Proximate Compositions, selected Minerals and Shelf Life of Garri fortified with Pretreated *Moringa* Leaves

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ABSTRACT

Food Enrichment is an integral part of improving the nutritional quality of food. This study was carried out to fortify garri with dried and weight *Moringa oleifera* leaves. Three different mix ratios of Cassava flour (Garri) to *Moringa* leaves (25: 75, 50:50 and 100%) were used. The proximate composition, Selected mineral analysis such as calcium, magnesium, potassium, iron , phosphorus, copper and bacterial count of the blends were determined using standard methods. The proximate composition of the dried *moringa* fortified 'Garri' showed increase in crude fat, crude fibre, ash and crude protein as the level of substitution increased respectively (0.205-1.865%), (1.657-3.775%), (4.650-8.508%). The mineral composition of wet *moringa* leaves with garri for Calcium (196.04-218.50mg/100g), Magnesium (150.25-165.20 mg/100g), Potassium (429.80-587.95 mg/100g), Iron (4.12- 5.90 mg/100g), Phosphorus (130.02-152.00.ppm) and Copper (4.50-6.05ppm).The proximate and mineral profile of the fortified 'garri' increased significantly (P≤0.05).Product 25:75 weight *moringa* fortified garri is relatively the most stable of all, followed by 2.5 dried *moringa* fortified hence recommended microbiologically. This study showed that garri can be fortified with *moringa* leaves to improve its nutritional quality, hence government, individual and nongovernmental organization should promote the fortification of garri with moringa leaves.

Keywords: Food Enrichment, proximate composition, minerals, *moringa* leaves and nutritional quality

INTRODUCTION

Garri is a staple food commonly eaten in different parts of Nigeria, it is a granular food product processed from peeled, grated, fermented, sieved and roasted cassava paste (*Manihot esculenta*). It is the most commonly consumed cassava product across most geo-political zones in Nigeria [Sanni,2005] and constitutes a common daily menu item consumed by greater proportion of the population [Fabiana *et al.*, 2015., Yusuf *et al.,* 2014]. Garri can be reconstituted with hot water to form a stiff paste, usually eaten with various vegetable soups as accompaniment or with cold water to obtain a free flowing mixture usually taken with added salt, sugar, groundnut, fish, etc.

The problem with consistent consumption of garri stems from its poor nutritional value common with all cassava products. Garri is known for its high caloric value, low protein, fat and micronutrients contents. Low protein garri based diets can predispose consumers to protein-energy malnutrition with compromised renal functions [Alozie *et al.,* 2017]. Protein-energy malnutrition and micronutrient deficiencies have been part of the most dreaded nutritional problems militating against developing countries. Food enrichment can be regarded as viable strategy for improving nutritional quality of foods and consequently enhance adequate nutritional intake among the vulnerable groups. Enrichment of garri with protein-rich plant foods (soy beans, groundnut, sea same seed, melon seed etc) usually result in garri product with improved nutrient quality and acceptable sensory properties [Alozie *et al*., 2017].

Moringa oleifera is a nutritious plant with potential uses for all leaves, seeds and roots. The seed is regarded as the most valued part of the plant; and can be eaten raw or toasted like nuts [Aja *et al.,* 2013]. *Moringa oleifera* seeds are good sources of minerals, indicated by high ash, lipids, crude fibre and protein contents [Aja et al., 2013]. Substituting cassava flour with *Moringa oleifera* seed flour in garri processing can present as a promising strategy for improving the nutritional quality of garri. There is need to explore the potentials of some other foods as enrichment materials in garri production and to compare individual contributions of different enrichment materials to nutrients intakes from garri. This study was carried out to investigate nutrient compositions, selected minerals and sensory properties of garri enriched with *moringa oleifera* seed. Cassava is an excellent energy source, but it contains only 4mg/100g, Iron. Cassavas consumers are at high risk of inadequate iron intakes.

Supplementation intervention programs or fortification of staple foods such as cassava-derived foods can represent available option to contrast iron deficiency. Anemia is a condition in which the total amount of Red Blood Cells is reduced. Iron deficiency occurs when iron dietary intake or absorption are inadequate resulting in a reduced hemoglobin synthesis. Iron deficiency compromises also immune system function and is associated with impaired cognitive development in children. Moreover, Iron deficiency anemia can cause reduced resistance to infection, preterm birth of under-weight babies and maternal death. A large percentage of population living in developing countries are unable to achieve their full mental and physical potentials owing to micronutrient.Therefore, the objective of this research work is to evaluate the effect of benoil leaf powder on the nutritional composition of 'Garri'

MATERIALS AND METHODS

Materials

Samples of cassava varieties locally named Paki was purchased from Abule Ojere. Cassava was harvested at maturity and immediately transported to the laboratory for the sample preparation while benoil (*Moringa oleifera)* fresh leaves was harvested from a private farm in Oke Ata, both in Abeokuta, Ogun State. Nigeria.

Processing of Cassava Tubers into Fufu

The method described by Oyewole and Odunfa (1989) was largely adopted. The cassava roots was sorted by visual assessment, peeled, washed, divided into two equal parts and soaked submerged in two 50-litre plastic containers for the 96 h-fermentation process under ambient condition (30±2^{o}C). However, in one container, the fermentation water remained unchanged throughout the soaking period (fixed fermentation) whereas in the second container, there was regular changing of water daily throughout the period of fermentation (unfixed fermentation). The resulting cassava roots were hand-pulverized or grated, wet-sieved and dewatered in clean jute bags (using heavy stones) to obtain the raw cassava mash. Five kilograms of the cassava mash obtained was diluted with three litres of distilled water and cook in a standardized procedure common to all samples (using a gas cooker) to a solid and firm consistency. Samples of raw cassava mash and cooked *garri* was collected for analysis.

Preparation of 'garri' -benoil leaf powder mixtures: 'garri' (fermented) powder was added to benoil (*Moringa oleifera*) leaf powder at addition levels of 100:0, 95:5, 90:10, 85:15, 80:20 and 75:25 (i.e. 'garri': benoil leaf powder). Each sample was thoroughly mixed together.

CHEMICAL ANALYSIS

Determination of Proximate Composition

The moisture, ash, crude fiber and fat (ether extract) contents was determined using a standard method (AOAC, 2000). Nitrogen content was determined using micro- kjeldahl and converted to crude protein (N x 6.25) (AOAC, 2000). Meanwhile the carbohydrate content was calculated by difference.

Determination of Mineral Content

The Iron content was measured colorimetrically at 480nm using standard method. For the calcium content, the reading of concentration was done on a spectrophotometer (AAS) while the method that was used for sodium content determination was flame photometric. The zinc and Phosphorus contents were determined.

Determination of Vitamin A (Beta-carotene) Content

The vitamin A content was determined using a standard method (AOAC, 2000).

Sensory Evaluation

Sensory quality was evaluated in a sensory evaluation room by preparing eba from the samples and served to panel of fifty judges comprising of students and staffs who were very familiar with gari. The panelists will be asked to score each sample on a 9-point hedonic scale, where 1 and 9 represent dislike extremely and like extremely respectively. Each sample was assessed for its sensory qualities such as colour, texture, aroma, taste and overall acceptability, with the aid of questionnaire (Ihekoronye and Ngoddy, 1985).

Statistical Analysis

Proximate composition analysis will be done in triplicates. Data will be expressed as mean±SD deviation and results will be evaluated by Duncan test analysis with the statistical software SPSS 11.5 for Windows. A significant level of $\alpha \leq 0.05$ was chosen. Figures will be done with Excel 2007 software for Microsoft office (XP-Microsoft Corporation).

RESULTS AND DISCUSSION

Proximate Composition

Enrichment of gari samples resulted in decreased moisture, fibre and carbohydrate contents; whereas, protein, fat and ash contents were increased. Similar observations have been made in gari samples fortified in previous studies [Oluwamukomi, 2015, Cook and Maduagwu 1978].

The proximate composition of the dried moringa fortified 'Garri' as presented in Table 1 showed an increase in crude fat, crude fibre, ash and crude protein. The moisture content of the fortified 'Garri' increased significantly (P≤0.05) with the dried 'Garri' having the higher moisture content. The increase in moisture content suggests that 'Garri' with wet moringa may keep longer since a reduction in moisture content would hinder the proliferation of micro-organisms (Oluwamukomi, 2015., Cook and Maduagwu 1978)).

The crude fat content of the dried and wet-fortified 'Garri' increased and differed significantly (P≤0.05) with increase in the addition of the moringa. The increase in the crude fat of the fortified 'Garri' may be attributed to the high fat content of *Moringa oleifera* leaves (Aja *et al*., 2013), therefore diet containing *Moringa oleifera* leaves should be palatable since dietary fats function to increase food palatability by absorbing and retaining flavours . This observation indicates that MOLP-fortified 'amala' will digest easily and may contribute to the prevention of colon cancer which is one of the functions of a diet high in crude fibre (Aja et al., 2013). High fat content of garri fortified with these materials can be of relevance in situations where higher energy intake from gari is desirable. Fortification decreased fibre contents of all samples, except for Moringa seed garri. This is not unexpected as moringa seed is reported to have high crude fibre content than other fortifying materials [Egbebi, 2014], and even cassava root [Montagnac, 2009]

The ash content of both the wet and dried-fortified 'Garri' was significantly (P≤0.05) affected by the level of addition of the moringa. The increasing trend observed in this study also suggests that moringa fortified Garri is a good source of minerals elements (Alozie et al., 2017).

The protein content of the protein - fortified 'Garri' varied significantly (P≤0.05) with increase in addition of moringa. Dried *Moringa oleifera* leaves have been reported by several researchers to contain appreciable amounts of protein (Alozie *et al*., 2017). A similar trend of increase in protein content was observed when fermented cassava flour was fortified with full fat soybeans, yam flour fortification with grain amaranth and addition of *Moringa oleifera* leaves to full fat and low fat yoghurt [Alozie *et al.,* 2017].

The high protein content of moringa could be responsible for the increase in the protein content of the fortified 'Garri' samples. Therefore, the nutritional status of consumers of 'Garri' could be improved using *Moringa oleifera* leaves as a source of dietary protein. This will further increase the utilization of this leaf and provide a protein rich diet for the malnourished group that can hardly afford a protein rich diet.

Mineral Composition

Table 2 shows the effect of addition *Moringa oleifera* leaves powder on the mineral composition of 'Garri'. The range of values obtained for the minerals were Calcium (200.20-220.55mg/100g), Magnesium (150.65-161.00 mg/100g), Potassium (430.84-599..87 mg/100g), Iron (4.20-6.24 mg/100g), Phosphorus (130.14-150.97.ppm) and Copper (4.85-5.90ppm) for the dried *moringa* fortified Garri while wet fortified moringa shows the values indicated as follows: Calcium (196.04-218.50mg/100g), Magnesium (150.25-165.20 mg/100g), Potassium (429.80-587.95 mg/100g), Iron (4.12-5.90 mg/100g), Phosphorus (130.02-152.00.ppm) and Copper (4.50-6.05ppm) . Generally, the mineral profile of the fortified 'amala' increased significantly (P≤0.05) with increase in addition of *Moringa oleifera* leaves powder. This observation confirms previous reports that *Moringa oleifera* leaves contain relatively high amounts of minerals particularly Ca, Mg, Na and P. Furthermore, the addition of *Moringa oleifera* leaves to Garri indicates that the *moringa* fortified Garri will increase the utilization of the leaves and thus promotes better health for consumer of this staple. Minerals are required for normal growth, cellular activity and oxygen transport (Cu and Fe), fluid balance and nerve transmission (Na and K) as well as regulation of acid-base balance (P) ([Alozie et al., 2017].). The increased Fe content suggests that the *moringa* fortified "Garri" may be a good source of micronutrient for the people most especially children, women of reproductive age and pregnant women that are most vulnerable to micronutrient deficiency and anemia. The result of the microbial analysis revealed that the eba fortified moringa is not shelf stable.

Table 1: Proximate Composition of Dried and Wet Moringa Fortified Garri

DRIED	M.C(%)	C.F(%)	C.Fibre(%)	Ash(%)	C.P(%)	CHO(%)
$DMOLPE_0$	60.75^a	0.205^e	1.010^d	1.657^c	4.650^e	
2.5	61.317^b	0.611^d	1.527^c	2.803^b	6.560^d	
5.0	61.320^c	1.202^c	1.960^b	2.802^b	7.001^c	
7.5	62.100^c	1.550^b	2.785^b	3.070^b	7.818^b	
10	62.720^d	1.865^a	3.110^a	3.775^a	8.508^a	

Wet Moringa

WET	M.C(%)	C.F(%)	C.Fibre(%)	Ash(%)	C.P(%)	CHO(%)
$WMOLPE_0$	60.785^a	0.205^e	1.010	1.657^d	4.650^e	
2.5	60.995^a	0.592^e	1.632	3.076^c	6.560^d	
5.0	61.409^b	1.323^d	1.990	3.600^d	7.040^c	
7.5	61.766^c	1.508^d	2.810	4.235^b	8.389^a	
10.0	62.005^d	1.729^b	3.375	4.903^a	10.122^a	

Table 2 : Mineral Composition of Dried and Wet Moringa Fortified Garri

Minerals	$WMOLPE_0$	$WMLPE_{2.5}$	$WMLPE_{5.0}$	$WMLPE_{7.5}$	$WMLPE_{10}$
Ca(mg/100g)	196.04	208.40	200.50	200.97	218.50
Mg(mg/100g)	150.55	150.50	150.25	150.52	165.25
K(mg/100g)	429.80	480.50	500.10	535.71	587.95
Fe(ppm)	4.12	4.40	5.00	4.30	5.90
P(ppm)	130.02	140.20	140.10	147.45	152.00
Cu(ppm)	4.50	4.65	5.00	6.05	5.50

Minerals	WMOLPE$_0$	WMLPE$_{2.5}$	WMLPE$_{5.0}$	WMLPE$_{7.5}$	WMLPE$_{10}$
Ca(mg/100g)	200.02^{b}	210.30^{a}	215.00^{a}	217.59^{a}	220.55^{a}
Mg(mg/100g)	150.65^{b}	152.70^{b}	157.67^{a}	160.16^{a}	161.04^{a}
K(mg/100g)	430.84^{d}	485.00^{c}	511.93^{b}	549.23^{b}	599.87^{a}
Fe(ppm)	4.20^{c}	4.81^{c}	5.16^{b}	5.97^{b}	6.24^{a}
P(ppm)	130.14^{c}	142.34^{b}	147.02^{b}	150.97^{b}	6.24^{a}
Cu(ppm)	4.85^{b}	4.97^{b}	5.16^{b}	5.56^{a}	5.90^{a}

TABLE OF RESULT

Total Plate Count of Fortified Eba Samples

Sample Code	Day 1	Day 2	Day 3
K	0.31×10^6	2.16×10^7	4.80×10^7
2.5W	1.65×10^6	3.28×10^7	3.68×10^7
2.5D	4.28×10^6	3.04×10^7	3.84×10^7
5.0W	3.79×10^6	5.68×10^7	7.68×10^7
5.0D	3.02×10^6	3.48×10^7	4.48×10^7
7.5W	4.73×10^6	3.88×10^7	2.96×10^7
7.5D	5.54×10^6	3.68×10^7	9.04×10^7
10W	1.42×10^6	3.00×10^7	8.16×10^7
10D	2.89×10^6	1.52×10^7	3.36×10^7

DISCUSSION/ CONCLUSION

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Minerals	WMOLPE$_0$	WMLPE$_{2.5}$	WMLPE$_{5.0}$	WMLPE$_{7.5}$	WMLPE$_{10}$
Ca(mg/100g)	196.04	208.40	200.50	200.97	218.50
Mg(mg/100g)	150.55	150.50	150.25	150.52	165.25
K(mg/100g)	429.80	480.50	500.10	535.71	587.95
Fe(ppm)	4.12	4.40	5.00	4.30	5.90
P(ppm)	130.02	140.20	140.10	147.45	152.00
Cu(ppm)	4.50	4.65	5.00	6.05	5.50

Proximate Composition of Moringa Fortified Garri

Dry Moringa

	M.C(%)	C.F(%)	C.Fibre(%)	Ash(%)	C.P(%)	CHO(%)
$DMOLPE_0$	60.75^a	0.205^e	1.010^d	1.657^c	4.650^e	
2.5	61.317^b	0.611^d	1.527^c	2.803^b	6.560^d	
5.0	61.320^c	1.202^c	1.960^b	2.802^b	7.001^c	
7.5	62.100^c	1.550^b	2.785^b	3.070^b	7.818^b	
10	62.720^d	1.865^a	3.110^a	3.775^a	8.508^a	

Wet Moringa

	M.C(%)	C.F(%)	C.Fibre(%)	Ash(%)	C.P(%)	CHO(%)
$WMOLPE_0$	60.785^a	0.205^e	1.010	1.657^d	4.650^e	
2.5	60.995^a	0.592^e	1.632	3.076^c	6.560^d	
5.0	61.409^b	1.323^d	1.990	3.600^d	7.040^c	
7.5	61.766^c	1.508^d	2.810	4.235^b	8.389^a	
10.0	62.005^d	1.729^b	3.375	4.903^a	10.122^a	

TABLE OF RESULT

Total Plate Count of Fortified Garri Samples

Sample Code	Day 1	Day 2	Day 3
K	0.31×10^6	2.16×10^7	4.80×10^7
2.5W	1.65×10^6	3.28×10^7	3.68×10^7
2.5D	4.28×10^6	3.04×10^7	3.84×10^7
5.0W	3.79×10^6	5.68×10^7	7.68×10^7
5.0D	3.02×10^6	3.48×10^7	4.48×10^7
7.5W	4.73×10^6	3.88×10^7	2.96×10^7
7.5D	5.54×10^6	3.68×10^7	9.04×10^7
10W	1.42×10^6	3.00×10^7	8.16×10^7
10D	2.89×10^6	1.52×10^7	3.36×10^7

W: Garri Fortified with wet Moringa

D: Garri Fortified with dried Moringa

REFERENCES

Aja, P. M., Ibiam, U. A., Uraku, A. J., Orji, O. U., Offor, C. E. and Nwali, B. U. (2013). Comparative Proximate and Mineral Composition of *Moringa oleifera* Leaf and Seed. Global Advanced Research Journal of Agricultural Science (ISSN: 2315-5094) Vol. 2 (5) pp. 137-141.

Alozie Yetunde Ezinwanyi, Ekerette Nkereuwem Ndaeyo. Proximate Compositions, Physicochemical and Sensory Properties of Gari Fortified with Soybean, Melon Seed and Moringa Seed Flours. International Journal of Nutrition and Food Sciences. Vol. 6, No. 2, 2017, pp. 105-110. doi: 10.11648/j.ijnfs.20170602.17

AOAC, (2000) Official Methods of Analysis of the Association of *Official Analytical Chemists,* 17th Edition, Washington Dc.

Besong, S. A., Ezekwe, M. O., Fosung, C. N. and Senwo, Z. N. (2011). Evaluation of nutrient composition of African melon oilseed (Cucumeropsis mannii Naudin) for human nutrition International Journal of Nutrition and Metabolism Vol. 3 (8), pp. 103 -108.

Cook, R. D. and E. N. Maduagwu, (1978). The effect of simple processing on the cyanide content of cassava chips. J. Food Technol., 13: 299-306.

Egbebi A. O. (2014). Comparative studies on the three different species melon seed; (Citrulus vulgaries, Cucumeropsis manni and Leganaria siceraria). Sky Journal of Food Science Vol. 3 (1), pp. 001–004.

Fabiana F. De Moura, Mourad Moursi, Abdelrahman Lubowa, Barbara Ha, Erick Boy, Babatunde Oguntona, Rasaki A. Sanusi, Busie Maziya-Dixon. (2015). Cassava Intake and Vitamin A Status among Women and Preschool Children in Akwa-Ibom, Nigeria. PLoS ONE 10 (6): e0129436.

Ihekoronye, A.I and Ngoddy, P.O. (1985) Integrated Food Science and Technology for the Tropics. Macmillan Publishers Ltd; London PP293-300.

Lokuruka Mni. (2010). Soybean Nutritional Properties: The Good and the Bad about Soy Foods Consumption-A Review. African Journal of Food Agriculture, Nutrition and Development, 10 (4): 2439-2459.

Montagnac, J. A., Davis, C. R. and Tanumihardjo, S. A. (2009). Nutritional Value of Cassava for Use as a Staple Food and Recent Advances for Improvement. Comprehensive Reviews in Food Science and Food Safety, 8: 181–194.

Oluwamukomi, M. O. (2015). Chemical and Sensory Properties of Garri Fortified with Sesame Seed Flour (Sesamum Indicum L.) FUTA Journal of Research in Sciences, 2015 (1): 123-131.

Oyewole, O.B and Odunfa, S.A (1989). Effect of fermentation on the carbohydrate, mineral and protein contents of cassava during ''Fufu'' production. Journal of Food Composition and Analysis, 2, 170-176.

Sanni, L. O. (2005). Food Safety, Weights, Measures, and Consumption Patterns: The Case of Gari in Enugu and Benin Markets. Online, Nigeria: International Institute of Tropical Agriculture.

Teresa Banaszkiewicz (2011). Nutritional Value of Soybean Meal, Soybean and Nutrition, Prof. Hany El-Shemy (Ed.), ISBN: 978-953-307-536-5, InTech, Available from: http://www.intechopen.com/books/soybeanandnutrition/nutritional-value-of-soybean-meal.

Yusuf A. Z., Zakir A., Shemau Z., Abdullahi M., Halima S. A., and SANI K. (2014). Visual defects among consumers of processed cassava (gari). Af rican Journal of Food Science. Vol 8 (1): 25-29.