



Nutritional and Sensory Properties of Sorghum-Maize ‘Ogi’ Fortified With Moringa Seeds and Leaves

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ABSTRACT

The effects of moringa leaves and seeds fortification on the nutritional value and overall acceptability of Sorghum-Maize ‘ogi’ was investigated. The ‘Ogi’ produced from sorghum and maize was enriched with moringa leaves and seeds at substitution level of 10%. Sorghum, maize and moringa seeds/ leaves were constituted in the ratio 45:45:10 while sorghum ogi with moringa leaf/seeds was constituted in the ratio 90:10. The proximate content, mineral and vitamins content and the sensory properties of the ogi samples were determined. There was increase in the proximate content with the variation in the ratio of sorghum and maize and 10% Moringa seed enrichment. There was increase in the mineral content. The swelling capacity decreased with 10% moringa leaf and seed substitution. The ogi sample with 10% moringa seeds substitution was rated close to the unfortified ogi sample.

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Introduction

“Ogi” or pap is a fermented semi solid food made from cereals such as maize (*zea mays*), sorghum (*Sorghum vulgare*) or millet (*pennisetum typoideum*). It is cheap, extremely light, easily digestible and serves as a staple food of West Africa. It is used as weaning foods for babies, breakfast cereal for adults, a meal to enhance breast milk production and recovery diet for the sick; but has low nutritional value since it is not an adequate source of micro and macro nutrients (Fasasi et al., 2006; Afolayan et al., 2010).

In the course of processing ‘ogi’, a lot of nutrients are lost including proteins and minerals. The traditional preparation of ogi involves soaking of corn kernels in water for 1 to 3 days followed by wet milling and sieving to remove bran, hulls and germ. The pomace is retained on the sieve and later discarded as animal feed while the filtrate is fermented (for 2-3 days) to yield ogi, which is sour, white starchy sediment (Ijabedeniyi and Adebolu, 2005). Studies have shown that ‘ogi’ has very little nutritive value. The situation is even made worse by the method of its processing which involves wet milling, wet sieving and several washings which deplete it of even the little nutrients it contains (Ogunola et al., 2007). Therefore, many research attempts have been made at fortifying ogi to improve its nutritional value with plant protein sources. A protein enriched ogi containing 10% soya flour was developed by the Federal Institute of Industrial Research Oshodi (FIIRO) in Lagos, Nigeria (Odufa, 2001). Other research attempts include fortification of ogi with okra seed flour, addition of pawpaw slurry at varying levels, fortification with groundnut etc (Adeyemi and Soluade, 1993; Aminigo and Akingbala, 2004; Ajanaku et al., 2012).

Moringa is a fast growing, drought resistant tree native to Sub-Himalayan India but which is now being grown throughout the tropics and subtropics. The leaf can be eaten fresh or prepared similar to spinach but it is reported to “contain over three times the amount of vitamin A found in

spinach, four times the amount of calcium found in cow milk, more Vitamin C than oranges, and more potassium than bananas, and the protein quality of Moringa leaves is comparable to that of milk and eggs” (Nadeem et al, 2012). They are reported to be low in fats and carbohydrates, but contain a very high content of protein, calcium, zinc, iron, and vitamins A, B, and when raw, vitamin C (Gopalakrishnan, Doriya, & Kumar, 2016). In recent times, there has been a lot of focus on the nutritional properties of Moringa in most countries where it is native because of its potential to combat malnutrition. Moringa seeds have been reported to contain fatty acids like Linoleic acid, linolenic acid, behenic acid, oleic acid (Ben oil), antibiotic called pterygospermin, phytochemicals like tannins, saponin, phenolics, phytate, flavanoids, terpenoids and lectins. Apart from these fats, it also contains fiber, proteins, minerals, vitamins like A, B, C and amino acid (Rockwood et al., 2013). Table 1 shows the nutrient compositions of moringa leaves, leaf powder, seeds and pods.

Some research work have been carried out on the fortification of maize- ogi with moringa leaves (Olorode et al, 2013; Abioye and Aka, 2015) and it was concluded that the 10% inclusion of moringa leaves powder was the preferred mix. There is little or no information however on the fortification of sorghum ogi with moringa neither do we have reports on the fortification of ogi with moringa seeds. This research was therefore carried out to investigate the effect of moringa seed fortification on the nutritive and sensory properties of sorghum-maize (composite) ogi and on sorghum ogi alone in comparison with the effect of moringa leaf fortification.

Materials and methods

The yellow variety of maize and the brown variety of sorghum were purchased from odo-ori market in Iwo town, Osun state while moringa leaves and seeds were harvested from a private farm in Ibadan, Oyo state.

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Table 1. The nutrient compositions of moringa leaves, leaf powder, seeds and pods.

Nutrients	Fresh Leaves	Dry Leaves	Leaf Powder	Seed	Pods
Calories (Cal)	92	329	205	-	26
Protein(G)	6.7	29.4	27.1	35.97±0.19	2.5
Fat(G)	1.7	502	2.3	38.67±0.03	0.1
Carbohydrate(G)	12.5	41.2	38.2	8.67±0.12	3.7
Fibre (G)	0.9	12.5	19.2	2.87±0.03	4.8
Vitamin B1(Mg)	0.06	2.02	2.64	0.05	0.05
Vitamin B2(Mg)	0.05	21.3	20.5	0.06	0.07
Vitamin B3(Mg)	0.8	7.6	8.2	0.2	0.2
Vitamin C(Mg)	220	15.8	17.3	4.5±0.17	120
Vitamin E(Mg)	448	10.8	113	751.67±4.41	-
Calcium(Mg)	440	2185	2003	45	30
Magnesium (Mg)	42	448	368	635±8.66	24
Phosphorous(Mg)	70	252	204	75	110
Potassium (Mg)	259	1236	1324	-	259
Copper (Mg)	0.07	0.49	0.57	5.20±0.15	3.1
Iron (Mg)	0.85	25.6	28.2	-	5.3
Sulphur (Mg)	-	-	870	0.05	137

All values are in 100 g per plant material (Gopalakrishnan, Doriya & Kumar, 2016).

Preparation of OGI (wet and dry form)

Ogi powder was prepared using a standard method (Akingabala et al., 1981; Otunola et al., 2007)

Preparation of moringa leaf and seed powder

This was done using the method of Beth and Lindsay (2005) with some modification. Leaves with stems were harvested and brought to the laboratory; they were stripped off the stems and rinsed in clean water to remove dirt and germs. The leaves were air dried in an area (shade) protected from direct sunlight to prevent the loss of vitamins e.g. Vitamin A. When leaves became brittle and crush easily, they were dry. Dried leaves were blended into powder. Moringa oleifera seed powder was produced as follows; freshly plucked Moringa seeds were deshelled and it was then milled and allowed to cool and packaged in cellophane bags until it was needed for further use.

Sorghum-Maize Fortified Ogi Formation

The amount of Sorghum, Maize, Moringa seeds and leaves was varied in each sample

Sample SML -45% Sorghum(S) +45% Maize (M) +10% Moringaleaves (L)

Sample SL - 90% Sorghum(S) +10% MoringaLeaves (L)

Sample SO (Sorghum only)- 100% Sorghum

Sample SMS -45% Sorghum(S) +45% Maize (M) +10% Moringaseeds (MS)

Sample SS -90% Sorghum(S) +10% Moringaseeds (MS)

They were mixed thoroughly to obtain moringa- ogi powder.

Determination of proximate composition

The moringa ogi were analysed for moisture, ash, crude fiber and fat (ether extract) contents using a standard method. Nitrogen content was determined using micro- kjeldahl and converted to crude protein (N x 6.25) while the carbohydrate content was calculated by difference as described by AOAC 2005.

Determination of mineral and vitamin content

These were done using standard methods as described by AOAC 2005.

Swelling Capacity and solubility

0.5g of sample was weighed into weighted test tubes into which 10ml of distilled water was added. The suspension was

stirred sufficiently and uniformly, avoiding excess speed to prevent fragmentation. This is transferred into pre-weighed centrifuge tubes and heated for 30 mins in a water bath at 80-85°C with constant stirring. The tube was then removed, wiped dry on the outside and cooled to room temperature. It was then centrifuge for 15 mins at 2200rpm. The supernatant was decanted into pre-weighed Petri dishes and dried at room temperature of 108°C for 2 hours. The weight of the sediment in the centrifuge tube was taken; the weight of the dried Petri dishes was taken. (Zakpaa et al, 2010) Swelling power and solubility was calculated as:

Swelling power = $\frac{\text{Weight of wet mass of sediment}}{\text{Weight of sample} - \text{Weight of soluble}}$

Solubility = $\frac{\text{Weight of soluble} \times 100}{\text{Weight of sample}}$

Solubility = $\frac{\text{Weight of soluble} \times 100}{\text{Weight of sample}}$

Sensory Evaluation

Sensory evaluation was carried out on the ogi by preparing semi solid porridge from the samples. The prepared ogi was dished into sample plates and assessed by twenty five untrained panelists who were asked to rank the ogi based on their sensory perceptions of the attributes. The panelists were made up of students who were very familiar with ogi gruel. A 9 point hedonic scale ranging from 9=like extremely to 1=neither like nor dislike was used to test for quality attributes such as color, flavor, taste, texture, aroma and overall acceptability.

Statistical Analysis

Means of duplicate determination were analyzed using the one way analysis (ANOVA) and multivariate analysis where applicable with $\alpha=0.05$ (SPSS 20.0 for windows, USA) to determine statistically or otherwise in differences between the quality attributes of proximate composition and sensory parameters of cookies samples. Duncan's multiple range test procedure at 95% confidence level discriminated among the means.

Result and Discussion

Proximate composition of the fortified 'ogi'

Table 2 shows the proximate composition of the ogi produced from Sorghum and Maize with Moringa leaves and seeds.

Table 2. Proximate Composition of the Fortified OGI.

SAMPLE	Moisture content	Ash	Fat	Fiber	Protein	CHO
SML	6.94±0.79 ^b	2.59±3.11 ^b	6.33±0.50 ^{bc}	0.98±0.21 ^b	11.72±1.12 ^{ab}	71.41±4.12 ^a
SL	9.09±1.36 ^b	6.22±5.10 ^{ab}	8.99±7.70 ^{abc}	2.20±1.05 ^b	11.75±1.92 ^{ab}	61.73±5.36 ^{ab}
SO	9.09±1.00 ^b	2.84±2.79 ^b	3.50±2.21 ^c	1.89±0.20 ^b	12.07±0.45 ^{ab}	70.59±4.79 ^a
SMS	6.30±3.20 ^b	3.30±0.72 ^b	11.34±3.47 ^a	0.86±0.14 ^c	15.24±1.30 ^{ab}	63.20±4.77 ^{ab}
SS	9.33±1.68 ^b	9.17±2.62 ^a	12.53±5.36 ^{ab}	3.12±0.87 ^a	17.24±1.37 ^a	51.26±9.15 ^b

Values are mean of two determination± standard deviation (n=2). Values with the different superscript within the same row are significantly different from each other (p≤0.05)

SML =45% sorghum (S) +45% maize(M) +10% moringaleaves(L)

SL =90% sorghum(S) +10% moringaleaves(L)

SO =100% sorghum (Sorghum Only)

SMS =45% sorghum (S) +45% maize (M) +10% moringaseed(S)

SS =90% sorghum (S) +10% moringaseed(S)

Table 3. Mineral and Vitamin Composition of Fortified OGI.

Sample	Ca (mg)	Fe (mg)	Zn (mg)	K (mg)	Cu (mg)	Mg (mg)	VIT (IU/100g)	A	THIAMINE (mg/100g)
SML	29.42	12.26	1.82	278.4	0.45	10.12	13.45		0.98
SL	23.30	4.15	0.27	135	0.27	12.14	9.28		0.34
SO	5.93	0.67	0.71	31.2	0.04	8.61	11.35		0.85
SMS	13.20	6.43	0.63	81.2	0.92	14.98	12.43		0.15
SS	11.06	3.41	0.41	75.6	0.86	13.94	12.05		0.56

The moisture content of the samples ranged from 6.30% to 9.09% as shown in table 2. The protein content of the fortified ogi ranged from (11.72% to 17.24%) which reflects about 47% increase in the protein content. The samples fortified with moringa seeds had higher protein content than their counterpart fortified with the leaves. This may be due to a higher protein content of the seeds than the leaves as reported by Gopalakrishnan, Doriya & Kumar (2016).

The difference in the protein content of the samples was however not significant and this may be related to the fact that sorghum itself has a relatively high protein content when compared to maize, and all the samples contain sorghum. The protein content obtained with the 10% moringa seed fortification is higher when compared to ogi fortified with okra seed, soybean, moringa leaves at the same level of fortification as previously studied and reported (Aminigo and Akingbala, 2004; Abioye and Aka, 2015; Adesokan *et al.*, 2011; Olorode, Idowu and Ilori, 2013). The carbohydrate content of the fortified ogi ranged from (51.26% to 71.41%).

The carbohydrate content of the sample SML with equal proportions of maize and sorghum and 10% moringa leaves inclusion was the highest with a value that is significantly different from the sample SS which was made from sorghum and moringa seeds only. This is in agreement with the fact that moringa seeds have a relatively low carbohydrate content. The ash content of the fortified ogi ranged from 2.59% to 9.17%. Ash which is the inorganic residue remaining after an inorganic matter has been burnt and also represent the total mineral content is higher in the moringa seeds than the moringa leaves. There was an increase of about 258% with the addition of moringa seeds which has been reported to be rich in some good fatty acids.

Mineral and Vitamin Composition of the Fortified Ogi

The Zinc, Calcium, Potassium, Iron, Copper and Magnesium were analyzed. The calcium content ranging from 5.93 to 29.42, the highest value was found in sample SML (29.42%), followed by sample SL (23.30%) and the lowest value was found the control sample 100%S. This result is similar to previous work done by Abioye and Aka (2015) This results shows that calcium is higher in the sample

containing the moringa leaves than the seeds. Calcium is needed in the development of bones and teeth. The iron content ranged from 0.67% to 12.26%, the highest value was found in sample SML. This result indicates the iron is more present in the leaves than the seeds. The zinc content ranged from 0.41% to 1.82% , the highest value was also found in sample SML. Generally, this results indicates that the samples fortified with moringa leaves were higher in calcium, iron, zinc and potassium content than their counterpart fortified with moringa seeds. Copper and magnesium were however higher in the samples fortified with moringa seeds than the ones fortified with moringa leaves although those fortified with moringa leaves still had higher value than what obtains in the sorghum only (SO) sample. These agrees with previous findings that composite ogi (that is combination of cereals to make ogi) has higher nutritional content than ogi made from a single cereal (Adesokan *et al.*, 2011)

The vitamin A content of the samples ranged from 9.28IU to 13.45IU. The sample with the second highest was found in sample with Moringa seeds. The Thiamine content of the samples ranged from 0.34mg to 0.98mg with the highest in sample A and the lowest in sample this results shows that Vitamin B1 content which is essential for carbohydrate metabolism, healthy appetite and functioning of the nerves.

Functional properties of the Fortified "Ogi"

The swelling power and solubility of the fortified ogi samples are shown in table 4.

Table 4. Functional Properties of the Fortified OGI.

SAMPLE	Swelling Power	Solubility (%)
SML	6.15±1.46 ^c	17.10±2.77 ^b
SL	8.65±2.18 ^{ab}	27.66±12.00 ^{ab}
SO	10.19±0.42 ^a	38.16±8.25 ^a
SMS	7.31±0.81 ^{bc}	10.16±9.18 ^b
SS	8.45±0.48 ^{ab}	15.63±2.48 ^b

Values are mean of two determination± standard deviation (n=2). Values with the different superscript within

Table 5: Sensory Properties of the Fortified OGI.

SAMPLES	COLOUR	TASTE	APPEARANCE	SMOOTHNESS	FLAVOUR	OVERALL
SML	5.05±2.32 ^c	5.00±2.20 ^b	4.20±2.66 ^b	5.15±2.45 ^b	4.35±2.51 ^b	4.35±2.66 ^c
SL	4.65±2.58 ^c	4.15±1.92 ^b	4.50±1.96 ^b	5.65±2.15 ^{ab}	4.30±2.08 ^b	4.85±2.05 ^{bc}
SO	6.90±1.77 ^{ab}	5.85±1.66 ^a	6.45±1.87 ^a	5.05±2.03 ^b	6.15±1.49 ^a	6.10±1.86 ^{ab}
SMS	7.25±2.07 ^a	5.70±2.34 ^a	7.00±1.33 ^a	6.65±1.87 ^a	5.80±2.66 ^{ab}	6.65±2.49 ^a
SS	7.05±1.60 ^a	5.95±2.25 ^a	6.70±1.68 ^a	6.20±2.33 ^{ab}	5.35±2.34 ^{ab}	6.80±1.76 ^a

the same row are significant different from each other ($p \leq 0.05$)

Swelling power and Solubility

The swelling power of the fortified ogi ranges from 6.15 to 10.19 with the lowest in the SML sample and the highest in 100% sorghum. The sample that has no moringa leaves substitution had the highest value while the ogi samples substituted with moringa leaves and seeds had lower values. This shows that the fortification of ogi with either moringa leaves or seeds both affected the swelling power of the ogi negatively.

The solubility of the fortified ogi ranges from 10.60% to 38.16% with the highest in sample SO (sorghum only). The samples fortified with moringa seeds had lower solubility than their counterparts fortified with moringa leaves. This may be due to the higher fat content of the seeds which may interfere with solubility. There was significant difference between the sample made from sorghum only and the samples fortified with moringa seeds and the sorghum-maize ogi fortified with moringa leaves.

Sensory Evaluation

Sensory evaluation was carried out on the fortified ogi using 20 panelists from different age group (with sample SO, that is 100% Sorghum as a control sample). Table 5 shows the mean sensory attributes of Moringa seeds and leaves fortified ogi. Most of the attributes were ranked in the 'like' categories on the 9-hedonic scale.

The highest rating (7.25) was given to sample SMS in terms of colour, the lowest rating (4.15) was given to sample SML in terms of taste. The color of the samples fortified with moringa seeds and the sorghum only were significantly different at ($p < 0.05$) from the samples fortified with the leaves. This is as a result of the unacceptable greenish colour conferred on the ogi by the moringa leaves. Addition of 10% of moringa seeds to equal proportion of sorghum and maize 'Ogi' gave the most acceptable colour.

The taste of the fortified ogi were also significantly different at ($p < 5$). The sample SS (90% sorghum = 10% moringa seeds) was the most preferred in terms of taste. For appearance and smoothness of the fortified ogi, the most preferred were the sample SMS, with the degree of likeness being significantly different from the samples fortified with leaves. This results shows the addition of moringa seeds blends better in the ogi than the sample that contains moringa leaves. The sorghum only sample (SO) was the most liked in terms of flavor, indicating that fortification with both moringa leaves and seeds imparted some flavor (which was not very desirable) on the ogi.

Overall, the sample SS was the most acceptable. Ogi fortified with moringa seeds were more acceptable than the ones with moringa leaves. Samples with moringa seeds were not significantly different from each other. The acceptability of this sample can be attributed to the fact that the seeds are flavor retainer and helps to improve the sensory properties of the ogi.

Conclusion and Recommendation

Substitution of Sorghum-Maize with Moringa seeds was found to increase the protein, ash, moisture, fat, carbohydrate and fiber contents of the 'Ogi'. The minerals and vitamins content of the ogi also increased as moringa leaves as it increases its nutritional benefits. This study concludes that the ogi 10% substitution of moringa seeds and leaves from the production of Ogi from Sorghum and Maize has improved the nutritional qualities of the ogi samples. The sample 90%S+10%M was the most acceptable in terms of consumer's acceptability. 'Ogi' supplemented with moringa seeds and leaves should be encouraged among infants, children, nursing mothers and old adults since it has more nutritional benefits.

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