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IMPACT OF INCORPORATING *Moringa oleifera* SEED ON THE NUTRITIONAL, PHYSICOCHEMICAL AND SENSORY PROPERTIES OF FERMENTED MAIZE PORRIDGE 'OGI' FLOUR

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Abstract

The quality of *Ogi* flour enriched with *Moringa oleifera* seed using different methods of incorporation was evaluated. Incorporation of *M. oleifera* seed was done using the same starting material ratio (White Maize: *M.oleifera* seed - 80:20) chosen from sensory evaluation of different mixes. *M.oleifera* seeds were wet milled with maize (MMS), wet milled and added to *Ogi* slurry (OSMS), dry milled into flour and added to *Ogi* flour (OFMS) to obtain three different mixes. The samples with the control (100% white maize *Ogi*) were evaluated for nutritional, functional and sensory attributes. Results showed that *Moringa-ogi* contained 9.73-15.77% protein, 0.67-1.21% ash, 0.85-1.51% fibre, 12.34-14.44% fat, 58.92-67.81% carbohydrate and 420.36-428.57 kcal energy. The mixes also contain 0.36-0.56 mg/g ascorbic acid, 24.40-46.00 μg/g total carotenoid and appreciable concentration of mineral elements. These values were significantly higher (p≤0.05) than values of the control (100% Maize *Ogi*) with sample MMS having the least values and sample OFMS having the highest values. pH (4.07-4.09) and bulk density (0.67-0.69 g/ml) were not significantly different (p≤0.05) from the control irrespective of the method of inclusion. Peak viscosity of *Moringa-ogi* in the range 168.42-243.33 RVU were significantly different from each other but lower than the value of the control (302.25 RVU). Sensory attributes assessed were acceptable. Maximum nutritional value can be derived from *moringa-ogi* if *M. oleifera* seed flour is added to *Ogi* flour but more acceptable to the consumer if the seed is milled together with the maize.

Keywords: Proximate, ascorbic acid, carotenoid, mineral, swelling, solubility, physicochemical, sensory and pasting properties

Introduction

M. oleifera tree commonly called ben oil tree, edible by man and animals, is widely grown in many countries in the tropics. The tree propagates with ease through both sexual and asexual means and has low demand for soil nutrients and water after being planted. The tree is one of the most useful tropical trees. All parts of *M. oleifera* are considered edible and are useful for food, medicine and water purification purposes. The tree has been termed natural nutrition for the tropics (Farooq *et al.*, 2006). Some parts of the tree such as leaves are used as primary food source and in the treatment of acute malnutrition (Faheh, 2006). The nutrients are very important for health and vitality because its parts contain so many essential nutrients daily required for both infants and adults. *M. oleifera* seed is rich in protein, lipids and minerals (Compaore *et al.* 2011; Oladeji *et al.* 2017a). The protein of *M. oleifera* seed is of high quality and is easily digested. The seed yield 38-40% edible oil. The oil is clear, odourless and resists rancidity (Farooq *et al* 2006; ASAT, 2009). The seed cake remaining after oil extraction may be used as fertilizer or as a flocculent that forms the particles into a solid to purify water. The oil and micronutrients have been reported to contain antitumor, antiepileptic, antidiuretic and anti-inflammatory (Kasolo *et al.*, 2010). Considering the nutritional richness of *M. oleifera* seed it may be useful in combating protein-energy malnutrition and various health problems arising from imbalance and inadequate nutrient daily required by the body. The seed also contain low level of antinutrients which are responsible for its slightly bitter taste and this can easily be removed by treatment (Ogunsina *et al.*, 2010; Oladeji *et al.*, 2017a). Studies exist on the effect of boiling and fermentation of *M. oleifera* seed used in the enrichment of *Ogi* (Oladeji *et al.*, 2017b) and also on nutritional composition of *M. oleifera* seed from different part of the world (Foidl *et al.*, 2001; Irinkoyenikan, 2015). There is dearth of information on method of inclusion of this seed in *ogi* process line. Oluwamukomi *et al.* (2005) studied the effect of different points and states of soybean inclusion on the quality of *Ogi*. The researchers reported that souring soy flour and *Ogi* slurry together for 24 h was most preferred upon sensory evaluation for *Soyogi*. This study is therefore aimed at providing information on method of inclusion of *M. oleifera* seed in *Ogi* process line such that the nutritional value of the seed is maintained and the end product is found acceptable to the consumers.

Materials and Methods

Materials collection

White maize (ART/98/SW05-OB-W) was obtained from the institute of Agricultural Research and Training (IAR&T), Ibadan, Nigeria. *M.oleifera* seed was obtained from the Teaching and research farm of Obafemi Awolowo University, Ile-Ife, Nigeria. All chemicals used were of analytical grade.

Preparation of *Ogi* and *Moringa-ogi* flour

Ogi was prepared using modified traditional method of Odunfa (1985) in which maize was fermented for 48 h, milled and sieved with double layer muslin cloth. The filtrate was allowed to stand for 24 h, dewatered, dried and milled to produce *Ogi* flour. *M. oleifera* seed was included in *Ogi* process line in ratio 80:20 (Maize : *M. oleifera* seed) at three different stage as shown in Figure 1 to obtain three samples of *Moringa-ogi* (MMS, OSMS, OFMS). 100% maize *Ogi* was used as control. Drying was done using locally fabricated hot air dryer in the Department of Food Science and Technology, Obafemi Awolowo University, Ile-Ife while grinding was done using Marlex Excella dry mill (Marlex Appliances PVT, Daman). The control sample and sample from each mixes were analysed to determine their proximate, mineral elements, ascorbic acid and; total carotenoid content, Sensory attributes, functional and pasting properties were also determined.

Proximate analysis of *Ogi* and *Moringa-ogi* flour

Proximate composition of the flour were determined by the standard method of analysis of the Association of Officaial Analytical Chemists (AOAC, 2000). Percent nitrogen was estimated by micro-kjeldah method using automated nitrogen distiller and crude protein content was calculated by multiplying the nitrogen value with 6.25. Crude fat was determined by the continous solvent extraction method using soxhlet apparatus. Determination of total ash content was done by ashing at 550^{o}C for 3 h. The crude fibre content was determined by digestion method and moisture content was done by weighing in crucible and drying in oven at 105 ^{o}C, until constant weight was obtained. Carbohydrated was determined by difference of the sum of all the proximate composition from 100.

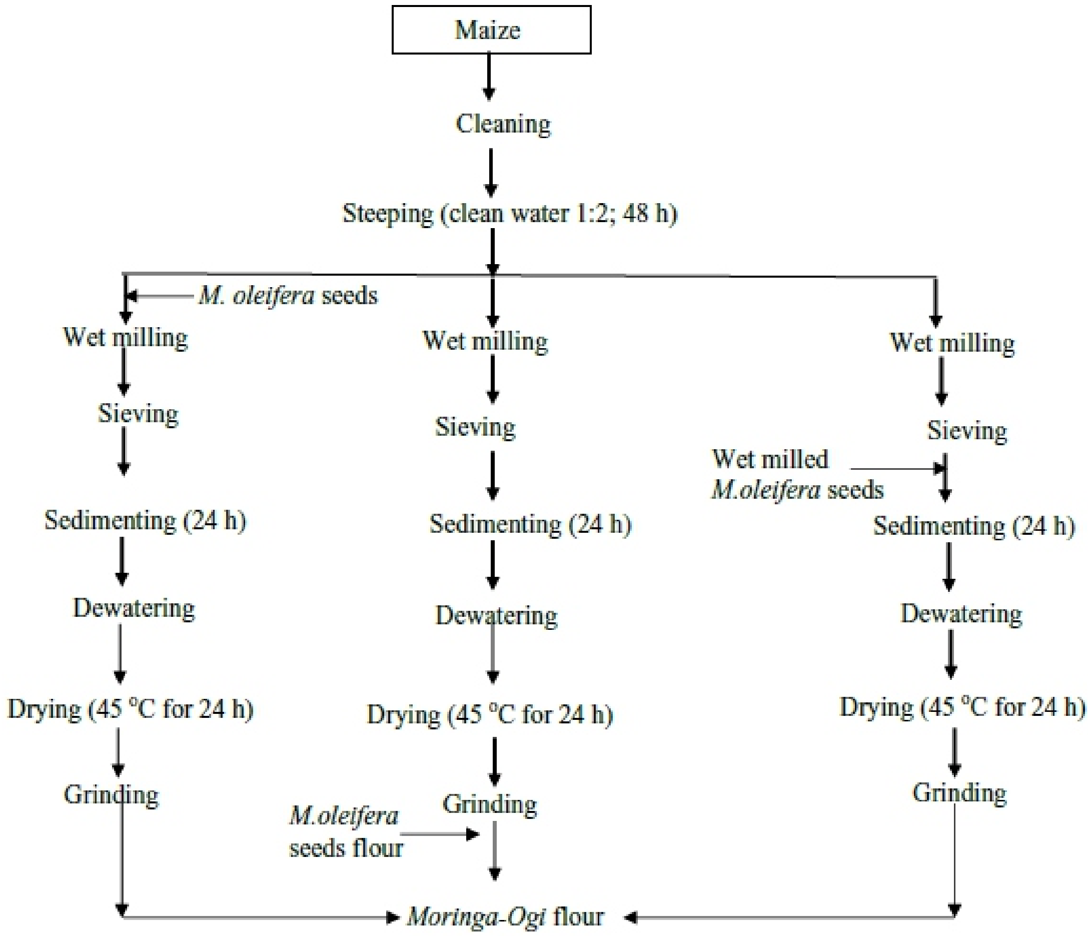

Figure 1: Chart showing point of inclusion of M.oleifera seeds in *O*gi flour process line

Total energy

The total energy (kcal/100g) value of the flour was determined using the equation shown below

Total energy = [(%carbohydrates x 4)+(%protein x 4)+ (% fat x 9)]

Mineral element analysis of *Ogi* and *Moringa-ogi* flour

The mineral compositions of the samples were determined according to the method of AOAC 2000. One gram (1 g) of flour was digested with nitric acid: perchloric acid: sulphuric acid mixture in the ratio 9:2:1 respectively and filtered. The filtrated was made up to mark in a 5ml volumetric flask. The filtered solution was loaded to an atomic absorption spectrophotometer (Perking Elmer, model 402) for the determination of calcium, magnesium, manganese, copper, iron and zinc. Sodium and potassium were determined by flame photometry while phosphorous was determined using the Vanado-molybdate method.

Ascorbic acid and total carotenoid analysis of *Ogi* and *Moringa-ogi* flour

Ascorbic acid content was determined using indo phenol titration method (AOAC, 2000). The total carotenoids was determined spectrophotometrically as described by Fish *et al.* (2002).

Physicochemical properties of O*gi* and M*oringa-ogi* flour

The pH was measured by making 10% w/v suspension of the flour sample in distilled water. The suspension was mixed thoroughly and the pH was measured with a Hanna checker pH meter (Model HI 1270) after it was calibrated with buffer 4.0 and 7.0. Bulk density was determined according to the method of Okezie and Bello (1988). Swelling power and solubility were determined at different temperature using modified method of Sathe and Salunkhe

(1981).

Pasting characteristics analysis of *Ogi* and *Moringa-ogi* flour

Pasting properties were determined using Rapid Visco Analyzer (Newport Scientific PTY Ltd. Warriewood NSW 2120, Australia). The moisture content of the sample was first determined to obtain the correct sample weight and amount of water required for the test. An aqueous suspension of sample was then made and spun at 75 rpm. The temperature-time conditions included a heating step from 50 °C to 95 °C at 6 °C/min (after an equilibrium time of 1min at 50 °C), a holding phase at 95 °C for 2 min. Reading were displayed on the monitor in a numerical and graphical form. Viscosities were expressed in rapid viscosity units (RVU).

Sensory evaluation of *Ogi* and *Moringa-ogi* flour

The flour (50 g) was reconstituted in 80 ml cold water and about 500ml boiling water was thereafter added until a viscous porridge was formed. The resultant ogi porridge was served hot to a fifteen member untrained panelist, who are familiar with *ogi*, made up of students and staffs of Department of Food Science and Technology, Obafemi Awolowo University, Nigeria. The assesment for taste, colour, aroma, consistency and overall acceptability was done on a 9-point Hedonic scale which was quantified from one for dislike extremely to nine like extremely.

Data analysis

Experimental data were generated in triplicate and the result expressed as mean ± standard deviation. Analysis of variance (ANOVA) was performed and difference in mean values were evaluated using Duncan of SPSS statistics software version 17.

RESULTS

Proximate composition of *Ogi* and *Moringa-ogi* flour

Proximate composition of *Ogi* enriched by the addition of *M. oleifera* seed at three different stages in *ogi* process line, with 100% maize *ogi* as the control (OF) is shown in Table 1. The moisture contents ranging from 8.15-8.95% were within the acceptable value for flour products. Crude protein content ranged from 9.73% for sample MMS (*M.oleifera* seed wet milled with fermented maize) to 15.77% for sample OFMS (*ogi* flour +*M.oleifera* seed flour). *Moringa-ogi* also contained 0.67-1.121% ash, 12.34-14.44% fat, 0.85-1.51% fibre and 58.92-67.83% carbohydrate. These values were significantly higher ($p \leq 0.05$) than the control which contains 6.76% protein, 0.53% ash, 5.05% fat, and 0.52% fibre except carbohydrate values which were significantly lower ($p \leq 0.05$) than the control (79.05). This showed that enriching *Ogi* with *M. oleifera* seed significantly improved essential nutrients. Sample MMS had the least nutritional value which could be due to the processing method in which some of the nutrients are lost during wet milling, sieving and decanting. However, the result obtained is comparable to the value reported by other researchers who enriched *Ogi* with vegetative seed (Egounlety *et al.*, 2002; Enujuigha, 2006; Oluwamukomi *et al.*, 2005). Higher values obtained for sample OFMS implies that *M.oleifera* may best be added to *Ogi* in its finished state.

Table 1: Proximate composition of *Ogi* and *Moringa-ogi* flour (%)

Composition	MMS	OSMS	OFMS	OF
Moisture	8.60±0.19 ab	8.95±0.31 b	8.15±0.30 a	8.27±0.06 ab
Crude Protein	9.73±0.25 b	10.86±0.25 c	15.77±0.25 d	6.58±0.12 a
Total Ash	0.67±0.04 b	0.99±0.03 c	1.21±0.01 d	0.53±0.04 a
Crude Fibre	0.85±0.03 b	0.98±0.01 c	1.51±0.01 d	0.52±0.01 a
Crude Fat	12.34±0.59 b	13.38±0.80 ab	14.44±0.19 c	5.05±0.11 a
Carbohydrate	67.81±0.64 c	64.84±1.37 b	58.92±0.76 a	79.05±0.67 d
Energy(kcal/100g)	420.36±1.12 b	423.22±1.32 b	428.62±0.75 b	388.71±0.23 a

[a] MMS (Maize + *Moringa oleifera* seed); OSMS (*ogi* slurry + *Moringa oleifera* seed); OFMS (*ogi* flour + *Moringa oleifera* seed flour): of (100% *ogi* flour-control). [b] values are expressed as means ± standard deviation; mean with same letters on same row are not significantly different ($p \leq 0.05$)

Mineral composition of *Ogi* and *Moringa-ogi* flour

The composition of mineral elements found in *Moringa-ogi* is shown in Table 2. Sample OFMS had the highest concentrations in mg/100g of all the mineral elements examined – K (81.25), P (199.36), Mg (234.45), Ca (26.94), Fe (6.15), Zn (9.94), Mn (1.78) and Cu (1.27) except sodium which was found to be higher in the control sample (30.34 mg/100g) than in the *Moringa-ogi* samples (ranged from 26.50 to 27.93 mg/100g for sample OSMS and OFMS respectively). Sample MMS had the least for K, P, Ca Fe, Zn, and Mn while least concentrations for Mg (184.10 mg/100g) is found in sample OSMS. The least concentration of the minerals observes in sample MMS and OSMS were still higher than the concentrations of the same mineral elements in the control sample (OF). This implies that though inclusion of *M. oleifera* seed in *ogi* increased mineral elements concentration, the amount imparted depends on the method of addition of *M. oleifera* seed. The result obtained in this study indicates that some minerals presents in *M. oleifera* seed were lost during processing of the seed in the production of *ogi*. Processes such as dehulling and leaching has been reported to reduce concentration of mineral elements (Ijeh *et al.*, 2010) Therefore, there may be need to process the seed separately before adding to *ogi* for the maximum concentration of mineral in the seed to be imparted into *ogi*. Mineral elements play important roles in health and disease states of human and domestic animals.

Table 2: Mineral composition of *Ogi* and *Moringa-ogi* flour

Elements (mg/100g)	MMS	OSMS	OFMS	OF
Potassium, K	68.75±0.82 [b]	81.20±0.17 [c]	81.25±0.46 [c]	62.50±0.29 [a]
Phosphorus, P	168.58±2.63 [b]	189.13±2.53 [c]	199.36±1.87 [d]	142.76±2.06 [a]
Magnesium, Mg	211.57±1.60 [c]	184.10±1.28 [b]	234.45±2.08 [d]	117.36±1.72 [a]
Sodium, Na	26.63±1.59 [a]	26.50±0.57 [a]	27.93±1.21 [a]	30.34±0.84 [b]
Calcium, Ca	18.63±0.08 [b]	18.94±0.36 [c]	26.94±0.17 [d]	14.95±0.07 [a]
Iron, Fe	4.05±0.59 [a]	6.04±0.55 [b]	6.15±0.63 [b]	3.66±0.16 [a]
Zinc, Zn	7.46±0.12 [b]	7.64±0.64 [b]	9.94±0.32 [c]	0.52±0.34 [a]
Manganese, Mn	1.47±0.86 [a]	1.66±0.11 [b]	1.78±0.06 [b]	1.40±0.06 [a]
Copper, Cu	0.89±0.03 [a]	0.85±0.11 [a]	1.27±0.34 [b]	1.05±0.05 [ab]

[a] MMS (Maize + *Moringa oleifera* seed); OSMS (*ogi* slurry + *Moringa oleifera* seed); OFMS (*ogi* flour + *Moringa oleifera* seed flour): OF (100% *ogi* flour-control). [b] values expressed as means ± standard deviation; mean with same letters on same row are not significantly different ($p \leq 0.05$)

Ascorbic acid and total carotenoid content of *Ogi* and *Moringa-ogi* flour

Total carotenoid and ascorbic acid content of the samples ranged from 24.40-46.00 µg/g and 0.36-0.56 mg/g respectively (Table 3) and were significantly higher ($p \leq 0.05$) than the control. Sample with the addition of *M. oleifera* seed flour to *Ogi* flour (OFMS) had the highest value for both total carotenoid and ascorbic acid while sample with *M.oleifera* seed milled with maize and processed to *Ogi* flour had the least value. The low value of total carotenoid observed in sample MMS and OSMS may be due to mechanical loss in the *M. oleifera* seed during milling and sieving since portion of the total fat is loss during these processes, there is possibility of losing portion of the fat-soluble vitamins. Loss in ascorbic acid of the same samples may be due to wet milling, several washing and decanting process involve in processing maize to *Ogi* (Figure 1) because ascorbic acid is water soluble. Ejigui *et al.* (2005) reported loss in β-carotene contained in a starchy endosperm of yellow maize due to repeated washing, sieving and decanting steps associated with fermentation. Rodriguez-Amaja (1999) also reported that carotenoid degradation increase with the destruction of food cellular structure, increase of surface area or porosity, length and severity of the processing conditions.

Table 3: Ascorbic Acid and Total carotenoid content of *Ogi* and *Moringa-ogi* flour

Components	MMS	OSMS	OFMS	OF
Total carotenoid (µg/g)	24.40±2.82 [b]	26.80±6.22 [b]	46.00±0.57 [c]	12.00±2.26 [a]
Ascorbic Acid (mg/g)	0.36±0.05 [b]	0.46±0.09 [b]	0.56±0.05 [b]	0.13±0.10 [a]

[a] MMS (Maize + *Moringa oleifera* seed); OSMS (*ogi* slurry + *Moringa oleifera* seed); OFMS (*ogi* flour + *Moringa oleifera* seed flour): OF (100% *ogi* flour-control). [b] values expressed as means ± standard deviation; mean with same letters on same row are not significantly different ($p \leq 0.05$)

Sensory attributes of *Ogi* and *Moringa-ogi* flour

The result of sensory evaluation is shown in Table 4. The taste of *moringa-ogi* samples was significantly different from each other and from the control. However, the taste was liked by the panelists except for the taste of sample OFMS which was neither like nor dislike (5.53). This may be due to slightly bitter taste imparted in the *ogi* by adding *M.oleifera* seed flour. This did not affect other samples (MMS and OSMS) as processing such as wet sieving, fermentation, and decanting processes might have taken care of such (Oladeji *et al.*, 2017a). Sensory score for the colour ranged from 7.93-8.60 meaning that the panelist likes the colour of *Moringa-ogi* irrespective of the method of addition of the seed in *Ogi* process line, likewise the aroma (6.40-7.80) and consistency (6.13-7.3). There was no difference in the overall acceptability of the sample MMS (7.73) and control (8.40) but sample OFMS (5.13) was neither accepted nor rejected. This shows that the method of adding wet milled *M.oleifera* seed to *O*gi slurry after sieving (OSMS) or wet milled together with the maize (MMS) is more acceptable than other method. Oluwamukomi *et al.* (2005) reported that souring soy flour with *Ogi* slurry had better consumer acceptability than just mixing soy flour with *Ogi* flour.

Table 4: Sensory attributes of *Ogi* and *Moringa-ogi* flour

Sensory attributes	MMS	OSMS	OFMS	OF
Taste	7.53±0.99 [c]	6.47±1.45 [b]	5.53±1.73 [a]	8.33±1.11 [d]
Colour	8.60±1.05 [b]	8.07±0.88 [ab]	7.93±1.05 [a]	8.93±0.96 [b]
Aroma	7.80±1.05 [c]	7.13±1.41 [b]	6.40±1.55 [a]	8.40±0.91 [c]
consistency	7.13±0.96 [b]	8.47±1.26 [b]	6.13±1.83 [a]	8.80±1.29 [b]
Overall acceptability	7.73±1.24 [c]	6.80±1.37 [b]	5.13±1.87 [a]	8.40±1.45 [c]

[a] MMS (Maize + *Moringa oleifera* seed); OSMS (*ogi* slurry + *Moringa oleifera* seed); OFMS (*ogi* flour + *Moringa oleifera* seed flour): OF (100% *ogi* flour-control). [b] values expressed as means ± standard deviation; mean with same letters on same row are not significantly different ($p \leq 0.05$)

Physicochemical properties of *Ogi* and *Moringa-ogi* flour

The pH range from 4.06-4.13 and bulk density ranged between 0.67 and 0.69 g/ml as shown in Table 5. The enriched samples were not significantly different from one another as well as the control. Least gelation concentration of the samples ranged between 5 to 7% with the control having 5% concentration. *Moringa-ogi* samples fully formed gel at 7 % concentration though partial gelation was observed for the enriched sample at 5 % concentration implying that the gelation of each samples including the control were not significantly different ($p \le 0.05$) from each other. The least gelation concentration obtained in this study was similar to the range reported by Ogunsina and Radha (2010). They reported that debittered *Moringa oleifera* seed started to gel between 4 to 8% concentration. This further indicates that *Moringa oleifera* seed may not exert significant difference on gelling concentration of *Moringa-ogi* samples.

The swelling capacity of *Moringa-ogi* samples at different temperatures ranged from 0.80 to 4.66 as presented in Figure 2. Swelling power of all the samples increased with increase in temperature. This is because increase in temperature during heating usually cause increase in swelling (Bolaji and Oyewo, 2017). However, control sample possessed higher swelling power than *Moringa-ogi* sample at all the temperature examined. This implies that inclusion of *M. oleifera* in *Ogi* reduced the starch content thereby causing a decrease in swelling ability (Irinkoyenikan, 2015). *Moringa.*

Table 5: Physicochemical properties of *Ogi* and *Moringa-ogi* flour

Functional Properties	MMS	OSMS	OFMS	OF
pH	4.07±0.05 [a]	4.13±0.20 [a]	4.09±0.10 [a]	4.06±0.30 [a]
Bulk density (g/ml)	0.67±0.01 [a]	0.69±0.07 [a]	0.69±0.01 [a]	0.67±0.01 [a]
Least gelation Concentration %	3	5	7	9
MMS	-	-+	++	++
OSMS	-	-+	++	++
OFMS	-	-+	++	++
OF	-	++	++	++

MMS (Maize + *Moringa oleifera* seed); OSMS (*ogi* slurry + *Moringa oleifera* seed); OFMS (*ogi* flour + *Moringa oleifera* seed flour): OF (100% *ogi* flour-control). Values expressed as means ± standard deviation; mean with same letters on same row are not significantly different ($p \le 0.05$); - not gelled -+partially gelled ++ gelled

Ogi samples have low swelling power at 60 and 70°C than at higher temperature. Sample MMS has improved swelling ability at higher temperature implying higher ability to absorb water than other *Moringa-ogi* samples. Rate of swelling of the samples may be a reflection of associative forces within starch granules and ratio of amylase to amylopectin components of the samples (Onitilo 2007). Solubility (Figure 3) also increased with increase in temperature up to 80 °C and decrease at 90 °C with the control sample having the least solubility index at all temperature examined. Solubility of samples MMS and OSMS were not different from one another while sample OFMS had the highest solubility index. This may be due to chemical components of the samples as a result of *M. oleifera* seed incorporated. Reduction in solubility is connected to the increase in leaching of amylose with increase in temperature (Bolaji and Oyewo, 2017).

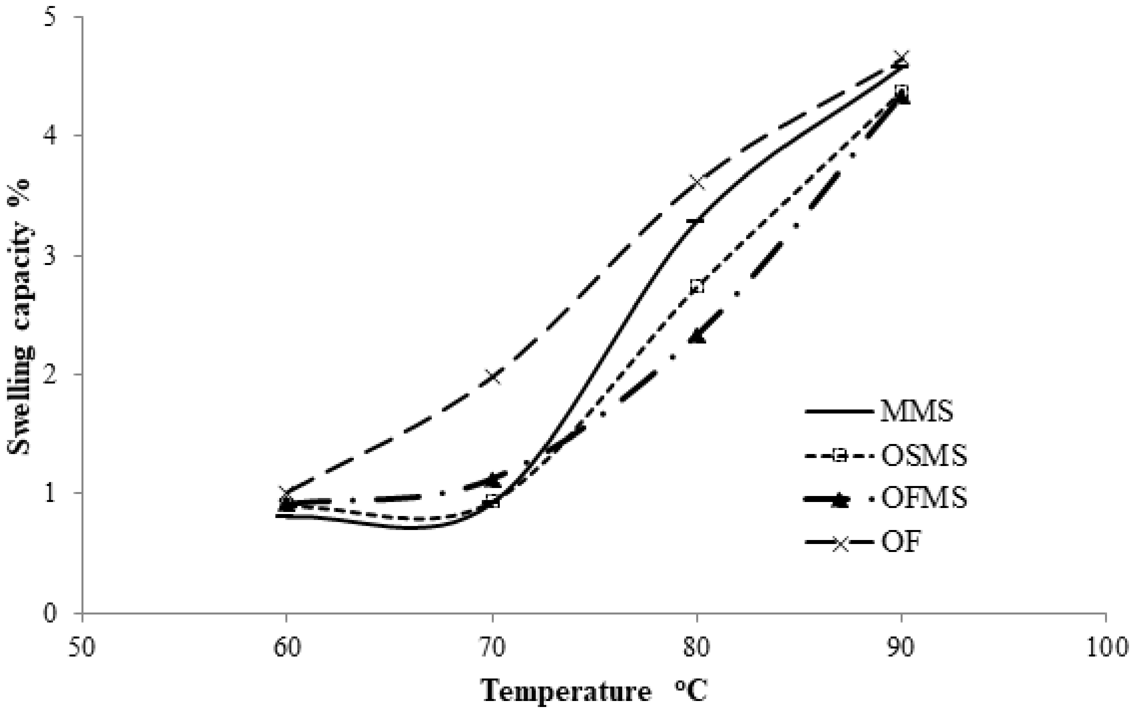

Figure 2: Effect of Temperature on Swelling Capacity of *Ogi* and *Moringa-ogi* Flour

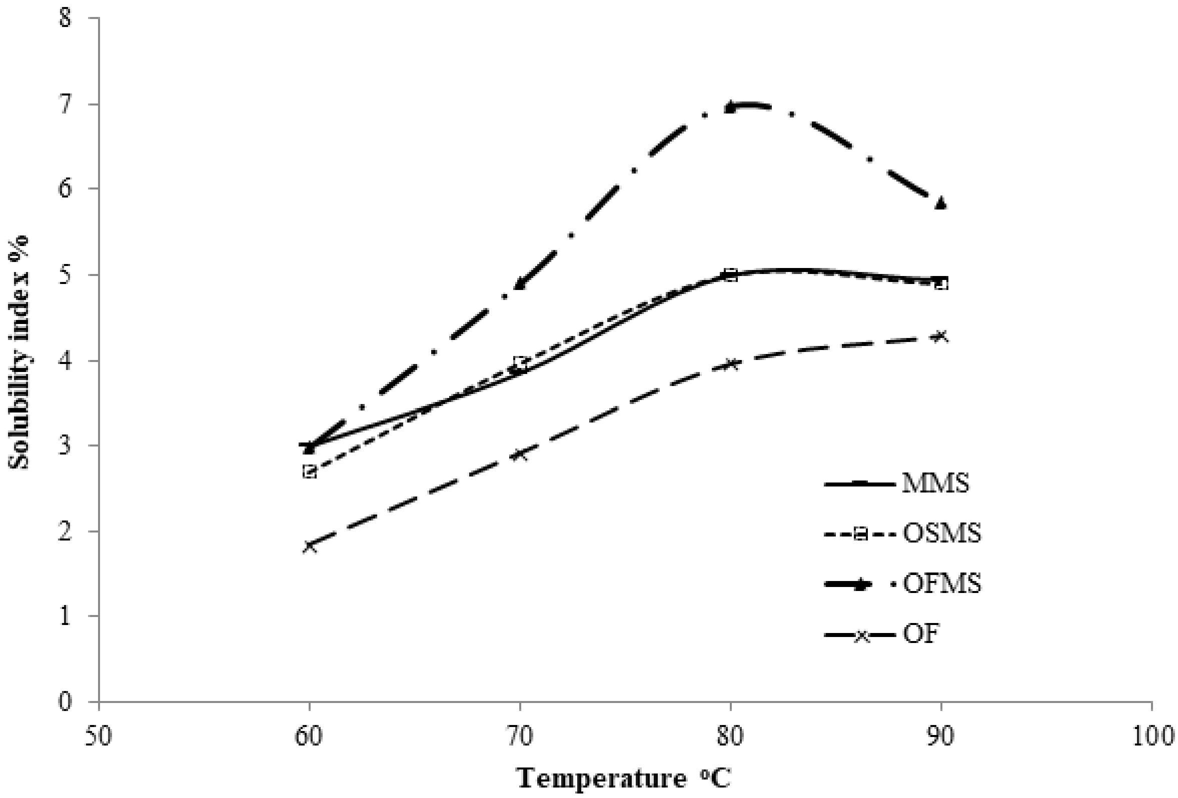

Figure 3: Effect of temperature on solubility of *Ogi* and *Moringa-ogi* flour

Pasting characteristics of *Ogi* and *Moringa-ogi* flour

The pasting characteristics are shown in Table 6. The values ranged from 168.42-302.25 RVU for peak viscosity, 82.29-103.30 RVU for trough (holding strength), 83.13-171.96 RVU for breakdown viscosity, 179.50-327.33 RVU for final viscosity and 83.13-197.04 for setback. The values obtain in this study were higher than the reported values for three days fermented *Ogi* by Adegunwa *et al.* (2011).

100% maize *Ogi* (OF) had the highest values for all the pasting qualities and were significantly higher than samples with *M. oleifera seed*. The reduction in the pasting viscosities could be due to presence and interaction of components, such as fat and proteins, from *M.oleifera* seed with the gelling properties of the starch components of *Ogi* flour (Oluwamukomi *et al.*, 2005). Sample OFMS had the least value for peak viscosity, holding strength and breakdown while sample OSMS had least value for final viscosity and setback. This implied that addition of *M.oleifera* seed to *Ogi* reduced values of the pasting viscosities of *Ogi* paste during and after cooking. This also showed that adding *M. oleifera* seed flour to *Ogi* flour will result in porridge with lower tendency to withstand high heat treatment, lower resistance to shear and its swollen granules can be more easily disintegrated as compared with the control (Lawal, 2005; Olayinka *et al.*, 2008). High value observed for final viscosity of sample showed that all the samples can maintain their gelling ability after cooking. Set back values indicate the samples have the tendency to harden on cooling which is a highly desirable quality for making *Eko* (a thick *Ogi* porridge). However, adding wet milled *M. oleifera* seed to *Ogi* slurry after sieving may result in porridge with lower tendency to maintain their gelling ability after cooking and hence lower tendency to harden on cooling when compared with porridge from 100% maize *Ogi*. Peak time ranged from 4.44-5.47 min while pasting temperature ranged from 73.80-75.88 °C. Pasting temperature of sample MMS was not significantly lower than control while sample OSMS and OFMS were significantly higher than the control but not different from each other. This implies that sample OSMS and OFMS may require more energy consumption to cook than the control. Sample OFMS has the highest peak time and pasting temperature but least peak viscosity implying that this sample with the addition of *M. oleifera* seed flour to *Ogi* flour will take longer time to gel as compared with other. This may be due to the buffering effect of the fat of the *M. oleifera* seed on the gelling properties of the starch *Ogi* (Oluwamukomi *et al.*, 2005).

Table 6: Pasting characteristics of *Ogi* and *Moringa-ogi* flour

Parameters	MMS	OSMS	OFMS	OF
Peak 1 (RVU)	243.33±4.82 c	193.29±7.37 b	168.42±2.70 a	302.25±7.07 d
Trough 1 (RVU)	98.42±2.12 b	96.37±1.35 b	82.29±1.24 a	103.30±2.30 c
Breakdown (RVU)	144.92±2.71 b	96.92±6.01 a	85.13±3.95 a	171.96±9.37 c
Final Viscosity (RVU)	220.29±3.94 b	179.50±4.48 a	227.83±3.53 b	327.33±3.53 c
Setback (RVU)	121.88±1.83 b	83.13±3.11 a	144.53±2.30 c	197.04±5.83 e
Peak time (min)	4.44±0.05 a	4.50±0.04 a	5.47±0.00 c	4.80±0.00 b
Pasting temp (°C)	73.80±0.57 a	75.40±0.57 b	75.88±0.04 b	74.57±0.60 a

MMS (Maize + *Moringa oleifera* seed); OSMS (*ogi* slurry + *Moringa oleifera* seed); OFMS (*ogi* flour + *Moringa oleifera* seed flour): OF (100% *ogi* flour-control). Values expressed as means ± standard deviation; mean with same letters on same row are not significantly different ($p \leq 0.05$)

Conclusions

The study showed that incorporation of *M. oleifera* seed in production of *Ogi* improved essential nutrients of the resulting products irrespective of the method of inclusion. Mixture of *M. oleifera* seed flour with *Ogi* flour resulted in better nutritional value but the taste was least accepted by the consumer. In the overall consumer acceptability, sample obtained by processing *M. oleifera* seed with raw maize was as acceptable as the control. Method of inclusion of *M. oleifera* seed in *Ogi* process line has no significant influence on the physicochemical attributes of *Moringa-ogi*. Therefore, it could be recommended that any of the methods could be used as desired by the consumer.

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