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Effect of Moringa Leaf Powder Addition on the Nutritional Composition and Sensory Evaluation of Plantain Flour Stiff Dough (Amala)

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Abstract: *In recent years, research efforts in the developing countries have focused on the improvement of nutritional quality of food products due to mass malnutrition. The dietary management of diabetes recommends the use of stiff plantain dough (amala), a starchy staple food in some parts of Africa including Nigeria. This research study investigated the effect of the addition of moringa leaf powder on the proximate composition and mineral content of plantain flours and their corresponding stiff dough (amala). The sensory evaluation of the amala was determined. The stiff plantain doughs were produced using different levels of plantain flour substituted with moringa leaf powder ranging from 0 – 15% at the interval of 2.5%. The result revealed that addition of moringa improves the proximate composition (Moisture, Fat, Ash, Crude fiber, Protein, Carbohydrate) of moringa fortified plantain flours and their corresponding stiff doughs. The inclusion of moringa caused the reduction in Na, K and P contents and increased the quantities of Ca, Mg, Fe and P in the flours and amala. The result of sensory evaluation for the fortified 'amala' revealed that 2.5 % to 5 % moringa leaf powder supplementation for plantain flour were equally rated, and are sufficient to improve the proximate and mineral composition of plantain flour amala without having significant effect on the sensory properties*

Keywords: *Nutritional Composition, Sensory Evaluation Stiff Dough (Amala), Plantain Flour. Moringa Leaf Powder*

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I. Introduction

Plantain (Musa paradisiacal) and banana belong to the family of Musaceae with the genus Musa, and is plant producing fruits that are invaluable source of carbohydrate and energy at maturity for millions of people in many parts of Africa, Asia and South America [1, 2]. Plantain plant consists of long, overlapping leafstalks and bears a stem which is 1.22 to 6.10 m high [3] and produces bunches with fewer but bigger fingers than the banana. Plantains represent the world's second largest fruit crop with an annual production of 144 million metric tons and closely follows rice, wheat, and maize, as the fourth most important global food commodity [4]). Nigeria with a yearly output of about 3.09 million metric tons ranks fifth after Cameroon, Ghana, Uganda, and Colombia in the world mostly obtained from the southern states

Plantain, a major economic source of energy food in many regions throughout the world, helps in weight control, suitable for diabetic patient due to its low glycemic index [5, 6] The fruit is extremely rich in Iron, potassium, and vitamin A [7], and mostly eaten raw, fried, boiled, roasted as a staple food In other instances, unripe plantains can be processed into flour, used traditionally for preparing a stiff dough (Amala) by reconstituting the flour in boiling water until a dark smooth paste is formed [8]. Amala is a regular staple food in the South Western part of Nigeria, and some part of Ghana and Cameroun where it is called Kokonte and 'foufou' respectively [9, 10]. Plantain food products are mainly carbohydrate food and unable to meet the protein requirements of consumers, especially among rural dwellers.

Consequently several authors worked on the possibility of enriching the nutritional value of the products by inclusion of legumes and other Protein-rich plant foods, such as Bambara groundnut protein concentrate [11], Moringa oleifera leaf powder [12], extruded soybeans [13]. Considering the relationship between food, health, and nutrition, Moringa oleifera is a promising plant which could aid better intake of some essential nutrients and beneficial phytochemicals in the human diet. Moringa oleifera, belong to Moringaceae family, native to India and northern Africa, is a "cure-all" remedy for thousands of years. It is a drought tolerant, medium-sized, evergreen tree that prefers warm, frost-free climates, and recently naturalised in many locations in the tropics and gaining wide acceptance, mostly in the northern part of Nigeria. Moringa is a beneficial tree, as almost every part of the tree can serve as food, and the leaves from the moringa plant, a powerhouse of nutrient, can be consumed fresh, cooked or processed to powder [14]. Good health is a function of eating healthy food. Therefore research efforts are recently geared toward the improvement of the nutritional quality of food products in many developing countries to fight malnutrition. This research study investigated the effect of the addition of moringa leaf powder on the nutrient composition, functional and pasting properties of the fortified plantain flours, and how it affects the nutrient and sensory evaluation of their corresponding stiff dough (amala).

II. Material And Methods

Sample procurement

Mature Unripe plantain fruits used for this study were collected from a local market at SayederoYewa South Ogun State, Nigeria, and fresh Moringa leaf powder was obtained from Rokarich International Company, Akure Ondo State, Nigeria. Preparation of Plantain Flour

Preparation of plantain flour

Using the modified of Ibeanu*et al*. method as described by Ilelaboye and Ogunsina [15], 20 kg of green plantain fingers washed, sun-dried for 30 min, and then hand peeled, sliced to a thickness of about 5 mm, and stored in water to avoid browning before drying. The sliced pulp, dried in a hot air oven for 6 hr at a temperature of 80 ^oC was milled with a hammer mill (Bentall Superb, Model 200 L 09), sieved through a 75 µm mesh sieve and kept in airtight plastic containers at room temperature for further use.

Preparation of various flour blends

The plantain flour and moringa flour were mixed according to the proportion in Table 1, and homogenised using a Cross-Flow blender for 30 min, and stored separately in tightly covered plastic containers for later use [15].

Table 1: Composite Mixture of Plantain - Moringa leaf flour

FLOUR	P	PM1	PM2	PM3	PM4	PM5	PM6
PLANTAIN (%)	100	97.5	95	92.5	90	87.5	85
MORINGA (%)	0	2.5	5	7.5	10	12.5	15

Preparation of Amala

50 g of the composite flour poured into 200 mL boiling water with continuous stirring to obtain a smooth, thick mixture that was allowed to simmer for about 5 min, stirred, and wrapped with thin labelled polythene wraps.

Chemical analysis

The proximate composition of the composite flours analysed using the procedure of Association of Official Analytical Chemist [16], and the energy value calculated using Atwater factors. Flame photometry method was used to analyse the potassium and sodium content of the samples [17]. Phosphorus was determined by Vanado-molybdatecolourimetric method.[18] Calcium, magnesium, and iron were determined spectrophotometrically by using Buck 200 atomic absorption spectrophotometer (Buck Scientific, Norwalk United Kingdom (UK)) [19].

Sensory evaluation

Sensory evaluation of the *amala* samples prepared from the plantain-moringa flours was performed 4 hr. after production using the 9 points Hedonic scale quality analysis [20]. 20 untrained panellists drawn from students and staff of the Federal Polytechnic, Ilaro Ogun State Nigeria, evaluated the coded amala samples for colour, aroma, taste, mouldability consistency and overall acceptability using the 9-point hedonic scale, where one (1) corresponds to like extremely, and nine (8) corresponds to dislike extremely.

Statistical analysis

All analyses carried out in triplicate, with statistical significance established using one-way analysis of variance (ANOVA), Mean comparison and separation done using Duncan Multiple range (DMR) test at p≤ 0.05, described by the SPSS 16.0 statistical package. [21]

III. Results And Discussion

Proximate compositions of the flours

According to the proximate composition table (Table 2), of moringa and the fortified flours, the addition of moringa to plantain caused significantly (P < .05) decrease in moisture content of plantain flours, ranging from sample P (10.22±..03 %) to sample PM6 (9.99±.02 %). Also, the moisture of prepared stiff dough (amala) shows the same trend (Table 3), and the per cent moisture of all the flours reported in this study is below 15% which is the recommended maximum limit for flours, suggesting longer shelf-life for the blends [22].

Table 2: The Proximate composition (%) and Energy (Kcal/100g) values of the moringa fortified plantain flours

**Sample	moisture	protein	fat	fibre	ash	carbohydrate	energy
M	$8.50\pm.04^{a*}$	$27.14\pm.03^{h}$.	$2.85\pm.03^{e}$	$9.44\pm.01^{a}$.	$10.39\pm..04^{h}$	$41.68\pm.03^{a}$.	300.93 ± 5.14^{a}
P	$10.22\pm..03^{e}$	$3.68\pm.03^{a}$	$1.37\pm.04^{a}$.	$2.45\pm.03^{b}$.	$2.88\pm.07^{.a}$	$79.4\pm.04^{g}$	344.15 ± 6.19^{b}
PM1	$10.20\pm.01.^{e}$	$3.95\pm.06^{.b}$	$1.42\pm.02^{ab}$.	$2.63\pm.02^{c}$.	$3.07\pm.07^{.b}$	$78.74\pm..07^{f}$	343.95 ± 4.10^{b}
						$78.02\pm.06^{ef}$	342.83 ± 5.45^{b}
PM2	$10.15\pm..00^{d}$	$4.21\pm.04.^{c}$	$1.55\pm.04.^{b}$	$2.83\pm.07^{d}$.	$3.25\pm.05^{c}$		
PM3	$10.10\pm..02^{c}$	$4.65\pm.02.^{d}$	$1.65\pm.02^{bc}$.	$2.98\pm.03^{e}$.	$3.38\pm.02.^{d}$	$77.26\pm.07^{e}$	342.06 ± 7.12^{b}
PM4	$10.04\pm..03^{b}$	$5.25\pm.04^{e}$	$1.73\pm.04^{cd}$.	$3.16\pm.04^{f}$.	3.63±.07.e	$76.21\pm.14^{d}$	341.83 ± 4.76^{b}
PM5	$10.02\pm.00^{b}$.	$5.83\pm.04^{f}$	$1.85\pm.02^{d}$.	$3.35\pm.05^{g}$.	$3.77\pm.00.^{f}$	$75.19\pm.14^{.c}$	340.89 ± 6.43^{b}
PM6	$9.99\pm.02^{b}$.	$6.68\pm.07.^{g}$	$1.93\pm.04.^{f}$	$3.51\pm.04^{h}$	$3.99\pm.04^{g}$	$73.91\pm.14^{b}$	339.74 ± 3.94^{b}

(%)

*Values are Mean± SD of triplicate determinations, and Mean values in the same column with different superscripts are significantly different at P < .05.

**Sample key = P [[100 Plantain: 0 Moringa leaf powder]; PM1 [[97.5 Plantain: 2.5 Moringa leaf powder]; PM2 [[95 Plantain: 5 Moringa leaf powder]; PM3 [[92.5 Plantain : 7.5 Moringa leaf powder]; PM4 [[90 Plantain : 10 Moringa leaf powder]; PM5 [[87.5 Plantain : 12.5 Moringa leaf powder]; PM6 [[85 Plantain : 15 Moringa leaf powder];

Table 3: The Proximate composition (%) and Energy (Kcal/100g) values of Amala prepared from fortified plantain flours

**Sample	moisture	protein	fat	fibre	ash	carbohydrate	energy
P	$70.63\pm.0^{e*}$	$3.95\pm.06^{a}$	$1.48\pm.06^{a}$	3.02 ± 04^{a}	$3.16\pm.03^{a}$	$17.76\pm.07^{d}$	99.88 ± 2.84^{e}
PM1	$70.44\pm.14^{d}$	$4.55\pm.04^{b}$	$1.68\pm.03^{ab}$	$3.68\pm.07^{b}$	$3.39\pm.07^{b}$	$16.25\pm.11^{c}$	100.83 ± 3.14^{d}
PM2	$69.49\pm.30^{c}$	$5.61\pm.07^{c}$	$1.73\pm.04^{b}$	$3.96\pm.07^{c}$	$3.47\pm.05^{c}$	$15.75\pm.32^{c}$	101.01 ± 1.94^{d}
PM3	$68.63\pm.07^{c}$	$6.91\pm.07^{d}$	1.82 ± 15^{c}	$4.24\pm.07^{d}$	$3.73\pm.13^{d}$	$14.68\pm.18^{b}$	102.69 ± 2.54^{c}
PM4	$67.86\pm.10^{b}$	$8.09\pm.08^{e}$	$1.87\pm.04^{d}$	$4.45\pm.04^{e}$	$3.96\pm.07^{e}$	$13.77\pm.21^{b}$	104.28 ± 3.14^{c}
PM5	$66.33\pm.71^{a}$	$9.61\pm.08^{f}$	$1.97\pm.07^{e}$	$4.64\pm.07^{f}$	4.11 ± 05^{f}	$13.16\pm.16^{b}$	108.83±2.19b
PM6	$65.63\pm.21^{a}$	$11.38\pm.11^{g}$	$2.06\pm.07^{f}$	4.89 ± 14^{g}	$4.43\pm.09^{g}$	11.92±.28a	111.72 ± 2.44^{a}

*Values are Mean± SD of triplicate determinations, and Mean values in the same column with different superscripts are significantly different at P < .05.

**Sample key = P [[100 Plantain: 0 Moringa leaf powder]; PM1 [[97.5 Plantain: 2.5 Moringa leaf powder]; PM2 [[95 Plantain: 5 Moringa leaf powder]; PM3 [[92.5 Plantain : 7.5 Moringa leaf powder]; PM4 [[90 Plantain : 10 Moringa leaf powder]; PM5 [[87.5 Plantain : 12.5 Moringa leaf powder]; PM6 [[85 Plantain : 15 Moringa leaf powder]

As shown in Table 2, moringa leaf powder possesses higher content of protein, fat, fibre, and ash, but a lower per cent of moisture, carbohydrate, and energy than plantain flour. This observation is similar to the reports of Jongrungruangchok et al., [23] for Moringa oleifera leaves, and Akubor et al., [5]; Zakpaa et al., [24] and Karim et al., [12] for plantain flour. Protein values of the fortified flours as depicted in Table 2, differs significantly (P < .05.), and ranges from 3.98±.03 % to 7.68±.07 %. The rise in per cent protein of these flours with an increase in the level of moringa substitution in the blends could be attributed to the additive effect of moringa *leaf powder* protein [27.14±.03 %] on the plantain flours The levels of protein in 100 % plantain observed in this study showed that the fruit is low in protein and cannot meet adult protein diet need, which for a healthy adult is about 0.75g per kg per day [25]. Amala from the fortified flours exhibits the same incremental trend in per cent protein (Table 3) as their corresponding flours. However, the protein content of the amala products increased significantly compared to their respective flour blends, implying that cooking the flour blends had a positive effect on the protein contents of the final product. The observation agrees with the findings of Adepoju [26], on the effects of processing on white.

The addition of moringa powder to plantain flour caused a significant increase in the fat content of the fortified flours as the level of moringa powder increases ranging from PM1 (1.42±.02 %) to PM6 (1.93±.04 %). This low-fat content of these flour suggests they prolong the shelf life of food products because fat can promote rancidity in food leading to the development of unpleasant and odorous compounds [27]. However processing the fortified plantain blends to amala further increased the fat content of the products confirming the claims of Oste, [28] and Adepoju [26], that Processing enhances the nutrient availability of food. The increase in percent fat of the fortified flours may be credited to the high fat content of *Moringa* leaf [29, 30], hence improving the palatability of amala containing *Moringa* leaf because dietary fats function to increase food palatability by absorbing and retaining flavours [31].

Crude fibre represents the content of the non-digestible components of food, such as lignin, cellulose, and hemicelluloses. As shown in Table 2 the crude fibre content increased significantly (P < .05.) with an increase in substitution level due to the high fibre content of Moringa leaf powder (9.44±.01%). Cooking the fortified flour to obtain amala further increase the fibre content of the flour blends (*Table 3), and this confirms that Processing enhances the nutrient availability in food products. [28, 32]*. This observation indicates that the enriched 'amala' will digest easily hence contribute to the prevention of colon cancer because a diet high in crude fibre *facilitates bowels movement.* [33].

Ash is the inorganic residue after removing the water, and organic matter by burning a food sample. The ash content of moringa leaf powder is significantly higher (4.25 times) than plantain flour ash content. Hence its inclusion in the flour blends significantly increased the per cent ash of fortified flours with an increase in the level of addition of the moringa leaf powder. Processing the flour blends into amala caused an increase in ash content of the fortified flours ranging from 100% plantain (3.16±.03 %) to 25 % Moringa leaf powder fortified plantain (4.43±.09 %). This observed increase in ash content agrees with the report of Karim *et al. [8] on* Amala' produced from yam flour fortified with 2.5, 5.0 and 7.5 % *moringa oliferea leaves powder.*

The carbohydrate content of moringa leaf powder (41.68±.03 %) as shown in Table 2 is very low compared to the carbohydrate content of sole plantain flour(79.4±. %), therefore inclusion of moringa in plantain brought about significant (P < .05.) reduction in carbohydrate value of the fortified flours with rising in addition of moringa. Processing the flour blends to amala further reduced the per cent carbohydrate of plantain flour, and this study finding is similar to that of Ilelaboye and Ogunsina [15] who observed a reduction in carbohydrate content (75.65±1.53to 64.33±5.32 %) of okara fortified plantain-sorghum flour with the addition of okara flour.

The energy values of the fortified flours, as shown, ranged between 344.15±6.19 kcal and 339.74±3.94 kcal, and did not vary significantly (P < .05.). The addition of moringa leaf powder to plantain flour caused a decline in the energy level of the blends.

Mineral composition

The mineral content of sole plantain flour, moringa leaf powder and fortified plantain flours as given in Table 4, revealed that 100% plantain flour possessed higher per cent of sodium (Na), potassium (K), and phosphorous (P), while moringa leaf powder has higher calcium (Ca), magnesium (Mg) and iron (Fe), and the minerals varied significantly ([p<0.05) at different degrees in the enriched flour blends. Calcium ions preserve the skeleton firmness and participate in most metabolic processes. The vertebrate skeleton is maintained by a form of calcium phosphate and is embedded in collagen fibrils [34]. The calcium content of the 100 % plantain flour was 234.06±28.41 mg/100g, while that of the moringa fortified flours increased significantly (P < .05.) from 277.66±18.44 mg/100g in PM1 to 478.49±32.90 mg/100g in PM6 as the level of moringa leaf powder increase in the blends. Cooking the flouts to amala brought reduction to their calcium content. However, consumption of about 100 g enriched amala will provide an estimated 18.20% to 31,94 % of the recommended daily allowance (RDA) for adult calcium (1100 mg/day) requirements [35]

Table 4: The mineral composition of the moringa fortified plantain flours (mg/100g)

**Sample	Ca	Mg	P	K	Na	Fe
M	$1978.12±59.73^{h*}$	$357.12±7,43^{c}$	$135.87±4.73^{a}$	$1486.12±97.3^{a}$	$167.79±9.73^{a}$	$34.75±2.81^{b}$
P	$234.06±28.41^{a}$	$199.06± 8.54^{a}$	$219.06±6.41^{b}$	$3856.06±84.1^{d}$	$239.06±8.41^{b}$	$12.56±1.34^{a}$
PM1	$277.66±18.44^{ab}$	$203.01±6.44^{ab}$	$216.98±7.44^{b}$	$3796.81±84.4^{cd}$	$237.28±8.44^{b}$	$13.11±1.37^{a}$
PM2	$321.26±18.47^{bc}$	$206.96±4.27^{ab}$	$214.90±4.48^{b}$	$3737.56±84.7^{bcd}$	$235.498.47^{b}$	$13.67±1.41^{a}$
PM3	$364.86±18.51^{cd}$	$210.91±5,71^{ab}$	$212.82±5.51^{b}$	$3678.31±85.1^{bcd}$	$233.72±8.51^{b}$	$14.22±1.44^{a}$
PM4	$401.57±18.29^{de}$	$214.86±7.54^{ab}$	$213.97±3.97^{b}$	$3710.19±92.34^{bcd}$	$237.41±8.44^{b}$	$13.96±2.63^{a}$
PM5	$435.07±32.62^{ef}$	$218.82±8.58^{ab}$	$211.89±4.00^{b}$	$3650.95±94.30^{bc}$	$235.63±8.47^{b}$	$14.52±2.67^{a}$
PM6	$478.49±32.90^{fg}$	$222.77±8.61^{b}$	$209.81±4.03^{b}$	$3591.70±90.27^{b}$	$233.85±8.51^{b}$	$15.07±2.70^{a}$

*Values are Mean± SD of triplicate determinations, and Mean values in the same column with different superscripts are significantly different at P < .05.

**Sample key = P [[100 Plantain: 0 Moringa leaf powder]; PM1 [[97.5 Plantain: 2.5 Moringa leaf powder]; PM2 [[95 Plantain: 5 Moringa leaf powder]; PM3 [[92.5 Plantain: 7.5 Moringa leaf powder]; PM4 [[90 Plantain : 10 Moringa leaf powder]; PM5 [[87.5 Plantain : 12.5 Moringa leaf powder]; PM6 [[85 Plantain : 15 Moringa leaf powder];

**Sample	Ca	Mg	P	K	Na	Fe
P	200.24±38.71[a]*	150.14±8.71[a]	187.34±18.71[d]	3315.16±98.71[g]	204.54±18.71[f]	11.16±.64[abc]
PM1	214.22±25.66[b]	154.22±5.66[ab]	175.55±15.66[cd]	2714.76±75.66[f]	190.13±15.66[e]	10.14±.04[a]
PM2	246.12±34.39[c]	157.30±4.39[ab]	171.58±14.39[bc]	2613.12±84.39[e]	186.11±14.39[de]	10.54±.16[ab]
PM3	267.34±26.36[d]	158.10±6.36[ab]	167.26±16.36[abc]	2542.86±66.36[d]	173.90±16.36[cd]	11.11±.44[abc]
PM4	296.72±14.24[e]	162.15±4.24[ab]	163.97±14.24[abc]	2445.02±74.24[c]	168.54±14.24[bc]	11.46±.62[abc]
PM5	326.32±35.37[f]	164.02±5.37[ab]	160.31±15.37[ab]	2377.64±55.37[b]	158.97±15.37[ab]	11.71±.49[bc]
PM6	351.44±24.88[g]	165.89±4.88[b]	155.97±14.88[a]	2281.85±44.88[a]	150.52±14.88[a]	12.10±.81[c]

Table 5: The mineral composition of Amala prepared from fortified plantain flours (mg/100g)

*Values are Mean± SD of triplicate determinations, and Mean values in the same column with different superscripts are significantly different at P < .05..

**Sample key = P [[100 Plantain: 0 Moringa leaf powder]; PM1 [[97.5 Plantain : 2.5 Moringa leaf powder]; PM2 [[95 Plantain : 5 Moringa leaf powder]; PM3 [[92.5 Plantain : 7.5 Moringa leaf powder]; PM4 [[90 Plantain : 10 Moringa leaf powder]; PM5 [[87.5 Plantain : 12.5 Moringa leaf powder]; PM6 [[85 Plantain : 15 Moringa leaf powder];

The magnesium content of the raw sample was 199.06± 8.54 mg/100g, while the magnesium content of the fortified flours ranged from 203.01±6.44 mg/100g to 222.77±8.61 mg/100g with the 15 % moringa substituted plantain flour having the highest value. Addition of moringa leaf powder caused no or slight significant different in magnesium content of the enriched flour; also the prepared amala exhibited the same trend with a reduction in their per cent magnesium (Table 5). Compared with their respective flours Soft tissue magnesium functions as a co-factor of many enzymes involved in energy metabolism, protein synthesis, RNA and DNA synthesis, and maintenance of the electrical potential of nervous tissues and cell membranes. [34]. The estimate recommended daily allowances for magnesium is 350 mg/day [35], out of which consumption of 100 g fortified Amala. Supplied 42.90 % to 47.40 % RDA

Phosphorus, a crucial element of the bone, exist in the mass ratio of 1 phosphorus to 2 calcium and partake in many and varied chemical reactions in the body. Bone. Contain roughly 85% (700 g) of the phosphorus in the adult body [36]. The phosphorus content of the enriched flours which ranged from 216.98±7.44 mg/100g to 209.81±4.03 mg/100g was insignificantly (P < .05.) reduced by an increase in the level of inclusion of moringa leaf powder to plantain flour. Reconstituting the flours to amala brought about an additional decrease in the phosphorous content of the prepared amala. The RDA for phosphorus is 800 mg/day for an adult [35], and amala can supply about 26.23 % to 27.12 % RDA.

The value of potassium of 100 % plantain flours (3856.06±84.1 mg/100g) is higher than that of moringa leaf powder (1486.12±97.3 mg/100g) and, fortification of plantain flour resulted in significant (P < .05.) reduction of the enriched flour mixes which ranged from 3796.81±84.4 mg/100g to 3591.70±90.27 mg/100g (Table 4). Also, cooking the flours to amala further reduced the potassium content of the products (Table 5), and consumers of amala will derive 48.55 % to 70.54 % of RDA for potassium, [35] which controls the electrical activity of your heart, making it vital to maintaining a healthy heart rhythm, the pH balance of the blood and support normal growth.

Excess intake of sodium can cause high blood pressure; the body needs sodium to arouse nerve and muscle function, maintain balance in the cells' fluid and aid the uptake of other nutrients including chloride, amino acids and glucose. Table 4 reveals that blending of plantain flour with moringa leaf powder resulted in non-significant) decrease in the sodium content of the fortified plantain flours, the and further reduction in per cent sodium was observed when the flours were reconstituted to amala (Table 5) The food is suitable for dietary management of hypertension due to its low sodium content [37].

Iron, a component of blood cell haemoglobin functions as a carrier of oxygen to the tissues from the lungs, electrons transport within cells, and an element of essential enzyme systems in several tissues [34]. The amount of iron in moringa leaf powder is about 2.77 times higher than its value in 100 % plantain flour, (12.56±1.34 mg/100g). Therefore the iron content of fortified flours increased significantly (P < .05.) with an increase in the level of moringa leaf powder inclusion. The iron content of amala is lower than the amount in their respective flours (Tables 4 & 5), and the quantity is enough to provide the RDA of iron (5mg/day) fur adult [[35]

Sensory properties:

Table 6: *The mean scores for sensory evaluation*

Sample	Colour	Aroma	Taste	Mouldability	Consistency	Overall Accep.
P	2.80±1.57[a]	2.90±1.20[a]	2.88±1.64[a]	3.10±1.29[a]	3.40±1.78[a]	2.97±1.29[a]
PM1	3.05±1.14[a]	3.20±1.93[ab]	3.12±1.32[ab]	3.20±1.40[a]	3.50±1.84[a]	3.10±1.84[ab]
PM2	3.18±2.00[a]	3.40±1.35[ab]	3.22±1.43[ab]	3.33±2.35[a]	3.65±2.13[ab]	3.23±2.64[ab]

PM3	3.90±1.66^{b}	4.30±1.57^{b}	3.80±1.43^{b}	4.10±1.97^{b}	4.00±2.05^{b}	3.67±1.97^{b}
PM4	4.10±2.51^{b}	4.90±1.97^{b}	4.42±2.05^{c}	4.30±1.70^{b}	4.20±2.35^{b}	4.19±1.78^{c}
PM5	4.40±2.07^{b}	5.00±1.89^{bc}	4.80±2.04^{c}	4.90±1.79^{c}	4.68±1.79^{bc}	4.70±2.21^{c}
PM6	5.33±2.23^{c}	6.00±1.83^{c}	4.90±1.91^{c}	5.80±2.10^{d}	5.30±2.21^{c}	5.30±2.10^{d}

*Values are Mean± SD of triplicate determinations, and Mean values in the same column with different superscripts are significantly different at $p < 0.05$.
**Sample key = P [[100 Plantain: 0 Moringa leaf powder]; PM1 [[97.5 Plantain : 2.5 Moringa leaf powder]; PM2 [[95 Plantain : 5 Moringa leaf powder]; PM3 [[92.5 Plantain : 7.5 Moringa leaf powder]; PM4 [[90 Plantain : 10 Moringa leaf powder]; PM5 [[87.5 Plantain : 12.5 Moringa leaf powder]; PM6 [[85 Plantain : 15 Moringa leaf powder]

An increase in the level of substitution of Moringa leaf powder for plantain flour affected the rating of all the sensory characteristics studied (Table 6). Generally, the control sample ('amala' from 100 % plantain flour), had the best rating for all the parameters. There were no significant differences (P < .05.) between the *amala* from sample P, PM1 and PM2 blend regarding colour and mouldability, and slightly differs t PM1 and PM2 amala regarding aroma, taste and overall acceptability. The consistency of the control amala sample P (Table 8) varied significantly (P < .05.) from the consistency of other amala samples except for sample PM1. *Amala* from flour blends PM3, PM4, PM5 and PM6 were less preferred to amala from sample P as regard colour, aroma, taste mouldability, consistency and overall acceptability. The PM6 blend colour was the darkest due to the dark green colour of moringa leaf powder which is a reflection of the chlorophyll content of the leaf. The observed increase in colouration of the amala products with an increase in the level of supplementation of Moringa leaf powder conforms with previous reports on fortification of yam flour and plantain flour using moringa oliferea leaves powder [8, 12] The result of overall acceptability for the fortified 'amala' revealed that samples PM1and PM2 were equally rated and slightly different from the control which had the best rating. In all, 2.5 % to 5 % Moringa leaf powder supplementation for plantain flour is sufficient to improve the proximate and mineral composition of plantain flour amala without having a significant effect on the sensory properties

IV. Conclusion

This investigation has revealed that the substitution of plantain flour with moringa leaf powder progressively increased the nutrient content of the flours, and the prepared stiff dough (amala) as the level of supplementation increased. The blends should have a long shelf life due to their low moisture and fat content, and moringa fortified plantain flour has the potential to combat protein-energy malnutrition and micronutrient deficiencies in developing countries. Though the 15 % substituted plantain flour had the best nutritional quality, but the result of sensory evaluation for the fortified 'amala' revealed that 2.5 % to 5 % supplementation were organoleptically acceptable and are sufficient to improve the nutrient composition of plantain flour amala without having a significant effect on the sensory properties.

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