FUNCTIONAL AND PASTING PROPERTIES OF A COMPLEMENTARY FOOD MADE FROM AFRICAN WALNUT AND FERMENTED MAIZE FLOUR

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Abstract

African walnut, turmeric roots and maize grains (Zea mays) were processed separately into flour and formulated into blends containing 25 to 45% African walnuts. The blends were evaluated for sensory properties while the most preferred blends by the sensory panelists were evaluated for functional and pasting properties using standard methods. The results of functional properties obtained were significantly different (p<0.05) to the control samples. Bulk densities of the formulated blends B and C which ranged from 0.405 – 0.409 g/ml, 0.408-0.410 g/ml were significantly different from that of the control. The water absorption capacity (WAC), Swelling power of the blends ranged from 173.6 – 217.7 % g/g, 9.3 – 10.2g/g and the control (ogi: 217.7 % g/g, 11.8g/g and cerelac: 11.3% g/g, 2.02g/g) respectively. Peak viscosity of the blends (172.1- 181.4 RVU), breakdown viscosity (55.3- 59.2RVU) and final viscosity (241.4-254.2 RVU), setback (22.5-28.1 RVU), peak time (4.1-4.9 min) and pasting temperature (75.1-75.9 °C) were higher than that of cerelac but similar to that of 'ogi''. The result of the sensory evaluation showed that all the formulated blends had higher mean score than the controls in term of colour, while of similar qualities with the control (cerelac) in other sensory parameters and generally acceptable. The study has shown that an acceptable nutrient-dense complementary food can be made from African walnut.

Keywords: African walnut, sensory evaluation, pasting, functional, peroxide, complementary food.

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1. INTRODUCTION

The production of high-protein foods of plant origin is essential in developing countries due to the shortage and high cost of animal protein. Consumption of high-protein foods plays a major role in combating malnutrition among infants and children, which is a serious problem in the developing countries. Cereals and legumes are important source of plant protein throughout the world. Maize constitutes about 90% of cereals consumed in southern Nigeria (Aminigo and Akingbala, 2004). The grain is often processed into a fermented product known as ogi. During ogi manufacture, nutrients including protein and minerals are lost from the grain thereby affecting nutritional quality adversely. A number of studies have been carried out to improve the nutritive value of *ogi*. The nutritive value of *ogi* was improved by fortification with okra seed meal (Aminigo and Akingbala, 2004).

Several researchers have reported that *ogi* can be fortified with different varieties of under-utilized legumes such as okra seed, bambara seed and African yam beans (Akinwande *et al*, 2008). Adebayo *et al*, 2012 worked on production and quality evaluation of complementary food formulated from fermented sorghum, walnut and ginger. It was discovered that the use of 1g of ginger can actually purge infants and children because their reproductive system is not strong enough to process some spices and foods. Ojo and Enujiugha (2016) also reported on physico-chemical, chemical, and acceptability of Instant 'ogi' from blends of fermented maize, conophor nut and melon. It was revealed that addition of melon to African walnut thereby increases the fat content of the formulated blend and reduces it shelf life and therefore go rancid very fast. And based on these limitations, African walnut could be explore to improve the nutritional composition of fermented maize flour (*ogi)* for wider appeal. A complementary food that is digestible could be developed from African walnut and fermented maize flour particularly for infants, children and elderly people who have problem of digestibility.

African walnut (*Tetracarpidium conophorum*), commonly called Cornophor nut, is a perennial climbing shrub found in the moist forest zones of sub- Sahara Africa. It belongs to the family Euphorbiacaea. Conophor plant is cultivated principally for the nut which are cooked and consumed as snacks, along with boiled corn in Nigeria (Edem *et. al*, 2009). In Nigeria, it is called "awusa" or "asala" in Yoruba; "ukpa" in ibo; and "okwe" in Edo (Edem *et. al*, 2009). The nut is spherical in shape and has a black shell inside which is embedded a milky kernel (Aviara and Ajikashile, 2011). It is found in Uyo, Akamkpa, Akpabuyo, Lagos, Kogi , Ajaawa-Ogbomoso, Ore and Ibadan.

African walnut is a good source of protein (Edem *et al*., 2009). It contains about 8.7% moisture content, 2.03% ash, 6.21% fat, 3.34% crude fibre, 35.22% protein, and 44.50% carbohydrate. It is rich in valuable minerals like phosphorus, potassium, sodium, magnesium and zinc (Ayoola, *et al.,* 2011). African walnuts are largely underutilized in developing countries like Nigeria with high wastage in the farm due to short shelf life of the nut. Despite the economic importance of conophor nut, no commercial production and industrial utilization of the crop takes place in Nigeria. Edem *et al*., (2009) noted that research has been concentrated only on the agronomics while work on the processing of the indigenous crops appears to have been neglected. These gaps therefore necessitated processing of the nuts to produce African walnut based complementary food, considering its high nutritional composition of protein content, complete essential amino acids and fatty acids to support adequate growth of infants and children.

Complementary food comprises of all liquid, semisolid and solid foods other than breast milk and breast milk substitutes which are fed to infants which are being weaned from the breast. It can be beverages, spoon-fed food, or finger-food. Complementary foods were censored by WHO/FAO (2003) to contain the necessary nutritional requirements, and standards which supplies the essential nutrients required for adequate growth and preventing diseases in children and young adult. African walnut is a potential source of protein for the fortification of ogi and improves its nutritive composition. In this study, maize grain, walnut and turmeric were used for production of complementary food for older infants and young children. The objectives of this study were therefore to develop African-walnut based complementary food and evaluate functional, pasting and sensory properties.

2. MATERIALS AND METHODS

Materials

African walnut and maize grain (suwan 1) and turmeric were purchased from a local market in Ibadan, Oyo State, Nigeria.

Methods

Flour Preparation:

Fermented maize flour (''Ogi'' flour) was produced according to Akingbala *et al.*, (2006) by soaking maize grains in water for 72 hours. The steeping water was decanted and the softened kernel / maize were wet milled and sieved to remove the germs and hulls. The "ogi" slurry was allowed to ferment naturally in clean plastic bucket anaerobically for 48-72 hours and the excess water was squeezed out to give "Ogi" cake. The cake was dried in hot air oven at 60 ºC for 12 hours and dry milled to produce "Ogi" flour which was packaged in clean polyethylene bag.

African walnut flour was produced according to the method of Adebayo *et al.,* (2012). The nuts was sorted, and washed to remove adhering contaminants and then cooked for 30 minutes in sulphited water to the removal of the shell and then soaked in 0.2% potassium metabisulfite for 5mins to facilitate the deshelling process. The deshelled walnut was size reduced with a stainless steel kitchen knife to increase surface area and then soaked to remove the bitter taste for 30mins and also blanched by adding into boiling water and allowed standing for 5mins before draining. This help to reduce the tannin content of the walnut. The blanched walnut will be dried in hot air oven at 60 ºC for 5-10 hours and ground to produce walnut flour. Then walnut flour will be packaged in clean polyethylene bag. Turmeric powder was produced according to the method of Adebayo *et al*, (2012). The turmeric roots were washed in sterile water after peeling and then dried in air oven at 50 ⁰C 5hrs and ground to powder and sieved using 0.25mm mesh screen and finally packaged.

Food formulation

The food samples were formulated with reference to FAO/WHO (2003) standards for infant/ children protein-energy requirement (10-15g/ day). Different samples were prepared by combining 74.5%, 69.5%, 64.5%59.5% and 54.5% fermented maize flour, 25%, 30%, 35%, 40% and 45% African walnut flour with a constant 0.5% of Turmeric powder (Table 1). The flours were then made into porridges.

Sensory Evaluation

All the formulated blends were made separately into gruels (20% w/v) by making a smooth cold paste and gradually pouring same into boiling water. This was stirred vigorously until the entire mass became viscous. One (1) teaspoon of sugar was added to each sample to taste. The gruels were kept separately in thermos flask for sensory evaluation with 50 semi-trained panelists drawn from Yoruba ethnic group among the staff and students of the University that are familiar with the porridge. The samples were evaluated for preference test using a nine point hedonic scale ranging from 1(extremely disliked) to 9 (extremely liked). The samples were coded appropriately in the hedonic scale. Each judge was given six white plastic cups and teaspoon for use in the sensory evaluation. The judges were provided with clean water to rinse their mouth in between testing of the gruels to avoid carry over effect. Each panelist evaluated the gruels for color, flavour, appearance, mouth feel, taste and overall acceptability.

Functional Properties

Bulk (Loose) and Tapped (Packed) density:
The method of Mpotokmane *et al* (2008) with slight modification as described by Falade and Kolawole (2012) was adopted for the determination of bulk density of the starches. A 100ml measuring cylinder was filled with the sample to mark and the content weighed after making provision for zeroing the cylinder's weight. The tapped density was obtained by following the same procedure but tapping until no considerable volume change is observed prior to weighing. Bulk and tapped density was calculated as the ratio of the bulk and tapped weight and the volume of the container (g/ml) respectively (Asoegwu *et al*, 2006).

Swelling power and solubility properties:
Swelling power was determined by the method described by Akinwande *et al* (2008). It involves weighing 1g of flour sample into 15ml centrifuge tube. 10ml of distilled water was added and mixed gently. The slurry was heated in a water bath at a temperature of 85 ºC for 15 minutes. During heating, the slurry was stirred gently to prevent clumping of the flour. On completion of 15 minutes, the tube containing the paste was centrifuged at 3000rpm for 10 minutes. The supernatant were decanted and weighed immediately after centrifuging. The weight of the sediment was then taken and recorded. The moisture content of the sediment gel was used to determine the dry matter content of the gel.

$$\text{Swelling power (g/g)} = \frac{\text{Weight of the paste}}{\text{Weight of the dry flour}}$$

$$\text{Solubility index (\%)} = \frac{\text{Weight of Solubles}}{\text{Weight of sample}} \times 100$$

Water absorption Capacity and Solubility index:
Water absorption capacity and solubility index were determined according (2000) and Akinwande *et al* (2008). The crucibles and centrifuge tubes were dried in the oven at 105 ºC for 20 minutes and allowed to cool in desiccators, after cooling, the crucible and the centrifuge tubes were weighed. 1g of each of

the sample was weighed into the tube and 10mls of distilled water was added and stirred gently with a stirring rod for 30 minutes. The tube containing the paste was centrifuged at 4000rpm for 30 minutes. The supernatants were decanted into crucibles and dried in the oven at 100 ºC until the supernatant was dried off. The residue remaining in the tubes were weighed and the crucible after drying with the supernatant.

Water absorption capacity was calculated as:

$$\frac{\text{(Weight of tube + residue after centrifuge) - Weight of empty tube}}{\text{Weight of sample}} \times 100$$

Water solubility index was calculated as:

$$\frac{\text{Weight of crucible after drying – weight of empty crucible}}{\text{Weight of sample}} \times 100$$

Determination of pasting properties

Pasting properties were determined with a Rapid Visco Analyser (RVA) (Newport Scientific RVA Super 3). An aliquot 3 grammes of sample were weighed in a vessel, 25 ml of distilled water were dispensed into a new test canister. The samples were then transferred into the water surface in the canister. The paddle was placed into the canister and the blade vigorously jogged through the sample up and down ten times. The test proceeded and terminated automatically. The slurry was heated from 50 to 90ºC and cools back to 50ºC within 12 minutes, rotating the can at a speed of 160 rpm with continuous stirring of the content with a plastic paddle. Parameters to be estimated were peak viscosity, setback viscosity, final viscosity, minimum viscosity, breakdown value, pasting temperature and time to reach peak viscosity (AOAC, 2004).

Peroxide Value:

Peroxide value was determined according to the method of AOAC (2004). Two (2) grams of the samples was weighed into glass-stoppered flask. 25mls for acetic acid - chloroform mixture (3.2), mixture was added and allowed to properly dissolve. The same was added carried out for blank. 1ml of saturated potassium iodide (KI) solution was added and mix. The content was now placed in the place for 10 minutes. 30 mls of water was added and mix very well. About 1 ml of starch solution was added and titrated with 0.01NNaS_2O_3.

Statistical Analysis

Data generated were subjected to analysis of variance (ANOVA) using SPSS and treatment means that are significantly different were compared using the Duncan's multiple range test to separate the means with the aid of System Analysis System (SAS).

Table 1: Formulations of African-walnut based complementary food.

Blends	Fermented Maize Flour (%)	Walnut flour (%)	Turmeric (%)
A	100	-	-
B	74.5	25	0.5
C	69.5	30	0.5
D	64.5	35	0.5
E	59.5	40	0.5
F	54.5	45	0.5

KEY:
A(FMF:WF:T, 100:0 :0),
B(FMF:WF:T,74.5:25:0.5),C(FMF:WF:T,69.5:30 :0.5)
D(FMF:WF:T, 64.5:35:0.5), E(FMF:WF:T,59.5:40:0.5),
F(FMF:WF:T 54.5:45 :0.5)
N:B FMF-Fermented maize flour, WF- Walnut flour, T-Turmeric.

3. RESULTS AND DISCUSSION

Sensory evaluation of the complementary food

The sensory evaluation of food products is an important criterion by which its consumer acceptability can be assessed. The acceptability parameters measured are taste, appearance, colour, aroma, mouth feel and overall acceptability. The results showed that blend B and C were the preferred blends with the highest score of (6.5). This was followed closely by blend D (6.2), blend E (5.9) in that order. Sensory analysis results showed that the complementary food had highest value in term of color and generally acceptable by the panelists. While the result of control samples (ogi & cerelac) in term of aroma, taste and mouth feel were slightly higher when compared with the formulated blends.

Sensory evaluation of the complementary food

Functional properties of the complementary food The results obtained revealed that there was a significant difference (0<0.05) between the bulk density, swelling capacity and water absorption capacity of the formulated food samples and the control samples (Table 3). However, there no was no significant different between the blend B and blend C complementary food samples when compared with control in term of bulk density (p<0.05). The loose bulk densities of blend B and C (0.405g/ml, 0.408/ml) are higher than that of "ogi" (0.382g/ml) and cerelac (0.381g/ml). The packed bulk density of the blend B and C (0.409g/ml, 0.410g/ml.) are also higher than that of "ogi" (0.380g/ml but slightly lesser that cerelac (0.453g/ml). Meanwhile, the loose and packaged densities of "ogi" and cerelac are similar. This result was in line with the findings of Arueya and Osundahunsi (2015). Bulk density is influenced by particle size and starch polymers structure (Arueya and Osundahunsi, 2015). Loose structure of the starch polymers could result in low bulk density. Low bulk density is desired in flour blends as it's contributes to lower dietary bulk, ease of packaging and transportation (Aluge *et al*., 2016). The lower loose bulk density implies that less quantity of the food sample would be packaged in constant volume thereby ensuring an economical packaging. However, the packed bulk densities would ensure more qualities of the food samples being packaged, but less economical. Nutritionally, loose bulk density promotes easy digestibility of food products, particularly among children with immature digestive system (Osundahunsi and Aworh, 2002).

The water absorption capacity of the complementary foods ranged between (173.60-217.76%). Blend C had 173.60%, Blend B had 217.76% while "ogi" flour had 217.67%, and cerelac had 11.3%. Water absorption capacity is the ability of flour to absorb water and swell for improved consistency food. It is desirable in food systems to improve yield and consistency and give body to the food (Osundahunsi *et al*, 2002). The water absorption capacity of the complementary flour decreased as the proportion of African walnut flour increased in the mixture. However, swelling power of blends B and C were about four or five times that of the commercial blend (10.2, 9.3, 2.02g/g) The swelling capacity is an important factor used in determining the amount of water that the food samples would absorb and the degree of swelling within a giving time.

Pasting properties of the complementary food

The pasting properties of the formulated complementary food, ''ogi'' and cerelac are shown in Table 4 below. The pasting results showed that Blend B and C exhibited peak viscosity 172.1 to 181.4 RVU to that of Nestle cerelac 25.6 RVU and 'ogi'' 214.4 RVU. Blend C (30% African walnut) had the highest value while the lowest value was recorded in blend B (25% African walnut). Peak viscosity is the maximum viscosity is the maximum viscosity attained during or soon after the heating portion of the test in RVU. The peak viscosity is indicative of the viscous load likely to be encountered during mixing (Maziya-Dixon *et al*., 2004). The higher the peak viscosity the higher the swelling index, while low paste viscosity is indicative of higher solubility as a result of starch degradation or dextrinization (Shittu *et al*., 2001).

Break down set point ranged from 55.3 to 59.2. Breakdown viscosity is the measure of the tendency of swollen starch granules to rupture when held at high temperatures and continuous shearing (Patindol *et al*., 2005). Breakdown viscosity is indicative of paste stability (Akanbi *et al*., 2009). The time at which peak viscosity occurred in minutes is termed peak time (Adebowale *et al*., 2005). The peak time of the complementary food in this study ranged from 4.1 to 4.9 RVU. The peak time was lower in the control (1.9, 1.8 min). However, low peak time is indicative of its ability to cook fast.

Pasting temperature value ranged from 75.2 ^{O}C to 76.9.^{O}C.

The pasting temperature of blend C of the complementary food (75.9^{O}C) was higher than that of blend B (75.1^{o}C) but similar to the commercial complementary foods (74.8^{o}C) and 'ogi'' (74.2^{o}C). This may be due to the relative higher starch content. The pasting temperature of the porridge is lower than the boiling temperature; hence the porridge can form a paste in hot water below boiling point. This means at a commercial level, there is a remarkable cost saving. Pasting temperature is a measure of the minimum temperature required to cook a given food sample and also gives an indication of the gelatinization time during processing. It is the temperature at which the first detectable viscosity is measured and an index characterized by initial change due to the swelling of starch, it can have implications for the stability of other components in a formula and also indicate energy costs. Pasting temperature has been reported to relate to water binding capacity, a higher pasting temperature implies higher water binding capacity property of starch due to high degree of association between starch granules (Adebayo *et al*, 2012). The peak viscosity indicates the water binding capacity of the starch and it is important to the user in order to obtain a useable starch paste (Shittu *et al*, 2001).

Final viscosity value ranged from 241.2 to 254.2 RVU. Final viscosity is the ability of starch to form a viscous paste on cooling. This viscosity was highest in blend B (254.2 RVU) compared to blend C (241.4 RVU) and cerelac (90.1 RVU) but lower than 'ogi'' (279.1 RVU). The increase in final viscosity might be due to the aggregation of amylose molecules which is indicative of quick retrogradation (Adebowale *et al*, 2005). Set back value of the blends ranged from 22.5 to 28.1 RVU compared to the control (ogi: 50.2 RVU, cerelac: 3.0 RVU). Setback value is the tendency of starch to associate and retrograde on cooling. Peroni *et al*. (2006) indicated that flours with low setback may have low values of amylose which have high molecular weight. The lower the retrogradation, the higher the setback value, during cooling of the products made from the flour (Ikegwu *et al*., 2010). High setback is associated with syneresis. Thus, Blend B, C and the control ''ogi'' could form a much better flour paste.

Peroxide value of the complementary food

Peroxide value was carried out on the formulated blends to determine rancidity value of the blends during storage. Peroxide value obtained in the most preferred formulated diet was 1.5 meq O_2 /kg fat at week 8. The amount of peroxide of fats indicates the degree of primary oxidation and therefore its likeliness of becoming rancid. The lower number of peroxide value obtained indicates a good source quality of sample and a good preservation status. Unsaturated free fatty acids react with oxygen and for peroxide, which determines a series of chain reactions that generate the production of smelling volatile smell.

Table 2: Sensory attributes of formulated blends compared with a commercial Complementary food (cerelac) and "ogi".

Blends	Colour	Aroma	Taste	Appearance	Mouthfeel	Overall acceptability
A	6.4^{b}	7.5^{a}	7.3^{a}	7.5^{a}	7.5^{a}	7.6^{a}
B	7.9^{a}	6.4^{b}	6.3^{b}	6.5^{b}	6.7^{b}	6.5^{b}
C	7.9^{a}	6.3^{b}	6.3^{b}	6.5^{b}	6.5^{b}	6.5^{b}
D	7.8^{a}	6.2^{bc}	6.2^{bc}	6.3^{bc}	6.3^{c}	6.2^{cd}
E	7.8^{a}	6.0^{c}	6.0^{c}	6.2^{c}	5.9^{d}	5.9^{d}
F	7.7^{a}	5.7^{d}	5.5^{d}	6.0^{d}	5.4^{e}	5.5^{e}
*CC	6.0^{c}	6.3^{b}	6.5^{ab}	6.0^{d}	7.0^{ab}	7.5^{ab}

KEY:
A (FMF:WF:T, 100:0:0), B (FMF:WF:T, 74.5:25:0.5), C (FMF:WF:T, 69.5:30:0.5); D (FMF:WF:T, 64.5:35:0.5) E (FMF:WF:T, 59.5:40:0.5), F (FMF:WF:T, 54.5:45:0.5); *CC (Commercial complementary food-cerelac); FMF-Fermented maize flour, WF- Walnut flour, T-Turmeric

Table 3: Some functional properties of the preferred complementary food, ogi (a traditional complementary food) and cerelac (a commercial formula).

Sample	Swelling power (g/g)	Water absorption capacity (%)	Loose density (g/ml)	Packed density (g/ml)
B	10.2±0.03	217.76±0.03	0.405±0.02	0.409±0.02
C	9.3±0.0.2	173.60±0.02	0.408±0.01	0.410±0.01
Ogi	11.8±0.02	217.67±0.01	0.382±0.01	0.386±0.02
Cerelac	2.02±0.03	11.3±0.01	0.381±0.01	0.453±0.02

N:B Mean of triplicate determination , significant at level (P<0.05)
KEY:
B (FMF:WF:T, 74.5:25:05), C (FMF:WF:T, 69.5:30:0.5)
FMF-Fermented maize flour, WF-Walnut flour, T-Turmeric

Table 4: Pasting properties of the preferred complementary food, ogi (a traditional complementary food) and cerelac (a commercial formula).

Sample	Peak Viscosity (RVU)	Peak Time (min)	Pasting Temp (°C)	Minimum viscosity (RVU)	Breakdown viscosity RVU)	Final viscosity (RVU)	Set back viscosity (RVU)
B	181.4	4.1	75.1	122.5	59.2	254.2	28.1
C	172.1	4.9	75.9	118.2	55.3	241.4	22.5
Ogi	214.4	1.8	74.2	163.0	68.1	279.1	50.2
Cerelac	25.6	1.9	74.8	7.40	18.4	90.1	3.0

N.B: Mean of triplicate determination , significant at level (P<0.05)
KEY:
B (FMF:WF:T, 74.5:25:05), C (FMF:WF:T, 69.5:30:0.5)
FMF-Fermented maize flour, WF-Walnut flour, T-Turmeric

4. CONCLUSION

The study has shown that an acceptable complementary food can be made from African walnut. The pasting temperature of blend C (75.9 ^{O}C), it's peak time (4.9 min) and peak viscosity (172.1 RVU) were within acceptable range. The functional properties of the preferred blends showed that the complementary food behaves well in water during processing, cooking, and will be easily digestible by the children. 25% and 30% of African walnut substitution formed an acceptable porridges. The Formulated African walnut based complementary food can therefore be considered suitable for consumption by the children.

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