 

# Proximate, Mineral and Sensory Qualities of 'Amala' Prepared from Yam flour fortified with Moringa leaf powder

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**Abstract**

The study was conducted to determine the proximate, mineral and sensory qualities of 'amala' prepared from yam flour fortified with *Moringa oleifera* leaf powder (MOLP). *Moringa oleifera* leaves were dried milled, sieved and added to yam flour in different proportions (0%, 2.5%, 5%, 7.5% and 10%). Samples were mixed to ensure uniform distribution of the leaves within the flour and subsequently prepared into 'amala'. Generally, the proximate composition except for moisture and carbohydrate content of all the samples increased significantly with an increase in the level MOLP with values ranging from 0.34-1.99% for crude fat; 1.10-2.21% for crude fibre; 1.74-2.78 for ash and 5.73-8.46% for crude protein and carbohydrate values from 8.35 -12.38%. Reduction in moisture content (wet basis) was observed from 78.72-76.21% and 12.375-8.350% for carbohydrate. The mineral composition ranged between (198.72-292.45 mg/100g), (140.23-159.00 mg/100g), (435.56-597.85 mg/100g), (473.95-543.02 mg/100g), (3.64-5.04ppm), (127.76-147.93ppm), (3.64-6.93ppm) and (4.77-5.54ppm) for Calcium (Ca), Magnesium (Mg), Potassium (K), Sodium (Na), Iron (Fe), Phosphorus (P), Manganese (Mn) and Copper (Cu) respectively. Generally, the mineral profile of the fortified 'amala' increased significantly ($P \leq 0.05$) with increase in addition of MOLP. There was no significant difference ($p<0.05$) among the samples for the sensory qualities of colour, mouldability and mouth feel except for sample fortified with 10% MOLP. However, the addition of MOLP greatly affected the aroma and overall acceptability of the sample. The sample prepared from yam flour fortified with 2.5% MOLP compared favourably well with the control in all sensory attributes. It was apparent that fortification of yam flour with MOLP at 2.5% level improved the proximate and mineral composition without affecting the overall acceptability and hence, could be used to improve the nutritional status of people and serves as an opportunity for the utilization of *Moringa oleifera* leaves.

**Keywords: Amala,** *Moringa oleifera* leaves, yam flour, proximate, mineral sensory.

## Introduction

Yams are major food crops in West Africa, the Caribbean, islands of the South Pacific, South East Asia, India and parts of Brazil (Ihekoronye and Ngoddy, 1985). It is the second most important root crop in Africa (FAO, 1997). Yam is an important source of carbohydrate for many people of the Sub Saharan region especially in the yam zone of West Africa (Akissoe *et al*., 2003). Nigeria is the World' largest producer of edible yams, with *Dioscorea rotundata* and *Dioscorea alata* as the two most cultivated yam species in the Country (Ukpabi *et al*., 2008). It is consumed in many different forms including boiled, roasted baked, fried and conversion into flours. The perishability nature of yam due to its high moisture content suggests the need to process it into less perishable products such as yam flour through drying process. The flour can be reconstituted with hot water to form a paste or gel called Kokonte in Ghana and 'Amala' in Nigeria (Jimoh and Olatidoye, 2009).

'Amala' is a popular yam flour dish in the Western part of Nigeria and some other African countries which is usually consumed with vegetables. It is a starchy gel prepared by reconstituting yam flour in boiling water until a dark smooth paste is formed. 'Amala' can also be made from either fermented cassava flour with the product having white appearance. The low protein content of yam flour and related products limits their use as nutritious foods (Sanni and Akinlua, 1996). Literature abounds on methods of improving the protein content of root and tuber products from plant sources (Oyewole and Aibor, 1993, Akingbala *et al*., 1995, Babalola *et al*., 2007). However, *Moringa oliefera* leaves are potential plant that can also be used to improve the nutrient profile of roots and tuber products.

*Moringa oliefera* tree is one of the most underutilized tropical crops with the leaves being a source of valuable nutrient (Oduro *et al*., 2008). The leaves are highly nutritious, being a significant source of beta-carotene, vitamin C, protein, iron and potassium (Joshi and Mehta 2010). The leaves are cooked and used like spinach and can be crushed into powder and used in soups and sauces (Joshi and Mehta 2010). The use of cheap plant protein rich commodities to fortify staple in the tropics have been reported in literatures. The use of soybean flour in yam flour fortification with an improvement in the nutritional quality of resulting meals (Jimoh and Oladitoye, 2009), the use of sweet potatoes and yellow maize in the fortification of yam flour used in the production of 'amala' (Ogunkoya and Titus, 2007) and use of grain amaranth flour in yam flour fortification (Babalola *et al*., 2007) have been reported Thus, to increase the utilization of *Moringa oleifera* leaves in fortification purposes it would be worthwhile to incorporate it into common staple in the tropics where malnutrition is prevalent. There is little or no information on the use of *Moringa oleifera* leaves in the fortification of yam flour, hence the objective of this study were to determine the proximate, mineral composition and sensory qualities of 'amala' prepared from yam flour fortified with *Moringa oleifera* leaves.

## Materials and Methods

### Formulation

Yam flour was prepared by method described by Babalola *et al*., (2007), while *Moringa oleifera* leaves powder (MOLP) was purchased from the University of Ilorin. The yam flour was sieved (2mm) to have uniform particle size and the MOLP was added at 2.5, 5, 7.5 and 10% levels. The mix was blended in a Kenwood Chef Mixer (Model KM 901D; Kenwood Electronic, Hertfordshire, UK) for 10 mins in order to have uniform distribution of the MOLP. Yam flour without MOLP (0%) served as the control. Each sample contained 400g of the yam flour packaged in polythene bags till analysis.

### Preparation of 'amala'

Each sample was prepared by pouring the flours into boiling water with continuous stirring until a homogenous paste was formed. The paste was covered and left on the fire for about 3 min to cook. It was further stirred, packed and wrapped with thin labeled polythene bag.

### Chemical Analysis

Proximate analysis for moisture, protein (N x 6.25), fat, ash, and crude fibre of samples were determined according to AOAC (1990) procedures. Carbohydrate content was calculated by difference.

**Digestion of Sample for Mineral Analysis**

Two-grammes each of the MOLP-fortified ‘amala’ were weighed into a 125ml Erlenmeyer flask which has been previously washed with acid and distilled water. This was followed by addition of 4ml perchloric acid, 25ml of conc. $HNO_3$ and 2ml conc. $H_2S0_4$ under a fume hood. The contents were mixed and heated gently at low heat on a hot plate until dense white fumes appeared. It was finally heated strongly for half a minute and then allowed to cool. About 40–50ml distilled water was added and the solution boiled for half a minute on the same plate at medium heat. The solution that emerged was allowed to cool and filtered completely into a 100ml Pyrex volumetric flask before making-up to mark with distilled water and later filtered with Whatman No 42 filter paper (9cm) (AOAC, 2000).

**Determination of minerals in ‘Amala’ fortified with Moringa Leaf Powder**

Four (4) macro (Ca, Na, K, Mg) and four (4) trace minerals (Fe, Cu, Mn, P) were determined with “Buck scientific Atomic Absorption Spectrophotometer Model 210A”. Standard solutions with optimum range for each element were prepared and all the operational instruction for setting up the instrument for the analysis of specific element was strictly followed. Phosphorus in the sample was determined colorimetrically using ascorbic acid method as described by AOAC (2000).

**Sensory Evaluation**

The organoleptic assessment of the MOLP-fortified ‘amala’ was carried out using panelists familiar with the consumption of ‘amala’ using a 5-point hedonic scale ranging from 1(Dislike extremely) to 5 (Like extremely).

**Statistical analysis**

All analyses were conducted in triplicates. Mean scores of the results and their standard deviation were reported. Data were subjected to analysis of variances, and Duncan multiple range (Duncan, 1955) test was used to separate the means.

 

**Results and Discussion**

**Proximate Composition**

The proximate composition of the MOLP-fortified 'amala' as presented in Table 1 showed an increase in crude fat, crude fibre, ash and crude protein and a decrease in carbohydrate and moisture content with increase in the levels of MOLP. The moisture content of the fortified 'amala' decreased significantly (P≤0.05) with the unfortified 'amala' (control) having the highest moisture content. The decrease in moisture content suggests that 'amala' with higher MOLP may keep longer since a reduction in moisture content would hinder the proliferation of micro-organisms (Adeyeye and Ayejuyo, 1994; Fennema and Tannenbaum, 1996).

The crude fat content of the MOLP-fortified 'amala' increased and differed significantly (P≤0.05) with increase in the addition of the MOLP. 'Amala' without MOLP and 'amala' with 10% MOLP had the lowest (0.340%) and highest (1.995%) crude fat respectively. The increase in the crude fat of the fortified 'amala may be attributed to the high fat content of *Moringa oleifera* leaves (Oduro *et al*., 2008; Ogbe and John, 2011), therefore diet containing *Moringa oleifera* leaves should be palatable since dietary fats function to increase food palatability by absorbing and retaining flavours (Lindsay, 1996).

Similarly, the crude fibre content increased with increase in the addition of the MOLP. 'Amala' without MOLP and 'amala' with 10% MOLP had the lowest (1.100%) and highest (2.205%) crude fibre respectively. There was no significant difference (P≤0.05) between 'amala fortified with 7.5% and 10% MOLP. Increase in the crude fibre content of the fortified 'amala' could also be attributed to the high content of crude fibre in *Moringa oleifera* leaves. 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 (Saldanha, 1995). According to Agostoni et al., (1995), non-starchy vegetables are the richest sources of dietary fibre and are employed in the treatment of diseases such as obesity, diabetes and gastrointestinal disorders (Saldanha, 1995), hence, MOLP-fortified 'amala' would contribute to promoting good health particularly in regions where 'amala' is staple.

The ash content of the MOLP-fortified 'amala' was significantly ($P \leq 0.05$) affected by the level of addition of the MOLP. The ash content also increased with increase in the level of addition of the MOLP. 'Amala' produced from yam flour fortified with 2.5, 5.0 and 7.5% MOLP are not different from one another ($P \leq 0.05$). 'Amala' with 10% MOLP had the highest ash content while the control (0%) had the lowest. The increasing trend observed in this study also suggests that MOLP is a good source of mineral elements.

The protein content of the MOLP-fortified 'amala' varied significantly ($P \leq 0.05$) with increase in addition of MOLP. The control (0% MOLP) had the lowest (5.730%) protein value showing clearly that yam flour is low in protein, while $MOLPA_{10}$ (10% *Moringa oleifera* leaves powder amala) had the highest (8.460%) protein content. Dried *Moringa oleifera* leaves have been reported by several researchers to contain appreciable amounts of protein (Ogbe and John, 2011; Joshi and Mehta, 2010; Oduro *et al*., 2008). A similar trend of increase in protein content was observed when fermented cassava flour was fortified with full fat soybeans (Sanni and Akinlua, 1996), yam flour fortification with grain amaranth (Babalola *et al*., 2007) and addition of *Moringa oleifera* leaves to full fat and low fat yoghurt (Muhammad and Abdulqadeer, 2011).

The high protein content of MOLP could be responsible for the increase in the protein content of the fortified 'amala' samples. Therefore, the nutritional status of consumers of 'amala' 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.

 

Similarly, as observed for moisture content (Table 1), the carbohydrate content expectedly decreased with increase in the addition of the MOLP, with the control (0% MOLP) having the highest (12.375%) and the $MOLPA_{10}$ (10% *Moringa oleifera* leaves powder amala) having the lowest (8.350%) carbohydrate content. This indicates that MOLP-fortified 'amala' may have a better keeping quality.

**Mineral Composition**

Table 2 shows the effect of addition of *Moringa oleifera* leaves powder on the mineral composition of 'amala'. The range of values obtained for the minerals were Calcium (198.72-292.45 mg/100g), Magnesium (140.23-159.00 mg/100g), Potassium (435.56-597.85 mg/100g), Sodium (473.95-543.02 mg/100g), Iron (3.64-5.04ppm), Phosphorus (127.76-147.93ppm), Manganese (3.64-6.93ppm) and Copper (4.77-5.54ppm). Generally, the mineral profile of the fortified 'amala' increased significantly ($P \leq 0.05$) with increase in addition of *Moringa oleifera* leaves powder. The 0% and 10% level of fortification had the lowest and highest values respectively for each of the mineral element. This observation confirms previous reports that *Moringa oleifera* leaves contain relatively high amounts of minerals particularly Ca, Mg, Na and P (Borlaug *et al*., 2007). Furthermore, the addition of *Moringa oleifera* leaves to amala indicates that the MOLP-fortified 'amala' will increase the utilization of the leaves and thus promote better health for consumers 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) (Ogbe and John, 2011). The increased Fe content suggests that the MOLP-fortified 'amala' may be useful in the prevention of anemia and other related diseases. Therefore the inclusion of MOLP to 'amala' may be a 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 (GDHS, 2004).

 

**Sensory Evaluation**

The result for sensory evaluation is presented in Table 3. Generally, the control sample ('amala' without MOLP), had the best rating for all the parameters. The result showed that $MOLPA_0$ (control) was rated high in colour than other samples. There was no significant ($P \leq 0.05$) difference in the colour of all the fortified samples except 'amala' fortified with 10% MOLP. The control sample ('amala' without MOLP) had the best rating while $MOLPA_{10}$ (10% *Moringa oleifera* leaves powder amala) had the least rating. The low rating observed for $MOLPA_{10}$ could be attributed to the dark green colour of MOLP which is a reflection of the chlorophyll content of the leaf. The dark brown colour of 'amala' may also have masked the dark green colour of the MOLP so that it did not affect the colour at lower levels.

The rating for aroma (Table 3) showed that panelist placed preference for the control ('amala' without MOLP) than other samples. All the samples were not significantly ($P \leq 0.05$) different from each other except the control. The reason for this could be attributed to the levels of MOLP in the fortified samples. The aroma of the MOLP has probably masked the natural aroma of 'amala' and hence could have led to lower ratings by the panelist. Ratings for mouldability showed no significant difference ($P \leq 0.05$) among all the samples. This observation indicates that the addition of MOLP did not affect the mouldability of the samples. 'Amala' prepared from 2.5% Moringa oleifera leaves powder ($MOLPA_{2.5}$) and the control had same rating and was rated best in all. The consistency and mouth feel showed significant difference among the samples with the control having the highest rating in each case and $MOLP_{10}$ (10% *Moringa oleifera* leaves powder amala) having the lowest. Ratings for mouth feel were similar for all the samples except for the control. The result of overall acceptability for the MOLP-fortified 'amala' revealed that the control and $MOLP_{2.5}$ (2.5% *Moringa oleifera* leaves powder amala) had the best rating. In all, the addition of MOLP affected the overall acceptability of the fortified 'amala' significantly ($P \leq 0.05$).

## Conclusion

The inclusion of MOLP to yam flours can serve as a pool house of nutrients and can therefore be used to improve the nutritional status of people. Fortification of yam flour with 2.5% MOLP is hereby recommended.

## References

Abulude, F. O and Ojediran, V. A. (2006). Development and quality evaluation of fortified 'amala'. Acta Sci. Pol. Technol. Aliment 5:(2)127-134.

Adeyeye, E. I. and Ayejuyo, O. O. (1994). Chemical Composition of Cola accuminata and Garcina kola seeds grown in Nigeria. International Journal of Food Science Nutrition 45:223-230

Agostoni, C., Riva, R., Giovannini, M. (1995). Dietary fiber in weaning foods of young children, Pediat (96):1000-1005.

Akissoe, N. H. (2003). Hounhouigan, J. D., Brica, N., Vernier, P., Nago, M. C. and Olorunda, O. A. (2003). Physical, Chemical an Sensory evaluation of dried yam (*Dioscorea rotundata*) tubers, flour and amala-a flour-derived product. Trop. Sci. 41:151-156.

Akingbala, J. O., Oguntimein, G. B., Sobande, A. O. (1995). Physicochemical properties and acceptability of yam flour substituted with soy flour, Plant Foods for Human Nutrition Vol. 48:73-80

Babalola, S. O., O Taylor, A. O. Babalola and O. A. Ashaye (2007). Chemical and sensory properties of yam (*Dioscorea alata*) flour substituted with grain amaranth (*Amaranthus cruentus*) flour

Borlaug, N., Cunningham A., Guyer, J. I., Herren, H., Juma, C., Mabogunje, A., Underwood, B and Yudelman, M. (2006). Lost Crops of Africa (Volume II, vegetables) National Academic Press. pp. 378.

Duncan, D.B. (1955). Multiple range and multiple F-tests. Biometrics, 11, 1–5. doi: 10.2307/3001478.

FAO (1997). Food Production Year Book. Food and Agriculture Organization, Rome Vol. 50.

Fennema, R. O. and Tannenbaum, S. R. (1996). Introduction to Food Chemistry. In: Fennema, R. O., Karel M, Sanderson, G. W., Tannenbaum, S. R., Walstra, P., Witaker J. R. (eds).

Food Chemistry, Marcel Dekker Inc. New York. pp. 1-64.

Oduro, I, W. O. Ellis and Owusu, D (2008). Nutritional potential of two leafy vegetables: *Moringa oleifera* leaves and *Ipomoea batatas* leaves. Scientific Research and Essay Vol. 3(2), pp. 057-060.

Ogbe, A. O. and John, P. A. (2011). Proximate study, mineral and anti-nutrient composition of *Moringa oleifera* leaves harvested from Lafia, Nigeria: Potential benefits in poultry nutrition and health.

Ihekoronye, A.I. and Ngoddy, P.O. (1985). Integrated Food science and Technology for the Tropics, Macmillian, London. Pp 293&391.

Ogunkoya, M. O. and Titus, F. A. (2007). Sensory evaluation and functional properyies of developed 'amala'. Continental Journal of Food Science and Technology 1:14-17.

Oyewole, O. B and Aibor, A. M. (1993). Fermentation of cassava with cowpea and soya bean for an enriched 'fufu', Tropical Science. Vol. 3 (1):9-15.

Joshi, P and Mehta, D.(2010). Effect of dehydration on the nutritive value of drum stick leaves. Journal of Metabolomics and Systems Biology Vol. 1(1), pp. 5-9.

Lindsay, R. C. (1996). Flavours. In: Fennema, R. O., Karel M, Sanderson, G. W., Tannenbaum, S. R., Walstra, P., Witaker J. R. (eds). Food Chemistry, Marcel Dekker Inc. New York. pp. 611-612.

Muhammad, B. F. and Abdulqadeer, A. M. (2011). Effect of Moringa (Moringa Oliefera LAM) Leaves Extract on Physicochemical and Organoleptic properties of Full fat and Low fat Yoghurt. ACT-Biotechnology Research Communications (In Press) pp 1-4.

Saldanha, L. G. (1995). Fibre in the diet of U. S. children: results of national surveys. Pediat. (96):994-996.

Sanni, L. O and Akinlua, O. (1996). Chemical, physical, physicochemical and sensory qualities of soy lafun, Nigerian Food Journal, Vol. 14 pp. 30-36.

Ukpabi, U. J., R. M. Omodamiro, J. G. Ikeorgu and R. Asiedu (2008). Sensory evaluation of 'amala' from improved water yam (*Dioscorea alata*) genotypes in Nigeria. African Journal of Biotechnology Vol. 7(8):1134-1138.

**Table 1: Proximate Composition of 'Amala' Fortified with MOLP**

| Sample | Moisture Content (%) | Crude Fat (%) | Crude Fibre (%) | Ash (%) | Crude Protein (%) | Carbohydrate (%) |
|---|---|---|---|---|---|---|
| $MOLPA_0$ | $78.720^a$ | $0.340^e$ | $1.100^d$ | $1.735^c$ | $5.730^e$ | $12.375^a$ |
| $MOLPA_{2.5}$ | $77.365^b$ | $0.780^d$ | $1.420^c$ | $2.110^b$ | $6.355^d$ | $11.970^b$ |
| $MOLPA_{5.0}$ | $76.895^c$ | $1.220^c$ | $1.785^b$ | $2.400^b$ | $7.115^c$ | $10.585^c$ |
| $MOLPA_{7.5}$ | $76.920^c$ | $1.540^b$ | $1.800^b$ | $2.365^b$ | $7.820^b$ | $9.555^d$ |
| $MOLPA_{10}$ | $76.215^d$ | 1.995 | $2.205^a$ | $2.775^a$ | $8.460^a$ | $8.350^e$ |

Mean with the same superscript along the same column are not significantly different at 5%

$MOLPA_0$ = 0% Moringa oleifera leaves powder 'amala'
$MOLPA_{2.5}$ =2.5%Moringa oleifera leaves powder 'amala'
$MOLPA_{5.0}$ =5.0%Moringa oleifera leaves powder 'amala'
$MOLPA_{7.5}$ =7.5%Moringa oleifera leaves powder 'amala'
$MOLPA_{10}$ =10%Moringa oleifera leaves powder 'amala'

**Table 2: Mineral Composition of 'Amala' Fortified with MOLP**

| Mineral | $MOLPA_0$ | $MOLPA_{2.5}$ | $MOLPA_{5.0}$ | $MOLPA_{7.5}$ | $MOLPA_{10}$ |
|---|---|---|---|---|---|
| Ca (mg/100g) | $198.72^{b}$ | $200.14^{a}$ | $200.73^{a}$ | $201.84^{a}$ | $202.45^{a}$ |
| Mg (mg/100g) | $140.23^{b}$ | $144.70^{b}$ | $150.20^{a}$ | $154.83^{a}$ | $159.00^{a}$ |
| K (mg/100g) | $435.36^{d}$ | $484.39^{c}$ | $510.71^{b}$ | $550.00^{b}$ | $597.85^{a}$ |
| Na (mg/100g) | $473.95^{c}$ | $503.39^{b}$ | $516.20^{b}$ | $520.71^{b}$ | $543.02^{a}$ |
| Fe (ppm) | $3.64^{c}$ | $3.67^{c}$ | $4.54^{b}$ | $4.87^{b}$ | $5.04^{a}$ |
| P (ppm) | $127.76^{c}$ | $133.34^{b}$ | $139.16^{b}$ | $142.63^{a}$ | $147.93^{a}$ |
| Mn (ppm) | $3.64^{e}$ | $4.67^{d}$ | $5.70^{c}$ | $6.06^{b}$ | $6.93^{a}$ |
| Cu (ppm) | $4.77^{b}$ | $4.89^{b}$ | $4.97^{b}$ | $5.16^{a}$ | $5.54^{a}$ |

Mean with the same superscript along the same row are not significantly different at 5%

**Table 3: Sensory Scores of 'Amala' Fortified with MOLP**

| Sample | Colour | Aroma | Mouldability | Consistency | Mouth feel | Overall Acceptability |
|---|---|---|---|---|---|---|
| $MOLPA_{0}$ | $4.25^{a}$ | $4.50^{a}$ | $4.00^{a}$ | $4.25^{a}$ | $4.00^{a}$ | $4.50^{a}$ |
| $MOLPA_{2.5}$ | $3.50^{a}$ | $3.00^{b}$ | $4.00^{a}$ | $4.00^{a}$ | $4.00^{a}$ | $4.00^{a}$ |
| $MOLPA_{5.0}$ | $3.25^{a}$ | $3.00^{b}$ | $3.75^{a}$ | $3.75^{ab}$ | $3.50^{a}$ | $3.50^{b}$ |
| $MOLPA_{7.5}$ | $3.25^{a}$ | $3.00^{b}$ | $3.50^{a}$ | $3.75^{ab}$ | $3.75^{a}$ | $3.50^{b}$ |
| $MOLPA_{10}$ | $2.00^{b}$ | $2.75^{b}$ | $3.00^{a}$ | $2.75^{b}$ | $2.25^{b}$ | $2.25^{c}$ |

Mean with the same superscript along the same row are not significantly different at 5%