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Effect of fermentation on the physicochemical properties, pasting profile and sensory scores of normal endosperm maize and quality protein maize flours

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Abstract

The aim of this study is to compare the effect of fermentation on the physicochemical properties, pasting profile and sensory scores of flour produced from normal endosperm maize variety and quality protein maize. Two maize varieties were studied; a yellow coloured quality protein maize (QPM) - TZE-YPOP-DT-STR-QPM in comparison with yellow coloured normal maize - SUWAN-ISR. Proximate compositions, mineral element content, some physicochemical properties and particle size analysis of the flour were determined. The pasting profiles as well as sensory scores of the flour samples were determined. The result shows that fermentation significantly ($p \leq 0.05$) reduced the protein content of both flour samples though more pronounced in normal maize flour; (7.90 to 6.00%) and (8.40 to 7.15%) for normal maize and QPM, respectively. Iron and zinc contents are high ranging from 4.78 to 68.14 mg/100g and 0.08 to 3.95 mg/100g, respectively. Fermentation reduced the bulk density of both normal maize flour and QPM flour. Yet, FQPM flour had the higher bulk density (0.49 g/ml). Mean particle size of the flour was improved by fermentation as FNM and FQPM were found to have smaller particle size than the unfermented counterparts. The peak viscosity of unfermented flour 58.00 and 45.50 RVU for UFNM and UFQPM are lower than the fermented samples; 197.33 and 135.08 RVU. The sensory attributes and overall acceptability of fermented samples were significantly better than that of unfermented samples at $p \leq 0.05$. FQPM is most preferred of all the samples. It can be concluded that fermentation improved the pasting profile and some physicochemical properties desirable in the production of weaning food. Also, the reduction effect of fermentation on some nutrient content of maize is more pronounced in normal endosperm than quality protein maize.

Introduction

Fermentation is one of the household food technologies reviewed extensively as means by which the nutritive value of plant foods could be improved (Obadina *et al*., 2008). Food samples such as maize, sorghum, millet, rice can be fermented to increase the nutrient content, carbohydrate digestibility, and energy densities of gruels, increase the bio-availability of amino acids and also improve their shelf life under controlled environment (WHO, 1998). Little wonder, the WHO food safety unit has given high priority to the research area of fermentation as a technique for preparation/storage of food (Sahlin, 1999). Apart from the preservative effect of fermentation, in the production of fermented foods, microorganisms play a vital and essential role contributing to the improvement of the physiochemical, sensory and safety characteristics of the final products (Cocolin and Ercolini, 2008).

Quality protein maize (QPM) has demonstrated superiority in protein quality and digestibility over the normal endosperm (Bressani, 1990). It was reported that QPM contains nearly twice as much usable protein as other maize (or corn) grown in the tropics and yields 10% more grain than traditional varieties of maize. QPM offers 90% the nutritional value of skim milk, the standard for adequate nutrition value. The percentage of lysine content in QPM varied between 0.33 and 0.54% with an average of 0.38. This was 46% higher than normal maize, and QPM contained 66 percent more tryptophan (0.08%) than normal maize. These two amino acids (lysine and tryptophan) allow the body to manufacture complete proteins (Palit and Suresh, 2003). Besides, the biological value of normal maize protein is 40%, while that of QPM protein is 80%. Only 37% of the common maize protein intake is utilized in monogastric animals compared to 74% of the same amount of QPM protein (Lopes and Larkins, 1991).

According to Potter and Hotchkiss (1995), fermentation can reduce the high bulk of the traditional complementary foods by reducing the viscosity of the cereal gruel or porridge. Fermentation improved

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the amino acid composition and vitamin content, increase protein and starch digestibility, increases the bioavailability of minerals, lower anti-nutrients level, reduced the level of contamination and extends the shelf-life of the food product (Simango, 1997; Wambugu *et al.*, 2006). An improvement in protein content, calcium and water absorption capacity of cereal product over the unfermented sample was established by Adhikari *et al*. (2013). Also, fermentation was earlier reported to have significant effects on the physico-chemical properties of ogi - a fermented maize gruel (Oladeji *et al.*, 2014). QPM was reported to have the potential of been transformed into edible product without any deterioration in its quality and acceptability (Gupta *et al*, 2009).

Scanty research reports are available on the effect of fermentation on the physicochemical properties and sensory characteristics of QPM. Therefore, this study was geared towards evaluating the effect of fermentation on the physicochemical properties, pasting profile and sensory characteristics of normal endosperm and quality protein maize flours.

Materials and Methods

Collection of materials

Two samples of maize varieties were studied; a yellow coloured QPM variety was studied in comparison with yellow coloured normal maize variety. The QPM variety: TZE-YPOP-DT-STR-QPM was obtained from IITA, Ibadan while the normal maize; SUWAN-ISR was obtained from IAR and T, Ibadan. Intact whole seeds were picked manually and stored at refrigeration temperature for further investigations.

Samples preparation

The maize samples were sorted to ensure wholesomeness. Each variety of the sorted grains were divided into two; a batch was fermented whole following the method of Oladeji *et al*.(2014) for traditional preparation of ogi. The maize obtained was washed and steeped in clean boiled water in a plastic container with cover. The water was decanted after three days (96 hrs) and the maize wet milled into slurry. The slurry was sieved using muslin cloth, which separated the pomace from the filtrate. The slurry was filtered and oven dried at 50^{o}C for 12 hrs. The dried ogi cake was fine milled to flour. The method of Oladeji (2014) was used to prepare the other batch. The grains was sorted, sprinkled with water and allowed to stand for about thirty minutes under ambient temperature to soften the coat. It was then transferred into a locally fabricated decorticating machine which separated the germ and the coat mechanically. The machine is provided with two separate receivers, one for the endosperm and the other for the mixture of germ and seed coat. The clean endosperm was milled into flour using attrition mill. The flour was packaged in cellophane pack prior to analysis.

Proximate composition

The flour samples were analysed for moisture content, crude fat, crude protein, total ash content and crude fibre according to the method of analysis of the Association of Official Analytical Chemists while carbohydrate content of the samples was determined by difference (AOAC, 2000).

Mineral content analysis

The analyses for essential minerals were carried out by Atomic Absorption Spectrophotometric method. The sample was digested as follows; 0.5 g was weighed into 75 ml digestion flask and 5 ml digestion mixture was added and left overnight in a hood. It was then digested for 2 h at 150°C, then left to cool for 10 minutes. To the sample, 3 ml of 6 M hydrochloric acid was added and digested for another one and half-hours. It was cooled and 30 ml of distilled water added. The mixture was vigorously stirred. A sample of digest was used to determine some elements (calcium, magnesium, manganese, copper, iron and zinc) on the Atomic Absorption Spectrophotometer (Perkin Elmer, model 402) while sodium and potassium were determined by flame photometry.

Physicochemical and functional properties

The particle size distribution of flour samples were carried out using a sieve analysis technique with the aid of Endecotts Test Sieve Shaker (SN 9229, Endecott Lt, England). Flour dispersibility was measured using the method of Punita (2006). The pH was measured using standard method AOAC, (2002) with a Hanna checker pH meter (Model HI 1270) after calibrating the pH meter with buffer 4 and 7. Bulk density was determined according to the method of Okezie and Bello (1988). While swelling power and solubility were determined on the samples at 60, 70, 80 and 90^{o}C for 30 mins each using a modified version of the method of Sathe and Salunkhe (1981). Briefly, 40 ml of 1% flour suspension (w/v) was prepared in a previously tarred 50 ml centrifuge tube. The tube was slowly shaken to keep the flour agitated and the temperature (60, 70, 80 and 90^{o}C) maintained constantly in water bath for 30 mins. The suspension was then centrifuged at 3500 × g for 20 mins, the

Table 1. Yield, proximate and mineral composition of the flours

Samples	UFNM	UFQPM	FNM	FQPM
% Yield	72.23	74.08	82.8	87.7
Protein	7.90 ± 0.10^b	8.40 ± 0.08^a	6.00 ± 0.01^d	7.15 ± 0.04^c
Moisture	4.95 ± 0.41^a	4.52 ± 0.06^b	3.35 ± 0.02^c	3.07 ± 0.05^c
Fat	3.72 ± 0.21^b	4.80 ± 0.67^a	3.55 ± 0.48^b	3.95 ± 0.04^b
Ash	1.39 ± 0.25^b	1.83 ± 0.06^a	0.95 ± 0.10^c	1.33 ± 0.15^b
Crude Fibre	1.77 ± 0.25^a	1.53 ± 0.06^a	0.90 ± 0.10^b	0.83 ± 0.10^b
Carbohydrate	79.27 ± 0.22^b	78.8 ± 0.25^b	83.85 ± 0.21^a	83.17 ± 0.25^a
Magnesium	0.99^b	1.09^a	0.24^c	0.24^b
Sodium	1.38^b	8.29^a	0.42^c	0.36^b
Potassium	57.50^a	28.33^b	8.33^d	22.50^b
Calcium	29.33^b	37.50^a	12.42^c	15.00^b
Iron	45.22^b	68.14^a	32.73^c	25.42^c
Copper	0.14^b	0.16^a	0.15^{ab}	0.12^b
Magnesium	0.22^b	0.45^a	0.15^c	0.13^b
Zinc	0.77^c	0.46^c	2.13^b	2.98^a

Values are mean of triplicate samples. Values with different superscript(s) along the roll are significantly different ($p \leq 0.05$)
Key UFNM-Unfermented decorticated normal maize, UFQPM-Unfermented decorticated quality protein maize, FNM-Fermented normal maize, FQPM- Fermented quality protein Maize

supernatant was then decanted and the swollen granules weighed. From the supernatant, 10 ml was dried in an air oven at 80°C for 4 hours in a crucible to constant weight. Swelling power is expressed as the weight of swollen granules (final weight) divided by the initial weight. Percentage solubility was calculated. The reconstitution index was estimated by the method of Akpapunam and Markakis (1981).

Pasting profile the flour samples

The pasting properties were measured using a Rapid Visco Analyser (Newport Scientific Australia). Flour samples (2.5 g) each are weighed into a dried empty canister; 25 ml of distilled water was dispensed into the canister containing the sample. The solution was thoroughly mixed and the canister was well fitted into the RVA, as recommended. The slurry was heated from 50 to 95°C with a holding time of 2 mins followed by cooling to 50°C with 2 mins holding time. The rate of heating and cooling were at constant rate of 11.25°C/min. Peak viscosity, trough, breakdown, final viscosity, set back, peak time and pasting temperature were read from the pasting profile with the aid of Thermocline for Windows Software connected to a computer.

Sensory evaluation

Consumer acceptability test of the product was carried out by using sensory evaluation process as described by Larmond (1982). Test was performed on all the samples. A twenty member untrained panelist consisting of lecturers, technologist and students of Food Science and Technology Department of Obafemi Awolowo University, Ile-Ife, Nigeria were engaged to evaluate the sensory characteristic of the products. The products was prepared (3:10 wt/vol. for flour and water) under the same condition of temperature, using the same volume of water, coded and rated for colour, taste, aroma, consistency, thickness and overall acceptability. Samples were evaluated for all sensory attributes on a 9- point Hedonic scale which was quantified from one for like extremely to nine dislike extremely.

Results and Discussion

Percentage yield and nutritional composition of flour sampless

Generally, QPM variety yields in different treatments were found to be higher than their normal maize counterparts (Table 1). The percentage yield for unfermented whole QPM (74.08%) was higher than 72.23% obtained for normal maize variety. Also, flour yield of fermented whole QPM (87.70%) was higher than that of Suwan-ISR (82.80%). The high yield reported for QPM variety agreed with several studies; Lopes and Larkins (1991) reported that QPM yields 10% more grain than traditional varieties of maize. Also, Cordova *et al*. (2000) observed that QPM, though similar in grain texture and colour with normal endosperm but has higher yield. The higher yield recorded for QPM products may be attributed to reduce level of shaft in its kernel which was shown in its higher bulk density (Table 2).

Proximate composition of the flour samples

The proximate composition of the flour samples (Table 1) showed that the moisture content of

Table 2. Physico-chemical properties and particle size of the flour samples

Samples	UFNM	UFQPM	FNM	FQPM
Physicochemical Characteristic				
pH	5.86±0.1^{b}	6.03±0.1^{a}	3.47±0.1^{d}	3.67±0.1^{c}
Bulk Density	0.57±0.02^{b}	0.62±0.01^{a}	0.44±0.02^{d}	0.49±0.01^{c}
Flour Dispersibility	72.5±0.3^{b}	74.8±0.6^{a}	69.5±0.5^{c}	72.2±0.3^{b}
Reconstitution index	68.3±1.5^{d}	81.0±1^{c}	90.3±0.6^{a}	88.3±0.6^{b}
Particle Size				
150 μm	21.87	10.74	1.56	1.68
315 μm	34.11	30.84	4.7	2.92
630 μm	40.69	56.74	93.74	93.62
63 m	3.33	1.86	-	-

Values reported are means± standard deviation. Mean values with different superscript(s) along the same roll are significantly different (p≤0.05)
Key UFNM-Unfermented decorticated normal maize, UFQPM-Unfermented decorticated quality protein maize, FNM-Fermented normal maize, FQPM- Fermented quality protein Maize

unfermented normal maize flour (4.95%) was significantly higher than that of unfermented QPM flour (4.52%). The same trend was followed by the moisture contents of their fermented samples (Table 1). In both varieties, fermented flour sample has lower moisture content compared to their unfermented counterparts. The range of moisture content (3.07 to 5.11%) obtained was lower than 11.7 to 12.7% reported for Baobas ogi (Adejuyitan, *et al*., 2012) and 8.24 and 11.60% reported for pawpaw fortified sorghum-ogi by Ajanaku *et al.* (2010). The level of the crude protein contents ranged from 6.00 to 8.40% (Table 1). Significant difference existed in the crude protein content of unfermented decorticated normal maize and QPM flours (p≤0.05) with unfermented decorticated QPM flour having the highest value (8.40%). Fermentation reduced significantly at 95% confidence limit, the protein content of flour produced from both varieties. This may be due to leaching of protein into the fermenting water and/or action of degrading enzymes which might have broken down protein to its lower fractions. The range of protein contents obtained for the flour samples (6.00 and 8.40%) was higher than 1.8 to 2.2% reported for Baobas-ogi by Adejuyitan *et al.* (2012). The result is however comparable with 4.10 to 8.96% reported for sorghum-ogi fortified with pawpaw (Ajanaku *et al.,* 2010). Crude fat contents of both unfermented and fermented flour samples ranged between 3.55 and 4.80% (Table 1). The crude fat contents are within similar range for all the samples. There was no significant difference in the fat contents of all the flour samples except for UFQPM flour which was found to be high (4.8%) and was significantly higher at p ≤ 0.05 than others. High crude fat content is not advantageous in maize especially if the focus end product is not oil; high fat is a threat to storage stability as it may cause rancidity which may negatively affect both the colour and especially the flavour of the product. Generally, fermentation reduced the crude fibre and ash contents of the flour sample but improved the carbohydrate content of the flour sample. Carbohydrate level ranged between 79.27 and 83.85% (Table 1). This range is similar to the reports of earlier studies for maize flours (Fasasi *et al*., 2007; Adejuyitan *et al.*, 2012).

Mineral elements composition of the flour samples

The quantities of the mineral elements varied from 0.24 to 0.99 mg/100g, 0.29 to 8.29 mg/100g, 6.74 to 57.50 mg/100g and 12.42 to 50.50 mg/100g for magnesium, sodium, potassium and calcium, respectively (Table 1). Fermentation caused a general reduction in the macro-elements contents of the flour samples (Table 1). Ijarotimi and Keshinro (2011) reported a reduction in potassium content from 9.00 mg/100g to 6.99 mg/100g for raw and fermented popcorn flour. There were no significant differences between the magnesium, sodium and calcium contents of FQPM and FNM flours but fermentation caused a significant difference (p≤0.05) in the potassium contents of FNM and FQPM flour (Table 1). Omafuvbe *et al.* (2004) also observed a reduction in the mineral composition of African locust bean *(Parkia biglobosa)* and Melon *(Citrullus vulgaris)* seeds during fermentation to condiments. The results show that the flour samples are rich in trace minerals. Iron and zinc contents are high ranging from 4.78 to 68.14 mg/100g and 0.08 to 3.95 mg/100g for Iron and zinc, respectively (Table 1). Significant difference existed (p≤0.05) in trace mineral contents between UFNM and UFQPM flours. Adeoti, *et al.* (2013) reported a lower Iron value of 0.64 mg/100g and a higher zinc value of 1.13 mg/100g for 90% maize tuwo. Also, Adeola *et al.* (2013) reported lower value (0.02 mg/100g) of zinc for 20% carrot pomace with fermented maize flour.

Physico-chemical properties and mean particle size of the flour samples

The pH of the flour samples was within the acidic range (3.37-6.03) as shown in Table 2. There was a significant difference between the pH of the normal maize flour and QPM flour. The flour of the unfermented normal maize was more acidic than unfermented QPM flour (5.86 and 6.03 for UFNM and UFQPM flour, respectively). Though, the result of the fermented flour samples followed the same trend with the unfermented flour samples, lower pH was observed in fermented flour samples than their unfermented counterparts; 3.47 and 3.67 for FNM and FQPM respectively (Table 2). The degree of acidity enhances the sour taste of fermented maize product and this give preference to its consumer acceptability. Significant differences existed in the bulk density of unfermented normal maize flour and QPM flour with UFQPM flour having the highest bulk density of 0.62 compared 0.57 for UFNM flour (Table 2). Fermentation reduced the bulk density of both normal maize flour and QPM flour. Yet, FQPM flour still had the higher bulk density (0.49). The reduction in bulk density might have resulted from the action of microfloral which had broken down and utilize complex starch and simple sugar. Ikujenlola *et al.* (2008) observed the same reduction in bulk density of both malted and unmalted maize after it had been blended with soybeans from 0.77 to 0.66 g/dm^3 and from 0.83 to 0.81 g/dm^3. The reduction of bulk density will be an advantage in using the fermented flour for complementary diet (Ijarotimi *et al.*, 2009). This kind complementary food will not be heavy and so it can be taken anytime of the day without adverse effect on the agility of the consumer. Fermentation improves the reconstitution index of both maize varieties' flour significantly at p≤0.05 (Table 2).

The mean particle size of maize flour samples obtained is presented in Table 2. Larger percentage of raw flour samples were recovered on sieve size 630 µm, followed by size 315 µm. The analysis showed that, the particle size of unfermented samples were bigger than the fermented samples as only unfermented samples (UFNM and UFQPM) were retained on size 63 m which was the largest sieve aperture used for the analysis (Table 2). Mean particle size of flour has been observed to influence the physicochemical properties such as swelling power, paste clarity and water-binding capacity of the flour and textural characteristics of food products derived from such flour (Hebrard *et al*., 2003; Singh *et al*., 2006). Larger particle size of unfermented flours affected both the swelling power and solubility of the flour. This is evidence in the behavioural pattern of their solubility and swelling power at the range of temperatures tested (Figures 1a and 1b). Varietal differences also affect the mean particle size of the flours. The particle size of the unfermented decorticated normal maize flour was smaller than that of QPM counterpart. Percentage flour retained on sieve 150 µm was 21.87 and 10.74% for UFNM and UFQPM respectively (Table 2).

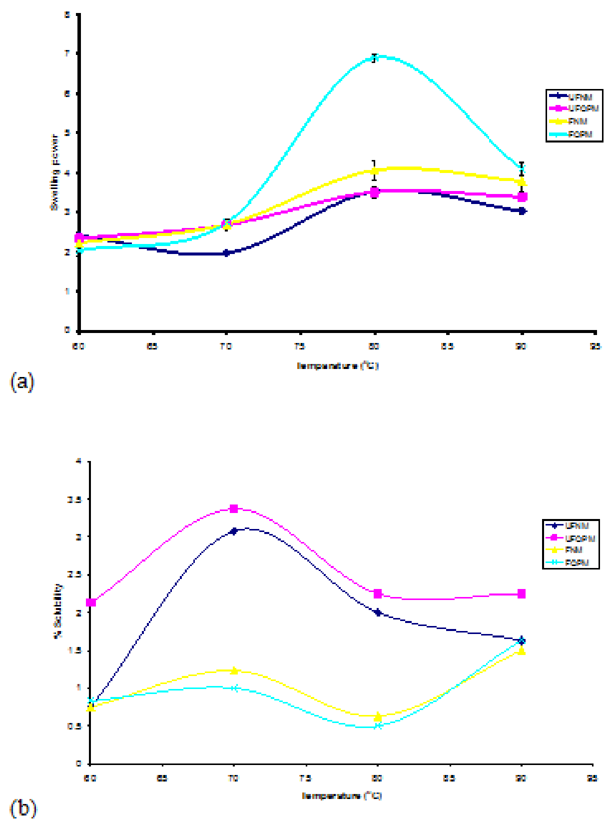

Figure 1 (a) and (b): Effect of temperature on the swelling power and solubility of flour samples

Key. UFNM-Unfermented decorticated normal maize, UFQPM-Unfermented decorticated quality protein maize, FNM-Fermented normal maize, FQPM- Fermented quality protein Maize

Table 3. Rheological properties of maize flour samples

	Parameter						
Sample	Peak 1 (RVU)	Trough 1 (RVU)	Breakdown (RVU)	Final Viscosity	Setback (RVU)	Peak Time (mins)	Pasting Temp (°C)
UFNM	58.00	55.08	2.92	146.75	91.67	5.62	92.45
UFQPM	45.50	42.00	3.50	107.67	65.67	5.88	93.65
FNM	197.33	158.92	38.42	249.25	90.33	5.49	92.48
FQPM	135.08	98.00	37.08	160.17	62.17	5.35	92.55

Values reported as means ± standard deviation.
Key UFNM-Unfermented decorticated normal maize, UFQPM- Unfermented decorticated quality protein maize, FNM-Fermented normal maize, FQPM-Fermented quality protein Maize

Effect of temperature on swelling power and solubility of flour samples

Little or no significant different was observed in the swelling power of both UFN (M2.41) and UFQPM (2.34) at temperature of 60°C. However, at 70°C UFNM flour sample recorded lower value (1.97) as compared with 2.68 obtained for UFQPM flour (Figure 1a). This suggests that QPM flour starch may contain higher amlylopectin fraction than the normal maize flour as swelling power correlates positively with amylopectin content (Sasaki and Matsuki, 1998; Adegunwa *et al.*, 2011). Increased in temperature to 70°C favour increase in swelling power of QPM flour but a decrease was observed in normal maize flour (Figure 1a). Both unfermented and fermented flour samples reached highest swelling power at temperature of 80°C indicating that at 80°C, starches might have gelatinized there by preventing further absorption of water (Figure 1a). At 80°C which was the peak point swelling power for all the flour samples, FQPM flour sample had the highest value of 6.90 while FNM had 4.06. Higher swelling power were obtained for fermented samples when compare with the unfermented ones. Onitilo *et al.* (2007) suggested that the swelling power of granules reflect the extent of the association of forces within the granules. Therefore this may imply that fermentation had improved force of cohesion between the starch granules leading to improve swelling ability. Generally, increase in temperature favoured increase swelling power till 80°C. This is excepted as increased in temperature increases thermodynamic mobility thereby enhances penetration of water into the starch granules.

The relationship between increase in temperature and solubility of the flour samples is shown in Figure 1b. Samples UFNM and UFQPM are slightly soluble at 60°C with UFQPM with higher solubility (2.13) followed by 0.75 for UFNM flour. Unfermented samples reached peak solubility at 70°C. The solubility curve of both unfermented flour sample slope down right at 80°C but rise a little at 90°C (Figure 1b). The solubility of UFQPM is expected to be higher than that of UFNM with higher swelling power (Figure 1b), since leaching of amylose is responsible for most of the solubility of starch based product (Adegunwa, 2011). Fermented flour samples of both normal maize and QPM (FNM and FQPM) were slightly soluble at 60°C and the solubility increases at 70°C. The increase was relative uniform until 90°C when it increased (Figure 1b). This result was lower than the solubility at a single temperature of yellow maize corn starch (Ogi) flour by Adegunwa (2011). Fasasi *et al.* (2007) reported an increase in solubility with increase in temperature for Maize-Tillapia flour. The increase in solubility of fermented flours with increased temperature up to 90°C can possibly be due to the formation of lower molecular weight compounds due to the activity of amylases and proteases during fermentation (Lukow and Bushuk, 1984). Also, solubility is bound to increase with increase in temperature as increased in temperature weaken intragranular binding forces and enhance leaching of granular particles.

Pasting profile of the flour samples

The pasting profiles of fermented and unfermented maize flour are presented on Table 3. Peak viscosity of UFNM flour (58.00 RVU) is higher than 45.50 RVU obtained for UFQPM indicating that the water binding capacity as well as swelling power of normal maize (Figure 1a) is higher than that of QPM flour as a result of stronger starch strenght. Fermentation increased the peak viscosity from 58.00 to 197.33

Table 4. Sensory score of the reconstituted flours

Samples	Colour	Taste	Aroma	Consistency	Overall Acceptability
UFNM	5.58c	6.33d	5.57d	6.33e	6.00d
UFQPM	5.08b	5.58cd	5.58cd	5.17cd	5.17cd
FNM	4.42ab	4.33bc	4.25abc	3.50bc	4.75b
FQPM	2.00a	3.08ab	4.42bcd	2.17a	3.58ab

Values reported as means ± standard deviation. Mean values with different superscript(s) along the same column are is significantly different ($p \leq 0.05$)
Key UFNM-Unfermented decorticated normal maize, UFQPM-Unfermented decorticated quality protein maize, FNM-Fermented normal maize, FQPM- Fermented quality protein Maize

RVU and from 45.50 to 135.08 RVU for normal maize and QPM flour, respectively (Table 3). This result is close to 156.33 RVU reported for three days fermented yellow maize ogi by Adegunwa et al. (2011) and lower than 310 BU reported for sorghum ogi by Ajanaku *et al*. (2012). The peak viscosity is a measure of maximum viscosity developed during cooking indicating that greater viscous load will be encountered during mixing of fermented maize flour compared to unfermented flour (Arionla *et al*., 2016). The values of peak time range between 5.35 and 5.88 min. FQPM flour has the least peak time and UFQPM flour recorded the highest peak time (Table 3). Several earlier studies reported similar range of peak time (Adegunwa *et al*., 2011; Eke-Ejiofor and Owuno, 2012). The pasting temperature value ranged between 92.45 and 93.65°C with UFQPM flour and UFNM having the highest and lowest respectively. The pasting temperature obtained in this study is higher than 63.95 to 65.25°C reported by Adegunwa *et al*. (2011) for yellow maize ogi flour. The values of breakdown for unfermented decorticated flour ranged between 2.92 and 3.50 RVU. While for fermented samples, values ranged from 37.08 to 38.42 RVU (Table 3). Final viscosity ranged between 107 and 249.25 RVU for all the samples. This is in agreement with earlier reports (Fasai *et al*., 2007; Adegunwa *et al*., 2011). Set back values ranged between 37.91 and 91.67 RVU, trough of fermented samples (FNM and FQPM) ranged between 98.00 and 158.92 RVU (Table 3). This result is lower than 178-205 RVU obtained for wheat/plantain flours enriched with bambara groundnut protein concentrate by Kiin-Kabari *et al*. (2015). The trough 1 (hold period) sometimes referred to as shear thinning, holding strength or hot paste viscosity is a period when the samples were subjected to a period of constant temperature and mechanical shear stress (Kiin-Kabari *et al*., 2015). The trough values of fermented samples (158.92 and 98.00 RVU) are significantly higher that their unfermented counterparts (55.08 and 42.00) for normal maize and QPM respectively as shown on table 3. This is an indication of the possibility that the starch of fermented samples can withstand shear stress especially during mixing better than unfermented samples. The setback values of fermented samples were slightly lower than that of unfermented samples, the higher the setback value, the lower the retrogradation during cooling and the lower the stailing rate of the products made from the starch (Akanbi *et al*., 2009). Also, high setback is also associated with syneresis during freeze thaw cycles for example, and substituted starches are commonly used where this presents a quality defect.

Sensory Score of the flour samples

The sensory characteristics of reconstituted flours are shown in Table 4. Significant differences existed ($p \leq 0.05$) in the unfermented flours (UFNM and UFQPM) for all the sensory attributes measured. Fermentation improved all the attributes measured as fermented samples (FNM and FQPM) were more preferred compared to unfermented samples and FQPM is more preferred to FNM in terms of colour, taste, consistency and overall acceptability with significant differences at $p \leq 0.05$ (Table 4).

Conclusion

The variety different and fermentation have significant influence on physicochemical properties, pasting profile and sensory scores of the flour samples. Fermentation increased flour yields, lower the moisture and crude fibre content of the two varieties of maize investigated. Carbohydrate contents of fermented samples were higher than unfermented samples. Fermentation improved the pasting profile and some physicochemical properties desirable in the production of weaning food. Also, the reduction effect of fermentation on some nutrient content of maize is more pronounced in normal endosperm than quality protein maize. It can therefore be concluded that fermentation is desirable in the processing of maize product especially for breakfast cereals and weaning food. Also, quality protein maize is preferred to normal endosperm maize due to the relative stability of it constituents during processing.

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