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Formulation, Proximate Analysis and Sensory Evaluation of *Mumu* from Pearl Millet, Irish Potato and Sesame Seed Blend

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Abstract

Mumu is a traditional cereal-based food product, particularly consumed by Tiv people of Benue State of Nigeria. It is usually produced from maize, sorghum or millet alone. The diversification of this food crop will increase its utilization and contribute, maximally, to food security. Unlike millet, post-harvest technology for potato (*Solanum tuberosum* L.) is very limited, thereby contributing minimally to food security. Consumers are constantly looking for novel food products where local produces are incorporated. This will give the much needed impetus to food manufacturers to explore and formulate new food products, with improved nutritional value, based on the local traditional knowledge available. This will lead to increased utilisation of some underutilized food as potato and sesame seed (*Sesamum indicum* L.) which are readily available. The study was, therefore, aimed at producing *Mumu*, a Nigerian indigenous snack Food, formulated from pearl millet, Irish potatoes and sesame seed. Formulation of blends was based on different levels of roasted pearl millet flour (RPMF), boiled Irish potato flour (BIPF), and roasted sesame seed flour (RSSF). The three ingredients were combined in the following ratios: RPMF 100 (control), 70:20:10, 65:25:10 and 65:20:15 of RPMF: BIPF: RSSF, respectively. Formulated blends were significantly higher ($p < 0.05$) in ash, fat and protein content and lower in carbohydrate, crude fibre and moisture than in control. The blends were significantly higher ($p < 0.05$) in minerals (K, Mg, Ca, Zn and Fe) content than in control. The formulated blends were generally low in phytate and oxalate contents. The significant decrease in moisture content of the blends generally indicates potential long shelf life. The increase in protein content with the decrease in carbohydrate value as roasted sesame seed flour is added making this formulation good for diabetic patients. Results of sensory evaluation show no significant

difference between blends and the control, implying that the locals can take their improved meal just like they use to take. Therefore, for a better healthy life of locals, such blends should be encouraged to be formulated and taken, a case of value and addition and reduction postharvest losses.

Keywords

1. Introduction

Nutrition is coming to the fore as a major modifiable determinant of chronic disease, with scientific evidence increasingly supporting the view that alterations in diet have strong effects, both positive and negative, on health throughout life. Most importantly, dietary adjustments may not only influence present health, but may determine whether or not an individual will develop such diseases as cancer, cardiovascular disease and diabetes much later in life [1] [2]. Changes in the world food economy are reflected in shifting dietary patterns, for example, increased consumption of energy-dense diets high in fat, particularly saturated fat, and low in unrefined carbohydrates [2].

Mumu is a traditional cereal-based food product in Nigeria, particularly consumed by Tiv people in Benue State. The snack can be produced from maize, sorghum or millet because their physico-chemical properties are generally similar; this factor makes it technically feasible for any of the cereals to replace either of the remaining two in food systems. The ready-to-eat food product could be consumed by both adults and children [3]. Just like most cereal-based foods, *Mumu* is a good source of carbohydrate, but limited in protein and fat [4]. This makes the product nutritionally deficient leading to decreased acceptability of such product and hence underutilized. *Mumu* has considerable potential as a food product. It can be supplemented to improve upon its nutritional value. It can be useful as a base for food product development [5].

Consumers are constantly looking for novel food products with improved nutritional value where local produces are incorporated. This paper presents the results of various analyses carried out on new blends for *Mumu*, where some underutilized food as potato and sesame seeds with great potentials as food ingredients were incorporated. These ingredients are also readily available. The study was, therefore, aimed at formulating *Mumu*, from pearl millet (*Pennisetum glaucum* (L.) R. Br.), potatoes (*Solanum tuberosum* L.) and sesame (*Sesamum indicum* L.) seeds.

2. Materials and Methods

2.1. Sample Collection

Pearl millet (*Pennisetum glaucum* (L.) R. Br.) Irish potato (*Solanum tuberosum*

L.) and Sesame (*Sesamum indicum* L.) seeds were purchased from Wurukum market, Makurdi. The sample of food items were identified and authenticated by the botanist at the Department of Biological Sciences, Benue State University, Makurdi.

2.2. Sample Preparation

2.2.1. Preparation of Roasted Pearl Millet Flour

Roasted pearl millet flour was prepared according to the method described by [3] [6] with slight modification. Pearl millet grains were sorted and winnowed to remove grain stalk, sticks and remaining cob parts. The grains were further subjected to visual screening to remove foreign particles such as stones. This was followed by washing with water to remove dust, soil particles and any over floats. Damaged, diseased or discoloured grains as well as immature or sprouted grains were discarded. Cleaned pearl millet grains were parboiled (wet cooking operation) for 45 minutes. Cooking with water tends to breakdown indigestible fibres, generally increasing digestibility of nutrient and also makes product more resistant to rancidity. The grains were roasted in microwave oven at 150˚C for 60 minutes. The roasted grains were allowed to cool and were milled using the locally fabricated attrition mill, the obtained pearl millet flour was sieved using 0.25 mm sieve and kept in an airtight polyethylene bag until when required for formulation of blends.

2.2.2. Preparation of Boiled Irish Potato Flour

The potato flour was prepared using the method of [7] with slight modification. Irish potato roots were washed thoroughly with water to remove adhering soil particles, the washed roots were boiled and then peeled using sharp knives and uniformly chipped into slices of about 2 mm thickness to facilitate drying using kitchen plantain slicer. The Irish potato chips were thinly spread on aluminum foil lined oven cabinet and dried at 65˚C to a constant weight, and milled using the locally fabricated attrition mill, the obtained Irish potato flour were sieved using 0.25 mm sieve and kept in an airtight polyethylene bag until when required for formulation of blends.

2.2.3. Preparation of Roasted Sesame Seed Flour

Roasted sesame seed flour was prepared by combining two methods [7] [8] with little modification. The sesame seeds were cleaned, manually picked and winnowed to remove all forms of foreign particles and defective seeds before processing commenced; the sesame seeds were roasted in microwave oven at 150˚C for 5 minutes to reduce cyanogenic glycosides (CG) content and to develop nutty flavour. Roasted sesame seeds were ground to powder in a domestic mixer (M/s Sumeet Mixer Model DXE plus) for 2 minutes and sieved. The obtained meal was kept in airtight polyethylene bag until when required for formulation of blends.

2.3. Formulation of Experimental Diets

The experimental diets were formulated from roasted pearl millet flour (RPMF), boiled Irish potato flour (BIPF), and roasted sesame seed flour (RSSF) using the methods of [9] with some modifications which are shown in Table 1.

2.4. Analysis of *Mumu*

Determination of proximate composition of *Mumu* was carried out at the Chemistry Laboratory, Benue State University, Markurdi-Nigeria. While determination of mineral composition and anti-nutrients of *Mumu* were carried out at the Central Laboratory, Federal University of Technology Akure-Nigeria.

2.5. Determination of Proximate Composition of *Mumu*

Moisture content was determined after oven drying to a constant weight at 105°C. Proteins, ash, fat and crude fibers were analyzed according to AOAC methods [10] and carbohydrates content was determined according to FAO [11] by difference as follows:

Carbohydrate % = 100 − (moisture % + protein % + ash % + fat % + crude fiber %).

2.6. Determination of Mineral Composition *Mumu* [12]

A whitish or greyish ash was obtained after the determination of ash. The ash was treated with concentrated hydrochloric acid transferred to a volumetric flask and made up to 100 mL before submission to atomic absorption spectrophotometry (AAS).

2.7. Determination of Anti-Nutrients *Mumu*

The levels of anti-nutrients like phytates, alkaloids, oxalates and phenolic compounds were investigated using standardized procedures.

2.8. Determination of Phytates [13]

About 4 g of each of the food blends were soaked into 100 mL of 2% hydrochloric acid for five hours and was filtered. About 25 mL of the filtrate were taken into a conical flask and 5 mL of 0.3% ammonium thiocyanate solution was

Table 1. Formulation of blends was based on different levels of roasted pearl millet flour (RPMF), boiled Irish potato flour (BIPF), and roasted sesame seed flour (RSSF).

Blend	Ingredient	Ratio
1	RPMF	Control
2	RPMF:BIPF:RSSF	70:20:10
3	RPMF:BIPF:RSSF	65:25:10
4	RPMF:BIPF:RSSF	65:20:15

added. The mixture was titrated with a standard solution of iron (III) chloride until a brownish-yellow colour persists for 5 minutes.

2.9. Determination of Alkaloids [14]

About 5 g of samples were weighed and dispersed into 50 mL of 10% acetic acid solution in ethanol. The mixture was well shaken and then allowed to stand for about 4 hour before being filtered. The filtrate was then evaporated to one quarter of its original volume on hot plate. Concentrated ammonium hydroxide was added drop wise in order to precipitate the alkaloids. A pre-weighed filter paper was used to filter off the precipitate and it was then washed with 1% ammonium hydroxide solution. The filter paper containing the precipitate was dried on an oven at 60˚C for 30 minutes, transferred into a desiccator to cool and then re-weighed until a constant weight was obtained. The constant weight was recorded. The weight of the alkaloid was determined by weight difference of the filter paper and expressed as a percentage of the sample weight analyzed.

2.10. Determination of Oxalates [15]

2 g of the samples was digested with 10 mL of 6 M hydrochloric acid for 1 hour and made up to 250 mL in a volumetric flask. The pH of the filtrate was adjusted with concentrated ammonium hydroxide solution until the colour of solution changed from salmon pink colour to a faint yellow colour. Thereafter, the filtrate was treated with 10 mL of 5% calcium chloride solution to precipitate the insoluble oxalate. The suspension was now centrifuged at 2500 rpm, after which the supernatant was decanted and the precipitate completely dissolved in 10 mL of 20% sulphuric acid. The total filtrate resulting from the dissolution in sulphuric acid is made up to 300 mL. An aliquot of 125 mL of the filtrate was heated until near boiling point and then titrated against 0.01 N of standardized potassium permanganate solution to a faint pink colour which persisted for about 30 seconds.

2.11. Determination of Total Phenolics [16]

The food blends were analyzed for total phenolics according to the Folin-Ciocalteu method. An amount of 2 g of sample paste was extracted with 20 mL of ethanol 80% for 1 h. The mixture was centrifuged at 3000 g for 10 min and the supernatant collected. To a volume of 100 µL of samples extracts, was added 1.150 mL of distilled water and 250 µL of the Folin-Ciocalteau solution. After 6 minutes, 2.5 mL of a solution of sodium carbonate 7% was added and the volume was adjusted to 6 mL with distilled water. The mixture was allowed to stand for 90 minutes. Optical density was measured at 760 nm using a spectrometer. The calibration curve was obtained using gallic acid as standard and the concentration ranged from 20 to 600 mg/mL. The results were expressed as gallic acid equivalents/100g of sample.

2.12. Mode of Utilization of *Mumu*

Mumu is a ready-to-eat food product which is reconstituted in cold water and eaten. Each of the blend used for sensory evaluation were reconstituted in cold water in the ratio of 1:3 (w/v) blends to water. The mixtures were then allowed to stand for 5 min. with the intention to improve the palatability of the paste, making it more appetizing before consumption.

2.13. Sensory Evaluation of *Mumu*

Sensory evaluation of the four different blends of *Mumu* were carried out according to the method described by [17] using twenty-member panelists consisting of students and staff members of Centre for Food Technology and Research, Benue State University (CEFTER-BSU). The product from each blend was presented in coded plastic plate. The order of presentation of sample to the panel was randomized. Potable water was provided for panelists to rinse mouth between evaluations. The panelists were instructed to evaluate the coded samples by indicating their likeness for aroma, taste, colour, texture and overall acceptability on a 9 point Hedonic Scale where 9 = like extremely; 8 = like very much; 7 = like moderately; 6 = like slightly; 5 = neither like nor dislike; 4 = dislike slightly; 3 = dislike moderately; 2 = dislike very much and 1 = dislike extremely.

2.14. Statistical Analysis

All analytical determinations were conducted in triplicates. Data were subjected to Analysis of Variance (ANOVA) followed by Duncan's Least Significant Difference(LSD) test to compare treatment means; differences were considered significant at 95% ($P \leq 0.05$) using the Statistical Package for Social Sciences for Windows program (IBM SPSS Statistics 20).

3. Results and Discussion

3.1. Proximate Composition of *Mumu*

The proximate composition of the formulated blends is shown in Table 2. The formulated blends were significantly higher ($p < 0.05$) in ash, fat and protein contents than the control sample (roasted pearl millet), and lower in carbohydrate, crude fibre and moisture than in control.

The moisture content was significantly lower ($P < 0.05$) in blends 2 and 3 (2.23% and 2.90%) than blend 1 (control) (3.59%) which was comparable to blend 4 (3.43%). The result indicates that blend 2 and 3 will have better storage stability according to Man C.M.D. and Jones A.A. [18]. The ash content were significantly higher ($P < 0.05$) in blends 2 to 4 (3.22% to 3.40%) than blend 1 (control) (2.67%) this could be as a result of the increase in ratio of boiled Irish potato flour and roasted sesame seed flour which have higher level of mineral content [19]. Fibre content was significantly lower ($P < 0.05$) in blends 2 to 4 (2.12% to 2.30%) than blend 1 (control) (3.11%) this may be due to the high

Table 2. Proximate composition of *Mumu*.

Blends	Moisture	Ash	Fibre	Fat	Protein	Carbohydrate
			Nutrient%			
1	3.59 ± 0.10^c	2.67 ± 0.08^a	3.11 ± 0.17^b	2.27 ± 0.05^a	12.58 ± 0.19^a	75.79 ± 0.30^d
2	2.23 ± 0.25^a	3.23 ± 0.15^b	2.30 ± 0.20^a	3.36 ± 0.06^b	18.89 ± 0.10^b	70.00 ± 0.18^c
3	2.90 ± 0.10^b	3.22 ± 0.12^b	2.12 ± 0.06^a	3.25 ± 0.05^b	18.87 ± 0.04^b	69.63 ± 0.33^b
4	3.43 ± 0.15^c	3.40 ± 0.10^b	2.15 ± 0.15^a	4.11 ± 0.10^c	20.97 ± 0.06^c	65.53 ± 0.26^a

Values are means ± SD of three replicate determinations. Figures in the same vertical column with the same superscript are not significantly different ($P > 0.05$).

fibre content in pearl millet [20]. The fat content were significantly higher ($P < 0.05$) in blends 2 to 4 (3.25% to 4.11%) than blend 1 (control) (2.27%). This could be ascribe to the increased amount of roasted sesame seed flour which have the fat of about 50.87% as reported by Kinman and Stark [21]. Protein content were significantly higher ($P < 0.05$) in blends 2 to 4 (18.87% to 20.97%) than blend 1 (control) (12.58%). This may be due to the fact that pearl millet has low level of protein ranging from 9% to 13% according to [22]. Carbohydrate content were significantly lower ($P < 0.05$) in blends 2 to 4 (65.53% to 70.00%) than blend 1 (control) (75.79%) owing to the fact that carbohydrate content in pearl millet is high as also suggested by Dayakar *et al*. [23]. Generally, the proximate results is similar to the reports received from studies by Shar *et al*. [6] in which Soy-Mumu was supplemented with *Moringa leaf powder*. A similar trend was observed by Anigo *et al*. [24] in attempt to formulate low-cost nutritive complementary foods by using malted maize, millet and sorghum with groundnut and soybean.

3.2. Mineral Composition of *Mumu*

The mineral composition of the formulated blends is shown in Table 3. The formulated blends were significantly higher ($p < 0.05$) in minerals (Na, K, Mg, Ca, Zn and Fe) content than in control.

The sodium content was significantly higher ($P < 0.05$) in blends 2 to 4 (6.86 to 7.35 mg/100g) than blend1 (control) (4.80 mg/100g). The potassium content was significantly higher ($P < 0.05$) in blends 2 to 4 (285 to 299.55 mg/100g) than blend 1 (control) (185.40 mg/100g). This indicates that the blends qualify for a health claim approved by the United States Food and Drug Administration, which states: 'Diets containing foods that are good source of potassium and that are low in sodium may reduce the risk of high blood pressure and stroke [25] [26]. The calcium content were significantly higher ($P < 0.05$) in blends 2 to 4 (206.90 to 275.95 mg/100g) than blend 1 (control) (7.10 mg/100g). The blends could also be used as a complementary food due to the high level of calcium which is an important constituent of bones and teeth and it is actively involved in the regulation of nerve and muscle functions [27]. The magnesium content

Table 3. Mineral composition of *Mumu.*

Blends	Mineral Composition (mg/100g)						
	Na	K	Ca	Mg	Zn	Fe	Se
1	4.80 ± 0.01^a	185.40 ± 0.01^a	7.10 ± 0.01^a	112.60 ± 0.01^a	1.70 ± 0.01^a	2.90 ± 0.01^a	BDL
2	6.86 ± 0.01^b	285.50 ± 0.01^b	206.90 ± 0.01^b	119.60 ± 0.01^c	1.94 ± 0.01^c	3.97 ± 0.00^c	BDL
3	7.03 ± 0.06^c	296.10 ± 0.01^c	207.11 ± 0.01^c	114.95 ± 0.01^b	1.87 ± 0.01^b	3.55 ± 0.00^b	BDL
4	7.35 ± 0.01^d	299.55 ± 0.01^d	275.95 ± 0.01^d	131.70 ± 0.01^d	2.21 ± 0.01^d	4.26 ± 0.01^d	BDL

Values are means ±SD of three replicate determinations. Figures in the same vertical column with the same superscript are not significantly different ($P > 0.05$). Note: BDL = Below Instrument Detection Limit (<0.001). Hence the other two values detected could not be statistically analysed.

were significantly higher ($P < 0.05$) in blends 2 to 4 (114.95 to 131.70 mg/100g) than blend 1 (control) (112.60 mg/100g). The high magnesium level indicates that the blends could be a good blend for diabetic patients since magnesium present in foods reduces the risk of diabetes as they lower the sudden increase of blood glucose [28]. The zinc content were significantly higher ($P < 0.05$) in blends 2 to 4 (3.55 to 4.26 mg/100g) than blend 1 (control) (2.90 mg/100g). The iron content were significantly higher (P < 0.05) in blends 2 to 4 (6.86 to 7.35 mg/100g) than blend 1 (control) (4.80 mg/100g). The selenium content was not statistically analysed since blends were below instrument detection limit (<0.001). The mineral compositions as reported by Abioye and Aka [29] showed increase in mineral contents when maize-ogi was fortified with moringa leaf powder. Similar to the results of Shar *et al.* [6] where the mineral contents of the Soymumu supplemented with moringa leaf powder was also higher. May be attributed to the high levels of mineral contents in dried Moringa leaves [30] [31].

3.3. Anti-Nutrient Composition of *Mumu*

The anti-nutrient composition of the formulated blends is shown in Table 4. The Alkaloid content were significantly lower ($P < 0.05$) in blends 4 (4.15 mg/100g) than blend 1 (control) (4.81 mg/100g) which is comparable to blend 2 and 4 (4.63 and 4.74 mg/100g). The results are lower than 29.5 mg/100g of alkaloids found by Adeniyi *et al.* [32] in Irish potatoes.

Oxalates can bind to calcium in food thereby rendering calcium unavailable for normal physiological and biochemical role [33]. Oxalates content were significantly higher ($P < 0.05$) in blends 2 to 4 (0.69 to 0.78 mg/100g) than blend 1 (control) (0.39 mg/100g). Phytic acid found in plant materials is known for its chelating effect on certain essential mineral elements such as Ca, Mg, Fe and Zn to form insoluble phytate salts [34]. Phytates content were significantly lower (P < 0.05) in blends 3 and 4 (24.66 and 24.22 mg/100g) than blend1 (control) (24.93 mg/100g) which is comparable to blend 3 (24.91 mg/100g). Total phenolic content in blend 2 to 4 were not significantly different ($P > 0.05$) from blend 1 (control).

Table 4. Anti-Nutrient composition of *Mumu*.

	Anti-Nutrient (mg/100g)			
Blends	Alkaloids	Oxalates	Phytates	Total Phenolic
1	4.81 ± 0.15^b	0.39 ± 0.05^a	24.93 ± 1.29^c	0.01 ± 0.00^a
2	4.74 ± 0.12^b	0.69 ± 0.05^b	24.91 ± 0.95^c	0.01 ± 0.00^a
3	4.63 ± 0.25^b	0.72 ± 0.09^b	24.66 ± 0.82^b	0.01 ± 0.00^a
4	4.15 ± 0.30^a	0.78 ± 0.10^b	24.22 ± 0.95^a	0.01 ± 0.00^a

Values are means ±SD of three replicate determinations. Figures in the same vertical column with the same superscript are not significantly different ($P > 0.05$).

3.4. Sensory Properties of *Mumu*

The sensory properties of the formulated blends are shown in Table 5. Results of sensory evaluation for the following parameters; Taste, Aroma, Appearance, Aftertaste and Overall acceptability show no significant difference ($P < 0.05$) between blends and the control. But for the texture parameter which showed that blend 3 is significantly higher than blend 1 (control) (5.50) and comparable to blend 2 and 4 (6.35 and 6.55).

4. Conclusions

From the results obtained the best blend was found to be blend 4, which has the lowest carbohydrate content, and has the highest protein content as well as a better mineral composition. This indicates that increase in the amount of sesame flour will not only enhance flavor but also improve the nutritional content of *Mumu.*

Results of anti-nutrient content showed that all the blends were generally high in phytate content even though all the anti-nutrients fall within the safety limit.

The decrease in carbohydrate content, high fibre and magnesium contents present in the blends could reduce the risk of diabetes as they slow down the sudden increase of blood glucose.

The blends generally show low-sodium and high potassium contents which indicate that it could be a good diet for people with high blood pressure and cardiovascular diseases. High dietary potassium as well as a low-sodium diet has been shown to have protective effects on blood pressure and cardiovascular diseases.

Nutritious complementary food could be produced from roasted pearl millet flour blended with boiled Irish potato flour and roasted sesame flour in respect to the high level of protein, calcium, zinc and iron. The low anti-nutrient which falls within safety limit makes the products suitable for infants and children. These products could be produced at the cottage level to alleviate the prevalent malnutrition problems.

Results of sensory evaluation show no significant difference between blends and the control, implying that the locals can take this improved meal just like

Table 5. Sensory scores of *Mumu.*

Blends	Texture	Taste	Aroma	Appearance	After Taste	Overall Acceptability
1	5.50 ± 2.01^a	5.85 ± 1.84^a	6.40 ± 2.06^a	6.20 ± 1.58^a	5.65 ± 2.58^a	5.80 ± 2.42^a
2	6.35 ± 1.76^{ab}	6.20 ± 1.64^a	6.95 ± 1.10^a	7.15 ± 1.39^a	6.00 ± 1.75^a	6.10 ± 1.71^a
3	6.70 ± 1.59^b	6.85 ± 1.50^a	7.20 ± 1.36^a	6.95 ± 1.76^a	6.05 ± 1.79^a	6.50 ± 1.85^a
4	6.55 ± 1.23^{ab}	6.55 ± 1.10^a	6.65 ± 1.14^a	6.20 ± 1.79^a	6.05 ± 1.50^a	6.70 ± 1.71^a

Values are means ± SD of three replicate determinations. Figures in the same vertical column with the same superscript are not significantly different ($P > 0.05$).

they used to take. Therefore, for a better healthy life of locals, such blend should be encouraged to be formulated and taken, a case of value addition and reduction of postharvest losses.

5. Recommendations

The following recommendations are made:

1) The mixture designs could be further modified to achieve a better nutritional outcome.

2) Other processing methods like fermentation, germination and dehulling of seeds could be employed in order to reduce the high phytate content.

3) Further analysis like amino acid profile could be carried out to ascertain the nutritional quality of the food product.

Due to the great health potentials assumed from the results further analysis are required as well as clinical trials to ascertain these assumptions.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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