fermented flour significantly ($p \leq 0.05$) differs; the boiled flour had the highest value of 21.44%, followed by fermented flour 15.44%.

Bulk density for the uncooked, boiled and fermented flours were 0.72 g/mL. 0.88 g/mL, and 0.75 g/ mL respectively. Bulk density evaluates the heaviness of flour samples and is essential in packaging conditions and material handling in the food industry (Adebowale *et al*., 2012). The results are in agreement with the report of Kasaye *et al*. (2018).

Pasting properties of uncooked, boiled, and fermented pumpkin pulp flour

The pasting properties of the uncooked, boiled, and fermented pumpkin pulp flour are presented in Table 2. Pasting properties indicates the changes that occur to flours during the application of heat in the presence of water. In all, the uncooked samples had the highest pasting characteristics while the fermented samples had the least. The peak viscosity indicates the ability of the starch to freely swell prior to breakdown. The lower value of final viscosity is indicative that fermented pumpkin pulp flour did not easily form a viscous paste. Low setback value indicates a tendency for retrogradation during the cooling of flour (Awolu *et al*., 2015). No pasting temperature was observed in the processed flours while the temperature of the uncooked flour was 50.40 ℃. There were significant differences in the peak time of the flour samples. The pasting temperature suggests the least temperature required to cook or gelatinize the flour while peak time determines the cooking time.

Proximate compositions of uncooked, boiled, and fermented pumpkin pulp flour

The proximate compositions of uncooked, boiled, and fermented pumpkin pulp flour are presented in Table 3. The moisture content of the uncooked, boiled, and fermented flour were 7.46%, 8.63%, and 8.62% respectively. There was a significant ($p \leq 0.05$) increase in the water content of the boiled and fermented flours. However, the values were lower than 10%, meaning they would not promote microbial growth and are hence relatively shelf-stable (Adebowale *et al*., 2012; Awolu *et al*., 2017).

The fat contents in the uncooked, boiled, and fermented flour were 3.35%, 2.51%, and 3.93% respectively. There was a significant ($p \leq 0.05$) difference in the fat contents of pumpkin flours. Low-fat values resulted from the breakdown of complex compounds into a simple form and thus could increase the shelf life in the flour samples (Ifesan and Olagunju, 2013).

The protein content was significantly ($p \leq 0.05$) higher in the fermented flour sample (11.49%). This increase was a result of metabolic activities of microorganisms during fermentation which resulted in higher protein content. Awolu *et al.* (2017) also reported an increase in the protein content of fermented kidney beans. The low protein content of boiled pumpkin flour was reported as a result of

Table 2: Physicochemical Properties of uncooked, boiled, and fermented pumpkin pulp flour.

Parameters	RPPF	BPPF	FPPF
Peak viscosity (RVU)	3652.00±3.05^{a}	95.00±0.02^{b}	59.00±0.02^{c}
Trough (RVU)	3091.00±3.01^{a}	85.00±3.01^{a}	57.00±0.02^{c}
Breakdown (RVU)	561.00±1.02^{a}	10.00±0.02^{b}	2.00±0.02^{b}
Final viscosity (RVU)	4855.00±4.01^{a}	164.00±0.02^{b}	74.00±0.01^{c}
Setback (RVU)	1764.00±1.03^{a}	79.00±2.03^{b}	17.00±2.01^{c}
Peak time (Min)	6.93^{b}	7.00^{a}	6.93^{b}
Pasting Temp (℃)	50.40^{a}	0.00^{b}	0.00^{b}

Mean ± (SD). Values with the same superscript along the same column are not significantly different ($p < 0.05$).

Key: RPPF: Uncooked Pumpkin pulp Flour; BPPF: Boiled Pumpkin pulp Flour; FPPF: Fermented Pumpkin pulp Flour.

Table 3: Proximate composition (%) of uncooked, boiled, and fermented pumpkin pulp flour.

Samples	Moisture (%)	Ash (%)	Crude protein (%)	Crude fat (%)	Crude fiber (%)	Carbohydrate (%)
RPPF	7.46±0.03^{b}	10.12±0.0^{a}	9.42±0.02 ^{b}	3.35±0.04^{b}	8.52±0.03^{c}	62.12±0.04^{a}
BPPF	8.63±0.04^{a}	7.94±0.07^{c}	9.29±0.02a^{b}	2.51±0.02^{c}	13.22±0.03^{a}	57.97±0.06^{b}
FPPF	8.62±0.03^{a}	8.04±0.03^{b}	11.49±0.01^{a}	3.93±0.01^{a}	10.88±0.01^{b}	57.03±0.02^{c}

Mean ± SD. Values with the same superscript along the same column are not significantly different ($p < 0.05$).

Key: RPPF: Uncooked Pumpkin pulp Flour; BPPF: Boiled Pumpkin pulp Flour; FPPF: Fermented Pumpkin pulp Flour.

leaching (Kasaye *et al*., 2018), for boiled yam and cassava flour. Fermentation improves the nutritional quality of food products especially protein content (Ojokoh *et al.,* 2013; Awolu *et al.*, 2017).

There was a reduction in the carbohydrate level of boiled and fermented flour. Microbial activities require energy and nutrient during fermentation leading to a decrease in carbohydrate content (Simwaka, 2017).

The values of the ash content were 10.12%, 7.94%, and 8.04% for uncooked, boiled, and fermented flour respectively; a slight reduction was observed in the fermented sample. Boiled pumpkin flour had the highest crude fiber (13.22%), and followed by fermented flour (10.88%). This result indicated that processing improved the fiber content of pumpkin pulp flours.

Minerals composition of uncooked, boiled, and fermented pumpkin pulp flour

The minerals compositions of uncooked, boiled, and fermented pumpkin pulp flour are presented in Table 4. There was a significant increase in the value of K, Na, and Ca in the boiled and fermented samples. However, fermentation improved the Fe content of the flour samples. Processing increases the bioavailability of micronutrients and increases protein digestibility. Reduction in the Fe value of boiled flour may be attributed to leaching (Saharan *et al*., 2001). There were significant ($p < 0.05$) differences observed in the potassium contents of the uncooked, boiled, and fermented flours. A high intake of potassium has a beneficial effect on sodium intake. The Na/K ratio was < 1, which revealed that a low sodium diet with high potassium would be recommended for patients with high blood pressure (Morrissey *et al*., 2020). The flours are a good source of calcium and phosphorus which are considered as a good source for bone and teeth development. Pumpkin pulp flour can be recommended in the diet of people who are hypertensive.

Antioxidant activities of uncooked, boiled, and fermented pumpkin pulp flour

The results of the antioxidant activities of the uncooked, boiled, and fermented flours are presented in Table 5. The total flavonoid contents of the fresh sample were significantly ($p \leq 0.05$) reduced by the processing method (boiling and fermentation) employed, there was a significant ($p \leq 0.05$) increase in the total phenolic contents as a result of the processing technique. Total phenol and total flavonoid contents have been classified as measurements of antioxidants ability of food samples (Okwu, 2004) because they are able to stabilize radical intermediates leading to the prevention of foods from oxidation processes (Maillard *et al*., 1996).

Fermentation significantly ($p \leq 0.05$) increased the DPPH radical scavenging ability while boiling reduced the DPPH. Also, while processing reduced the ABTS scavenging ability of the uncooked flour samples, the processing techniques significantly ($p \leq 0.05$) increased the ferric reducing properties. Specifically, ABTS scavenging ability compounds act by inhibiting lipid peroxidation.

Fermentation significantly increased (($p \leq 0.05$) the carotenoid and Vitamin A content while boiling significantly reduced ($p \leq 0.05$) them. Carotenoids are precursors for vitamin A and lack of vitamin A can result in blindness, the reduction in carotenoid content observed in the boiled flour could be as a result of thermal processing (Azizah *et al*., 2009).

The effect of total carotenoid and vitamins is shown in Figure 1. The processing techniques significantly ($p \leq 0.05$) reduced the vitamin C contents because

Table 4: Mineral composition of processed flours (mg/100g) of uncooked, boiled, and fermented pumpkin pulp flour.

Samples	Potassium	Calcium	Sodium	Iron	Phosphorus	Ca/P
RPPF	150.05±0.01^{c}	101.96±0.01^{c}	45.00±0.02^{c}	0.76±0.01^{b}	6.18±0.03^{a}	16.49
BPPF	160.50±0.01^{b}	210.96±0.03^{a}	52.02±0.03^{b}	0.74±0.02^{b}	6.01±0.03^{ab}	35.10
FPPF	169.75±0.02^{a}	209.96±0.02^{b}	57.04±0.01^{a}	0.85±0.01^{a}	5.96±0.01^{b}	35.23

Mean ± SD. Values with the same superscript along the same column are not significantly different ($p \leq 0.05$).
Key: RPPF: Uncooked Pumpkin pulp Flour; BPPF: Boiled Pumpkin pulp Flour; FPPF: Fermented Pumpkin pulp Flour.

Table 5: Antioxidant activities of uncooked, boiled, and fermented pumpkin pulp flour.

Samples	Total flavonoid (mg QE g-1)	Total Phenol (mg/g)	DPPH (mg/mL)	ABTS (mMol/g)	FRAP (mg/g)
RPPF	3.69±0.21^{a}	2.72±0.25^{c}	8.80±0.56^{b}	89.24±0.74^{a}	6.03±0.27^{c}
BPPF	2.25±0.18^{c}	2.93±0.08^{a}	1.46±0.84^{c}	73.66±2.05^{c}	8.21±0.32^{a}
FPPF	3.63±0.11^{ab}	2.84±0.27^{b}	18.04±0.17^{a}	76.50±0.78^{b}	6.95±0.02^{b}

Mean ± (SD). Values with the same superscript along the same column are not significantly different ($p < 0.05$).
Key: RPPF: Uncooked Pumpkin pulp Flour; BPPF: Boiled Pumpkin pulp Flour; FPPF: Fermented Pumpkin pulp Flour.

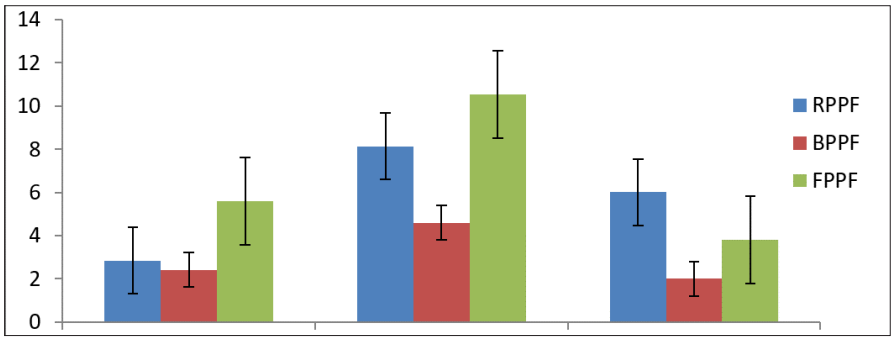

Figure 1: Antioxidants properties (total carotenoid and vitamins A and C (mg/100 mL)) contents of the uncooked and processed flours. Bars are mean values.
Key: RPPF: Uncooked Pumpkin pulp Flour; BPPF: Boiled Pumpkin pulp Flour; FPPF: Fermented Pumpkin pulp Flour.

Table 6: Phytoconstituents of uncooked, boiled, and fermented pumpkin pulp flour.

Sample	Tannin (mg/g)	Saponin (mg/g)	Phytate (mg/g)	Alkaloid (%)
RPPF	1.55±0.13^{b}	40.30±0.53^{c}	14.72±0.13^{a}	18.52±0.08^{b}
BPPF	1.58±0.04^{a}	84.85±1.05^{a}	12.42±0.09^{b}	28.55±0.49^{a}
FPPF	0.95±0.19^{c}	46.06±2.28^{b}	10.6 8±0.09^{c}	8.16±0.12^{c}

Mean ± (SD). Values with the same superscript along the same column are not significantly.
Key: RPPF: Uncooked Pumpkin pulp Flour; BPPF: Boiled Pumpkin pulp Flour; FPPF: Fermented Pumpkin pulp Flour.

vitamin C is a water-soluble vitamin that might have been lost in the water during processing. Ascorbic acid acts as an antioxidant as well as helping with iron absorption, essential in boosting the body's immune system. The vitamin C contents of the samples were however sufficient for the daily recommended dietary intake.

Phytoconstituents content of uncooked, boiled, and fermented pumpkin pulp flour

The phytoconstituent content of pumpkin pulp flour samples as presented in Table 6 indicated that fermentation reduces phytoconstituent contents. Boiling, however, increased the phytoconstituent contents. Phytoconstituent have been reported to interfere with the digestion, absorption, and nutrient bioavailability of foods (Ifesan and Olagunju, 2013). The enzyme tannase produced by lactobacillus during fermentation has shown to be responsible for the breakdown of tannin complexes, and thereby increase protein digestibility. However, fermentation had a limited effect on the saponin content of the pumpkin flour. Fermentation has been reported to generally decrease phytonutrient contents due to the secretion of some enzymes and activities of microflora (Achinewhu and Ischei, 1990).

CONCLUSION

The research revealed that fermentation positively impacted the physicochemical properties of the pumpkin flour such as the protein, fibre, total carotenoid, vitamins, and mineral contents. However, boiling improved the crude fibre content. The samples were all shelf-stable irrespective of the processing technique as seen in the pH value. In addition, fermentation also reduced the phytoconstituent contents in the samples.

DECLARATION OF CONFLICT OF INTEREST

The authors declare no competing interests.

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