Applied Tropical Agriculture
Volume 24, No 1, 223-229, 2019
© A publication of the School of Agriculture and Agricultural Technology, The Federal University of Technology, Akure, Nigeria

PHYSICO-CHEMICAL PROPERTIES OF FLOUR BLENDS PRODUCED FROM THREE INDIGENOUS CROPS (MAIZE/COWPEA/*MORINGA* SEEDS)

Shakpo, I. O.[1], Ademulegun, T. I.[2], Ajala, O. A.[1], Aladekoyi, G[1] and Olatinpo, M. K.[3]

[1]Food Science and Technology Department, Rufus Giwa Polytechnic, Owo
[2]Nutrition and Dietetics Department, Rufus Giwa Polytechnic, Owo
[3]Hospitality Management Technology, Rufus Giwa Polytechnic, Owo.
*Corresponding author Email: de.kings.io@gmail.com. Tel: +2348036267170.

ABSTRACT

The objective of the study was to increase the nutrient content of the cereal and improve the nutritional intake of the rural consumers. Flour blends were produced from maize, cowpea and moringa seed flours in the following ratios of maize:cowpea:moringa seed; 100:0:0; 80:10:10, 75:15:10, 75:10:15, 75:20:05 respectively Physico-chemical analyses (proximate and functional properties) were carried out on the flour blends using standard methods. The result for the proximate composition shows that the moisture, ash, fat and fibre contents ranged from 8.75% to 11.23%, 2.00% to 3.10%, 8.15 to 15.00 and 2.00 to 3.94% respectively, while protein and carbohydrate contents ranged from 10.05% to 15.10% and 57.40 to 66.57% respectively. The result of the functional properties shows that; least gelation, bulk density (BD) and foaming capacity of the samples ranged from 4.00 to 8.00%, 0.80 to 1.44 g/ml and 4.96 to 13.92% respectively. The swelling index, water and oil absorption ranged from 0.3 to 0.96 ml/g, 70 to 190%, 124 to 220% respectively. The trend observed in the functional properties of the flour blends suggests that addition of cowpea and moringa seeds flour to maize significantly influenced the water and oil absorption capacities, swelling index and foaming capacity of the maize flour. This increase in foaming capacity can be attributed to increase in protein concentration. Thus the lower BD of samples 75:10:15 and 75:20:05 will encourage the intake of more calorie and nutrients from the samples. Conclusively, enrichment of maize flour with 10% cowpea and 15% moringa seeds flours will produce a most acceptable and affordable nutritious flour blends with considerable proximate and functional properties that can serve as potential raw material for indigenous snack production as well as weaning food.

Keywords: Indigenous crops, complementary foods, nutrient, moringa seeds, Cowpea and maize.

INTRODUCTION

Plant foods are processed into flours or staple and used in the preparation of various nutrients snacks such biscuits, chin-chin etc. (Chikwendu, 2007). These most widely consumed cereal-based snacks products which generally are low in nutrient density (Rhee et al., 2004). Plant foods are deficient in one or more essential amino acid(s), for this reason, cereal and legume are known to complement each other when consumed together so as to provide adequate nutrient for the improvement of the nutritional well-being of the people. Legumes not only hold great promises in meeting protein needs of poor population, but also contribute to solving some health related problem of the world.

Yellow maize (Zea mays) is a popular cereal in Southern part of Nigeria. Its protein ranges from 8 to 11% (FAO, 1992). Dry maize seed are used to prepare different dishes such as spiced steamed maize paste. It can also be roasted, kneaded, spiced and fried to produce snacks ("Aadun and Kokoro") (Adegoke and Adebayo, 1994). It is recorded recently that maize is one of the popular cereal foods that is used to make snack foods that it is widely consumed by Nigerians and it is made of low protein with lysine and tryptophan as limiting amino acid (Omueti et al., 1992). Fortification of such snacks becomes relevant for adequate contribution to total nutrient intake. Omueti and Morton (1996) reported that fortification of starch- based foods with suitable protein food would improve their nutritional quality to ensure a wide consumption of good quality snack foods.

The high dependence on maize as a staple food in tropical Africa, coupled with the low nutritive value of the commodity has led to the investigation of simple traditional methods in the improvement of chemical and functional qualities of maize based snacks foods. The use of legumes such as cowpea and moringa seeds can be successfully used to increase the nutritional value of cereal foods (Martin et al., 2016).

Cowpea (Vigna unguiculata) is the most widely consumed legumes in Nigeria, primarily because of its taste and the ease with which it is prepared and incorporated into other recipes (Onigbinde and Akinyele, 1983). It constitutes more than 50% of all legumes consumed (Fashakin and Fasanya, 1988; Philips and McWatter, 1991). These beans serve as the largest single contributor to the total protein intake of many rural and urban families (Dolvo et al., 1976). Cowpea have high protein of about 25%, 67% of carbohydrate (Giami et al., 2003) and constitute the natural protein supplement to staple diet, also contain vitamins (thiamine and niacin), minerals (phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg) and dietary fiber. Protein quality is synergistically improved to cereals –legumes blends because of the lysine contributed by the cereal (Awoyale *et al.*, 2011). It is an important source of protein in developing countries especially in Nigeria, though deficient in methionine. It is an example of grain legume which has found utilization in various ways in traditional and modern food processing in the world (Odedeji and Oyeleke, 2011).

Moringa seed can also serve as a food fortification agent. Moringa seed is from Moringa oleifera which is the most widely cultivated species of the genus Moringa, which is a genus in the family Moringaceae. The seeds sometimes remove from more mature pods and eaten like peas or roasted like nuts (Michael, 2010). Moringa pods, bark, flower, fruits, leaves, roots and seeds are all useful. All of them contain various valuable nutrients, antioxidants as well as amino acids. Because of that, this plant has various benefits to humans and animals. These moringa seeds are full of nutrients and also can be easily digested. Moringa seeds contain a good amount of vitamin A, vitamin B, Vitamin C, vitamin D, vitamin E as well as iron. Actually moringa seeds have more amount of Vitamin compared with various food that is claimed a prime source of them such as oranges, carrot and milk. It can be eaten as supplement as it is full of nutrients and completely natural. It is also able to make minor injuries like bruises, cuts, or even burns heals faster because of the nutrients it has. Moringa seed also serve as a good source of protein (Michael, 2010). Moringa seeds do not only serve as protein source but can also be used as medicine and food commodity which has received enormous attention as the natural nutrition of the tropics. Moringa seeds had been reported to be a good source of fat, crude fibre and proteins (especially rich in cysteine and methionine amino acids which are lacking in cowpea) (El Sohalmy et al., 2015). This study aimed at increasing the nutrient content of cereal-based flour thereby improving the nutritional intake of the consumers and also promotes flour production from indigenous crops.

MATERIALS AND METHODS

Materials

Dried yellow maize (Zea mays), cowpea (Vigna unguiculata) and other ingredients (onion, fresh pepper, palm oil, vegetable oil) used for this research were sourced from Obada market in Emure-ile, Owo L.G.A of Ondo State, Nigeria. While the AAS (Model 210 VGP Buck Atomic Absorption Spectrophotometer) and flame photometer used for mineral determination were from the Chemistry Laboratory of Science Laboratory Technology Department of Rufus Giwa Polytechnic, Owo. Hot air oven (Model Memmert 854, Gallenkamp, UK), water bath (Model HH - 6), Kenwood mixer (Model A 907 D, Kenwood Ltd, England) and other equipment used for this research were from the Food Chemistry Laboratory of the Department of Food Science and Technology, Rufus Giwa Polytechnic, Owo, Ondo State. All chemicals used for the proximate analysis were of analytical grade and were supplied by Pascal Scientific Limited, Akure.

Production of maize, cowpea and moringa seed flour

Maize flour was produced following the procedure adopted by Barber et al., (2010) with slight modification. The maize grains were sorted to remove extraneous matter and washed with potable water. The drying was achieved with the aid of hot air oven (Memmert 854, Gallenkamp, UK) at 55 ^{o}C for 8 h. The dried maize was milled into flour using attrition mill and was stored in air tight container until needed for further analysis. Matured and dried cowpea seeds were carefully cleaned, sorted to remove defective ones, stones and other extraneous matters. The cleaned seeds were soaked in potable water for just 10 min to soften the seed coat which was manually dehulled. The dehulled cowpea was dried in cabinet dryer at 60 ^{o}C for 24 h and milled into flour, which was stored in polythene until needed. Moringa seed flour was produced by removing the dried and mature seeds from the pods and was dried at 50 ^{o}C in an hot air oven (Model Memmert 854, Gallenkamp, UK) for 5 hours in order to give room for easy breaking. After breaking, the dried seeds were size reduced in laboratory mortar and pestle before milling into flour with the aid of Kenwood blender and the flour was stored in air tight container for further analysis. The maize:cowpea:moringa seeds flour blend were formulated into five ratios: 100:0:0; 80:10:10, 75:15: 10, 75:10:15, 75:20:05 respectively, which were kept in air tight container until needed to be used for analysis.

Determination of proximate composition

Proximate composition such as moisture, fat, total ash, crude fibre and crude protein contents were determined according to the methods of AOAC, (1990), while the carbohydrate content was calculated by difference.

Functional properties

Determination of bulk density

The bulk density (BD) was determined according to the method described by Okaka and Potter (1977). A 50 g sample was put into a 100 ml graduated cylinder. The cylinder was tapped on the palm for 40 to 50 times and the bulk density was determined by reading the final volume. Bulk density was calculated as:

$$BD = \frac{\text{mass of materials}}{\text{volume of material after tapping}} \qquad \text{eq. 7}$$

Determination of foaming capacity

The method of Coffman and Garcia (1977) was employed in the determination of foaming capacity. Sample (1 g) was whipped with 50 ml distilled water for 5 minutes in a Kenwood blender at speed set at maximum and was poured into a 100 ml graduated cylinder. Total volume at time interval at 0, 5 mins, 10 mins until 1 hour was noted to study the foaming capacity.

$$\%\,\text{Volume increase} = \frac{\text{Vol. after whipping} - \text{Vol. before whipping}}{\text{volume before whipping}} \qquad \text{eq. 8}$$

Determination of least gelation

The modified procedure of Coffman and Garcia (1977) was used to determine gelation properties. Appropriate sample suspension of 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8 g were prepared in 5ml of distilled water each to make 2 - 20 % (w/v) suspension. The test tubes containing these suspensions were heated for 1 hour in boiling water (bath) followed by rapid cooling under running tap water, the test tubes were then cooled for 1 hour. The least gelation concentration was determined as concentration when the sample from the inverted test tube did not fall down or slip.

$$\%\text{Least gelation} = \frac{\text{weight of samples}}{5(\text{ml})\text{of water}} \times \frac{100}{1} \qquad \text{eq. 9}$$

Determination of water and oil absorption capacities

Water absorption capacities (WAC) of the samples were determined by a combination of the AACC (2000) and Sathe *et al.*, (1982) methods. Sample (1.0 g) was dispersed in 10ml of distilled water. The content was mixed for 5 minutes on a magnetic stirrer or using glass rod, the mixture was centrifuged at 3,500 rpm for 30 minutes and the volume of the supernatant left after centrifuging was noted. Water bound was calculated from the difference in volume of the initial volume of the water used and the final volume after centrifuging. The same procedure was used for oil absorption capacity (OAC), just that oil was used in place of water.

$$WAC = \frac{\text{Volume of water absorbed}}{\text{weight of sample}} \times \frac{100}{1} \qquad \text{eq. 10}$$

$$OAC = \frac{\text{Volume of oil absorbed}}{\text{weight of sample}} \times \frac{100}{1} \qquad \text{eq. 11}$$

Determination of emulsion capacity and stability

The emulsion capacity (EC) and stability (ES) was determined by the method of Masumaten (1972). The emulsion, 20 g sample, 20 ml distilled water and 20 ml soybean oil was prepared in a calibrated centrifuge tube. The emulsion was centrifuged at 3,500 rpm for 5 min. The ratio of the height of the emulsion layer to the total height of the mixture was calculated as the emulsion activity expressed in percentage. The emulsion stability was estimated after heating the emulsion contained in a calibrated centrifuge tube at 80 °C for 30 min in a water bath, cooled for 15 minutes under running tap water and centrifuged at 2000 rpm for 15 min. The emulsion stability expressed as a percentage was calculated as the ratio of the height of the emulsified layer to the total height of the mixture.

$$EC = \frac{\text{height of the emulsion layer}}{\text{total height of the mixture}} \times \frac{100}{1} \qquad \text{eq. 12}$$

$$ES = \frac{\text{height of the emulsified layer}}{\text{total height of the mixture after heating}} \times \frac{100}{1} \qquad \text{eq. 13}$$

Determination of swelling index

The swelling index was determined using the method of Ukpabi and Ndimele (1990). Twenty five grams of each sample was weighed into a 210 ml measuring cylinder; 150 ml of water was added and allowed to stand for four (4) hours and the level of swelling was observed thereafter.

$$\text{Swelling index} = \frac{\text{Volume after soaking} - \text{Volume before soaking}}{\text{weight of sample}} \qquad \text{eq. 14}$$

Statistical analysis

The SPSS for windows programme version 15.0 was used to analyze the results obtained, means and standard deviation of all the samples were calculated and compared. The results obtained were in triplicate and subjected to analysis of variance ANOVA and the means were separated by New Duncan Multiple Range Test (NDMRT).

RESULTS AND DISCUSSION

Proximate composition of the flour blends

The result for the proximate composition of maize/cowpea/moringa seeds flour blends is as presented in Table 1. The moisture content (MC) ranged from 8.75% to 11.23% with sample A (100:0:0 maize/cowpea/moringa seed) having the highest (11.23%) and sample D (75:10:15) had the least (8.75%) respectively. These values were significantly higher than those reported by Shakpo and Osundahunsi (2016) (which ranged from 2.67 to 5.77%) were only cowpea was used to enrich maize but similar to those obtained by Abegunde *et al*. (2014) (which ranged from 10.45 to 11.05). The 100% maize retained the highest value of moisture compared to the blends, with no significant difference between the 100% maize and 80:10:10 blend whereas sample E (75:20:05 maize/cowpea/moringa seeds) was significantly difference from the rest blends. It has been shown that moisture content in food products facilitates the growth of microorganisms, which in turns causes spoilage and low nutritional qualities of the food products (Udensil *et al*., 2012; Oyarekhua, 2013). The ash content ranged from 2.00 to 3.10% with the least value recorded for the 100:0:0 maize/cowpea/moringa seeds. The ash content of sample B was not significantly different from sample C but different significantly from sample D and E, moringa seeds and cowpea inclusion to maize flour significantly improved the ash content of the flour. This thus gives an idea of the inorganic content of the sample from where the mineral content could be determined (Bello *et al*., 2008). Fats are essential because they provide the body with maximum energy, approximately twice that for an equal amount of protein and carbohydrate (Dreon *et al*., 1990; Salma *et al*., 2009) . Lipids facilitate intestinal absorption and transport of fat soluble vitamins A, D, E and K and also provide varying quantities of essential nutrients such as linoneic acid (Leeson *et al*., 2001). Fat and fibre contents which ranged between 8.15 to 15.00 and 2.00 to 3.94% respectively varied significantly among the 100:0:0 maize/cowpea/moringa seed and the blends with the 100:0:0 maize/cowpea/moringa seed having the least value in each case. Sample C, D and E were not significantly different from one another in term of fibre but significantly different in fat, whereas the sample containing 100:0:0 maize/cowpea/moringa seed was similar in fibre content to the sample 80:10:10 maize/cowpea/moringa seed but significantly different in fat content. The lower fibre content recorded for samples A and B (with higher proportion of maize) must have been due to the intensity of the processing of the maize to flour causing great loss of fibre. Increase in the fat content of samples B to E with addition of moringa seed flour is a reflection of the high fat content (41.58 to 45.84%) of moringa seed (Anhwange *et al*., 2004; Abiodun *et al*., 2012). The protein content of the samples ranged from 10.05% to 15.10%, the blends had higher values than the 100:0:0 and these values were significantly difference among the blends and the control. Sample D (with 75:10:15 maize/cowpea/moringa seed) had the highest protein value while the 100:0:0 had the least. The appreciable protein content of moringa seeds (40.31%) as supplement to food (Makkar and Becker, 1997) was supported by the findings of this research. Sample D had lower moisture content than Cerelac (commercial maize/soya complementary food (11.3%), similar to ash and protein content. The fat, fibre and energy contents were within ranges recommended for infant complementary foods (at least 1.6 g/100 g, 400 kcal/100 g and 5 g/100 g respectively) (FAO/WHO, 1991) Conversely, carbohydrate was higher in 100:0:0 than in the blends and the highest energy value was recorded for sample D (75:10:15).

Functional properties of the flour blends

The trend observed in the functional properties of the flour blends suggests that addition of cowpea and moringa seeds flour to maize significantly influenced the water (70 to 190%) and oil (124 to 220%) absorption capacities, swelling index (0.3 to 0.96 ml/g) and foaming capacity (4.96 to 13.92%) of the maize flour. However, the maize flour had the least value in each case. Katungwe *et al.* (2010) also observed increase in water absorption (WAC), swelling index and least gelation of maize-cowpea flour blend. The highest WAC recorded for sample D is a reflection of the higher protein content which absorbs and binds with more water (Otegbayo *et al*., 2000). The foaming capacity of the flour blends (12.94 – 13.92%), which was significantly higher than that of 100% maize was in agreement with the findings of Barber *et al.* (2010) where it was also reported that the blends had higher foaming capacity (12 – 32%) than the 100% maize

(8%). This increase in foaming capacity can be attributed to increase in protein concentration, whereas there was little or no significant difference in other parameters examined such as bulk density and least gelation. The result of the functional properties shows that; least gelation and bulk density (BD) of the samples ranged from 4.00 to 8.00% and 0.80 to 1.44 g/ml respectively.

Study (Onimawo and Egbekun,1998) had shown the reflection of lower BD to be from higher amount of flour particles that can stay together thereby increases the energy content derivable from such diets. Thus the lower BD of samples D and E will encourage the intake of more calorie and nutrients from the samples. This property will also make the samples appropriate complementary diets for infants (Omueti *et al*., 2009), because of the small capacity of their stomach that would not be able to accommodate large volume of food to satisfy their energy and nutrient requirements.

Table 1: Proximate Composition of Maize/Cowpea/Moringa Seeds Flour Blends (%)

Samples	Moisture	Ash	Fat	Fibre	Protein	Carbohydrate	Energy (Kcal)
A (100:0:0)	11.23±1.33a	2.00±0.80c	8.15±0.65e	2.00±1.50b	10.05±1.22d	66.57±1.80a	379.83±2.23e
B (80:10:10)	10.50±0.00a	2.50±0.50b	9.14±0.13d	2.20±1.00b	11.25±0.57c	64.41±1.50b	384.90±1.88d
C (75:15:10)	8.93±0.25c	2.88±0.50b	10.58±0.20c	3.80±0.05a	11.50±0.70b	62.31±2.20c	390.46±0.50c
D (75:10:15)	8.75±0.58c	3.00±0.50a	15.00±1.60a	3.94±0.50a	15.10±2.55a	54.21±0.33e	412.24±2.00a
E (75:20:05)	9.50±2.30b	3.10±1.05a	14.10±3.05b	3.90±0.50a	12.00±0.55b	57.40±0.55d	404.50±2.50b

Values with the same letters along the column are not significantly different ($p \leq 0.05$) A(100:0:0): Ratio of Maize (M) :Cowpea (C) :Moringa seeds flour (MSF); B (80:10:10): Ratio of M:C:MSF; C (75:15:10): Ratio of M:C:MSF; D (75:10:15) Ratio of M:C:MSF; E (75:20:05): Ratio of M:C:MSF. Letters a-e shows the degree of significant difference.

Table 2: Functional Properties of Maize/Cowpea/Moringa Seeds Flour Blends

Samples	Least Gelation (%)	Bulk Density (g/ml)	Foaming Capacity (%)	Swelling Index (ml/g)	Water Absorption Capacity (%)	Oil Absorption Capacity (%)
A (100:0:0)	6.00±1.00ab	1.44±0.22a	4.96±0.02b	0.30±0.10b	70.00±2.00d	124.00±6.00e
B (80:10:10)	8.00±0.00a	1.40±0.20a	12.94±0.04a	0.50±0.20b	160.00±6.00c	150.00±2.00d
C (75:15:10)	4.00±1.00b	1.20±0.02a	13.05±0.30a	0.54±0.07b	180.00±5.00b	180.00±5.00b
D (75:10:15)	4.00±0.00b	0.80±0.05b	13.92±2.54a	0.96±0.30a	190.00±4.00a	160.00±10.00c
E (75:20:05)	8.00±2.40a	0.82±0.32b	12.96±2.16a	0.46±0.15b	180.00±4.00b	220.00±4.00a

Values with the same letters along the column are not significantly different ($p \leq 0.05$) A(100:0:0): Ratio of Maize (M) :Cowpea (C) :Moringa seeds flour (MSF); B (80:10:10): Ratio of M:C:MSF; C (75:15:10): Ratio of M:C:MSF; D (75:10:15) Ratio of M:C:MSF; E (75:20:05): Ratio of M:C:MSF. Letters a-e shows the degree of significant difference.

CONCLUSION

Sample D showed greater significant attributes in almost all the parameters examined and was the closest to standard complementary food (Cerelac) in term of proximate and functional properties, due to its highest moringa seeds inclusion in this research. Therefore, enriching maize with 10% cowpea and 15% moringa seeds will produce an acceptable and affordable flour blends which can serve as complementary foods for infant and a source of composite flour for snack production.

ACKNOWLEDGEMENTS

Worthy of appreciation is the effort of Centre for Research and Development of Rufus Giwa Polytechnic, Owo, Nigeria for their support and supervision of this research work and Tertiary Education Trust Fund (TETFUND) for sponsoring this project. To our entire academic mentors too numerous to mention, we say thanks a million for your impacts.

REFERENCES

AACC (2000): Approved Methods of the American Association of Cereal Chemists (10th ed): 2000. St. Paul, M. N.

Abegunde T.A., Bolaji O.T., and Adeyemo T.B. (2014). Quality Evaluation of Maize Chips (Kokoro) Fortified With Cowpea Flour. Vol 32 (1): pg 97-104, doi:10.1016/S0189.

Abiodun, O.A., Adegbite, J.A. and Omolola, A.O.(2012). Chemical and physicochemical properties of moringa flours and oil. Global

Journal of Science Frontier Research vol. xii (v): 13- 17.

Adegoke, G. O. and Adebayo, C. O. (1994): Production, Nutritional Profile and Storability of Aadun and Kokoro. Plant Foods for Human Nutrition (Impact Factor1.98) 03/1994 45(2): 139-144. 1994 Kluwer Academy Publisher. Printed in the Netherland

Anhwange, B.A; Ajibola, V.O and Oniye, S.J. (2004). Chemical studies of the seeds of Moringa Oleifara (Lam) and detarium micro carpum (Gull and Spear). Journal of Biological Sciences 4(6):711 – 715.

A.O.A.C (2005): Official Methods of Analytical Chemists (17th edition) (2005) Association of Official Analytical Chemists, Washington D.C.

Awoyale, W., Maziya-Dixon, B. and Abebe, M. (2011): Nutritional and Sensory Properties of a Maize-based Snack (Kokoro) International Journal of Food Science and Technology

Barber, L.F., Bebeya, E., Eke Ejiofor, J., Owuno, F. (2010): Effect of Cowpea Supplementation on the Physico-Chemical and Sensory characteristic of "Epiti" a steamed maize and plantain pudding. Journal of Nigeria Food Journal, Vol. 28, No 2. 2010 pg 448 – 453.

Bello, M. O., Fadake, O. S., Adewusi, S. R. A. and Olawore, N. O. (2008): Studies on the Chemical Compositions and Antinutrients of some Lesser Known Nigeria Fruits. African Journal of Biotechnology Vol. 7 (21) pp 3972-3979

Chikwendu, N.J. (2007): Chemical composition of "AKARA" (Fried groundbean paste) Developed from Fermented and Germinated Groundbean (Kerstingiella georcarpa) and Maize (Zea mays) Blends. Journal of Agriculture, Food, Environment and Extension. Vol. 6 Number 1, January, 2007

Coffman, C and Garcia V.V (1977): Functional properties of the Protein Isolate from many Flour. Journal of Food Technology 12:473-484.

Dreon, D.M., K.M. Vranizan., R.M. Krauss., M.A. Austin and P.D.wood (1990). The effects of poly unsaturated fat and monounsaturated fat on plasma lipoproteins. J. American Med. Assoc., 263: 2462.

El Sohalmy, S. A., Hamad G. M., Mohamed, S. E., Amar, M. H. and Al-Hindi R. R. (2015): Biochemical and Functional Properties of Moringa oleifera Leaves and their Potential as a Functional Food. Global Advanced Research Journal of Agricultural Science (ISSN: 2315-5094) Vol. 4(4) pp. 188-199, April, 2015. Available online http://garj.org/garjas/index.htm

FAO (1992): Food and Agricultural Organization. Maize in Human Nutrition, UN Rome

Fashakin, J. B. and Fasanya, J. I. (1988) Chemical Composition and Nutritive Change of some Improved Varieties of Cowpea. Some Selected Varieties from the International Institute of Tropical Agriculture, Ibadan, Nigeria. Tropical Sci. 28: 111-118

Giami, S. Y., Akusu, M. O. and Jaja, I. R. (2003). Production, Organoleptic Assessment and Nutritional Properties of Akara from Cowpea and Maize Flour Blends. Plant Foods for Human Nutrition,58, 1-9

Leeson, S. Scott, M.L and summer, J.D (2001). Scott's nutrition University Book, Greelph, Canada; ISBN – 13; 97809695560043. Pp591.

Makkar, H.P.S.and K.Becker (1997).Nutrient and anti – quality factors in different morphological parts of M. Oleifera tree. J. Agric. Sci. Cambridge, 128:311 – 322.

Martin, A. M., Emilienne, C. N., Christian, B. B. and Samuel, R. M. (2016): A Comparison Study on the Nutritional Quality of Proteins from Moringa oleifera Leaves and Seeds Journal Cogent Food & Agriculture Volume 2, 2016 - Issue 1

Masumaten, (1972): Whipping and Emulsifying Properties of Soybean Products Agric. Bio Chem. 36: 719-727.

Michael, Lea (2010): "Current Protocols in Microbiology" doi:10.1002/9780471729259. M/org 02516.ISBN 0471729256

Odedeji, J.O., and Oyeleke, W. A., (2011): Proximate, Physico-chemical and Organoleptic Properties of Whole and Dehulled Cowpea Seed Flour (Vigna unguiculata) Pakistan Journal of Nutrition 10 (12) 1175 – 1178: 2011 ISSN 1680- 5194

Okaka, J.C. and Potter, N.N. (1977). Sensory, Nutritional and Storage Properties of Cowpea Powders Processed to Reduce Beany Flavor. J. Food Sci. 44, 1539-1542. 49

Omueti, O., Morton, I. D., and Emery, P. W., (1992): Nutritional characteristics of soybean seed flour after processing with sodium bicarbonate or trona. Int. J. Food Sci Nutri 43:147 – 153

Omueti, O. and Morton, I. D., (1996): Development by Extrusion of Soybean Snack Sticks a Nutrionally Improved Soya-maize Product Based on the Nigeria Snack (kokoro). Inter. J.

Food Sci. Nutrition 47: 5 – 13

Onigbinde, A. O. and Akinyele, I. O. (1983): Oligosaccharide Content of 20 Varieties of Cowpea in Nigeria . Journal of Food Science 48, 1250 - 1251

Oyarekua, M.A. (2013). Comparative studies of co-fermented maize(pigeon pea and maize) (mucuna as infants complementary foods. Woodpecker journal of Food Technology. 1(1):1 – 8.

Philips, R. D. and McWatters, K. H. (1991): Contribution of Cowpea to Nutrition and Health. Food Technol., 45: 127 – 130

Rhee, K. S., Kim, E. S., Kim, B. K., Jung, B.M., Rhee, K. C., (2004): Extrusion of Minced Catfish with Corn and Defatted Soyflours for Snack Foods. J. Food Process. Pres. 28(6) 493-496

Salma, U., Miah, AG., Mak T., Nishimra M., and Tsuji, H(2009). Effects of dietary fat on cholesterol concentration and fatty acid composition in broiler meat.poult. sci; 86:1920 – 1926)

Sathe, S. K., Desphande, S. S. and Salunke, D.K. (1982): Functional Properties of Lupin Seed (Lipnus mutabilis) Protein and Protein Concentrates. Journal of Food Sciences 47: 491-497

Shakpo, I. O. and Osundahunsi, O. F. (2016): Effect of Cowpea Enrichment on the Physico-chemical, Mineral and Microbiological Properties of Maize:cowpea Flour Blends. Research Journal of Food Science and Nutrition Volume 1: 35-41.

Udensil, E.A., Odom, T.C., Nwaorgul, O.J., Emecheto, R.O., and Ihemanma, C.A (2012). Production and evaluation of the nutritional quality of weaning food formulated from roasted millet and mucuna cochinesis. Sky journal offood science, 1(1):1 - 5

Ukpabi, U. J. and Ndimele, C., (1990): Evaluation of Gari Production in Imo State, Nigeria. Nigeria Food Journal, 8: 105 -110.