Effect of Bambara Nut Flour Addition on Proximate, Mineral Composition and Sensory Quality of Millet Based Madidi: A Nigerian Solid Gel Food

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Authors' contributions

This work was carried out in collaboration between both authors. Author JAA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author FA analyzed the samples, managed the analyses of the study. Both authors read and approved the final manuscript.

Original Research Article

ABSTRACT

Madidi was produced from different formulations of pearl millet ogi and bambara nut flours. Five madidi products were produced at the laboratory scale using 100:0 (control), 95:5, 90:10, 85:15 and 80:20 millet to bambara groundnut flours, respectively. Bambara ground nut were cleaned, sorted (to remove foreign materials), soaked in cold water for 2 hours, dried and toasted for 30 minutes by using oven. The five formulated products were subjected to proximate, minerals and sensory analysis. The results showed that the protein contents increased with increased addition of bambara groundnut flour. The protein contents ranged from 1.79 to 3.51% on dry weight basis. The fat contents ranged from 0.26 to 1.22%. Carbohydrate content decreased from 22.00 to 13.21% as the proportion of bambara flour increased. Magnesium and phosphorous increased significantly (p=0.05), however potassium and iron were not significant affected (p=0.05). The 100% millet (0.17 mg/100 g) was significantly high in magnesium (p=0.05) followed by 95% millet and 5% bambara nut (0.09 mg/100 g). The phosphorous composition increased with increase in bambara nut (0.17– 0.22 mg/100 g). The average scores of parameters for all the products are relatively high. Product 85:15 millet to bambara flour was most acceptable. It is concluded that an acceptable madidi can be produced from millet and bambara nut at 15% substitution level.

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1. INTRODUCTION

Madidi is a thick porridge, gel-like fermented starchy food item made from millet [1]. Madidi is commonly consumed in the Northern part of Nigeria as either breakfast or weaning cereal. Porridges general are produced primarily from cereals such as maize, sorghum, millet, acha [2] and are predominantly eaten in developing countries [2]. *Madidi* is basically consumed as breakfast meal with soup [3] or beans cake (*akara/kose*), weaning of infants and meal for patients [4]. Although, it is eaten by all population of both young and old [1].

Madidi production is basically a village technology involving soaking of millet grains for 1-3 days in cold water wet milled and sieved to produce slurry [5,6]. The smooth slurry is mixed with hot water, while stirring until it gelatinizes and the gel-like food is wrapped in leaves and cooked again to produce thick porridge [1].

The physicochemical properties, product quality and shelf life of thick porridge are greatly influenced by the technique of milling grain and packaging materials used. *Madidi* is conventionally wrapped in leaves and marketed [2]. Howbeit, little or no efforts are made on the aseptic condition of this local packaging.

Considering the important role of millet in the diets of Nigerian, improving its protein quality becomes necessary. Thus, fortification with other cheap but protein rich plant food will be beneficial to the poor and rural populace. Legumes could readily serve these purposes as they are essentially economical sources of protein, minerals and B-vitamins [2].

Madidi commonly consumed by all classes of populace but poor in protein and other nutrient content. Bambara nut rich in protein content is produced in large quantity but under-utilized.

The fortification of madidi with bambara nutif acceptable will improve the nutritional intake of the consumers and will improve the uses of bambara nut in general. The objective of this study is to determine the effect of added bambara nut on the proximate, mineral and sensory quality of madidi millet based fast food.

2. MATERIALS AND METHODS

2.1 Materials

Materials for this study were millet (*Pennisetumglaucum*), bambara nut *(Vigna subterranean)* banana leaf (packaging material), milling machine, pot, muslin cloth, sieve, gas cooker, turning stick. Millet bambara nut *(Vigna subterranean)* and banana leaves (package material) were purchase from central market Wukari Taraba State, Nigeria.

2.2 Production of Bambara Nut

The bambara nut flour was prepared as decribed by Ayinde and Olusegun [7]. Bambara ground nut were cleaned, sorted (to remove foreign materials), soaked in cold water for 2 hours, dried, and toasted for 30 minutes by using oven. The toasted peas were dehulled manually (by using mortal), cleaned and dry-milled (Attrition milling machine) sieved and packed.

2.3 Production of Ogi Slurry

Millet ogi was prepared as decribed by Nkama et al., [7]. Pearl millet grains were cleaned (to remove stones, dirts, shafts and other foreign bodies that may affect the quality of the final product), steeped in water (for 12 hrs at room temperature), drained, rinsed (with clean water) and wet-milled (Attrition milling machine. The milled grain was sieved (using a clean muslin cloth), and over tail was discarded), allowed to sediment, decanted and fine slurry obtained (wet ogi slurry).

2.4 Production of Madidi

Five formulations designated composites, A, B, C, D, and E were prepared by mixing various proportions of millet ogi slurry and bambara flour recipes. Sample A is the control with 100% millet ogi slurry, B is 95% ogi slurry and 5% Bambara flour, C is 90% ogi slurry and 10% Bambara flour, D is 85% ogi slurry and15%bambara flour, E is 80% ogi slurry and 20% bambara flour on dry and wet weight basis. The blends were mixed and reconstituted separately in water. The reconstituted blends were cooked in 500ml of water with continuous stirring until a stiff gel is obtained. The gel is packed in banana leaf and allowed to cool.

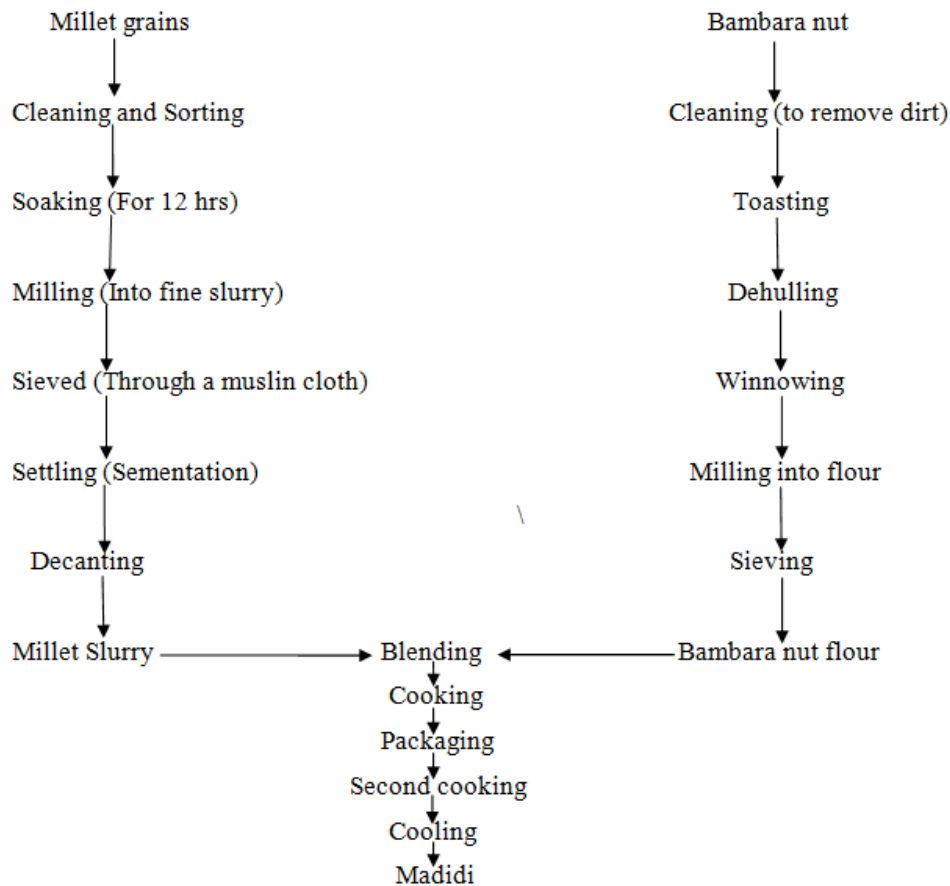The production flow chart for the production blend madidi is shown in Fig. 1.

Millet grains → Cleaning and Sorting → Soaking (For 12 hrs) → Milling (Into fine slurry) → Sieved (Through a muslin cloth) → Settling (Sementation) → Decanting → Millet Slurry

Bambara nut → Cleaning (to remove dirt) → Toasting → Dehulling → Winnowing → Milling into flour → Sieving → Bambara nut flour

Millet Slurry → Blending ← Bambara nut flour → Cooking → Packaging → Second cooking → Cooling → Madidi

**Fig. 1. The process flow diagram of Bambara nut flour-millet based madidi
(Personal interview work)**

2.5 Analytical Methods

2.5.1 Proximate composition of bambara nut flour - millet based madidi

Madidi sample were analysed for moisture, crude protein, crude fat, ash, crude fibre and carbohydrate contents.

Determination of moisture content: The Moisture Content was determined using the procedure described by AOAC [8]. The five gram of the sample was weighed into an aluminium moisture can. The sample was then dried to constant weight at 105±2°C.The moisture content was calculated as:

% Moiture content =
$$\frac{(Weight\ of\ can + samle) - (Weight\ of\ empty\ can \times 100)}{Weight\ of\ sample}$$

Determination of crude protein content: The macro Kjeldhal method as described by the

AOAC [8] method was used. Ten gram of the sample was weighed into a conical flask (250 ml), 0.8 g of the catalyst (potassium sulphate) was poured into the conical flask and 5 ml of sulphuric acid and three glass beads (anti bumps) were dropped inside the conical flask and swirled. The mixture was heated on the Kjeldhal apparatus for 2-3 hours at 100°C, until it turned bluish white. The digest' was allowed to cool in the air and diluted with 10 ml distilled water. This was distilled using Markham distillation apparatus where 100 ml conical flask containing 5 ml of boric and 2-3 drops of mixed indicator was attached. The 5 ml of the digest was introduced into the body of the apparatus and followed by 10 ml of 40-45% sodium hydroxide solution. The distillate collected as ammonium sulphate which was titrated against 0.1 M hydrochloric acid. A blank titration was carried out using distilled Water instead of the distilled. Percentage nitrogen was calculated using the formula:

% Nitrogen = $\frac{(Titre\ value - Blank \times 0.0014\ g \times 100\ \times 25)}{Weight\ of\ sample \times 5\ ml}$

% Crudeprotein = %N × 6.25 (conversion factor)

On the assomption that N_2 contribute 16% to protein

Determination of crude fat content: Fat was extracted using Soxhlet extractor with hexane and quantified gravimetrically. One gram of sample was weighed into an extraction thimble and then put on hold with grease-free cotton. Before extraction commenced the round bottom cans was dried, cooled and weighed. The thimble was placed in extraction chamber and 80 ml hexane was added to extract the fat. The extraction was carried out at 135°C for 1 hour 40 minutes after which the fat collected at the bottom of the cans cooled in a desiccator [8].

$$Fat = \frac{(Weight\ of\ fat\ \times 100)}{Weight\ of\ sample}$$

Determination of ash content: The ash content was determined by the AOAC [8] method. Two grams of the sample was weighed into a dried pre-weighed porcelain crucible. The sample was transferred into a preheated muffle furnace (carbolite Bamford S30 2AU) and heated at 550°C for 2h. The ash was removed and cooled in a desiccator and weighed. The percentage ash was calculated as:

$$\%Ash = \frac{Weight\ of\ Ash}{Weight\ of\ original\ food} \times 100$$

Determination of crude fibre content: Crude fibre was determined using the method described by the AOAC [8] method. 2 g of the samples were weighted into 500 ml beaker and in 200 ml WI t) 1 & 30 minutes. 11 weight suspension was filtered using a white filter pipa and rinsed with hot water to obtain filtrate. The residue obtained was transferred into a crucible and placed in an oven for 40 other 30 minutes. The dried residue was cooled in desiccators and weighed. Percentage crude fibre was calculated using the formula:

$$\%\ Crude\ fibre = \frac{Loss\ in\ weight\ of\ terincineration}{Weight\ of\ original\ food} \times 100$$

Determination of carbohydrates content: Carbohydrate was calculated by difference as described by Ihekoroye and Ngoddy, [9]:

%Carbohydrate=100-(%Moisture+%Fat+ %Protein+%Ash+%Cruder fibre).

2.5.2 Determination of mineral content of bambara nut

The mineral contents of the samples were evaluated using the methods described by Adedeye and Adewoke [10]. One gram of dried sample was digested with 2.5 ml of 0.03N hydrochloric acid (HCl). The digest was boiled for 5 minutes, allowed to cool to room temperature and transferred to 50 ml volumetric flask and made up to the mark with distilled water. The resulting digest was filtered with ashless Whatman No. 1 filter paper. Filtrate from each sample was analyzed for mineral (calcium, phosphorus, magnesium, Iron, sodium, manganese, copper and zinc) contents using Atomic Absorption Spectrophotometer (Buck Scientific Atomic Absorption Emission Spectrophotometer model 205, manufactured by Nowalk, Connecticut, USA) using standard wavelengths. The real values were extrapolated from the respective standard curves. Values obtained were adjusted for HCl-extractability for the respective ions. All determinations were performed in triplicates.

Determination of Phosphorous (P) content: Determination of phosphorous was done according to the method of AOAC [8]. Twenty five grams (25 g) of ammonium molybdate and 1.25 g of ammonium metavanadate were added to 300 ml of distilled water, warmed to dissolve, cooled and made up to 500 ml with water. Concentrated HCl (215 ml) was diluted to 500 ml with water and mixed with ammonium molybdate-ammonium metavanadate reagent. Phosphorous stock was prepared by dissolving 0.879 g of dried phosphorous dihydrogen orthophosphate (dried at 105°C for one hour) with water and 1 ml of conc. HCl added. It was diluted to 200 ml with the first reagent and 2 ml of toluene was added to give 1 mg/ml. The working standard was prepared by measuring 2 ml of phosphorous to 0, 2, 4, 6, 8 and 10 ml of standard phosphorous solution into six 200-ml volumetric flasks and diluted to mark with water. Each phosphorous standard solution (5ml) was pipetted into a 500-ml graduated flask. Molybdate mixture (10 ml) was added and diluted to the mark with water. It was allowed to stand for 15 minutes for colour development, and the absorbance measured at 400nm against blank. A calibration curve relating absorbance to mg of phosphorous was used to read the phosphorus content of the sample solution in mg/ml, and the number of phosphorous equivalent to the absorbance of the sample blank determined was calculated.

4

Determination of Iron (Fe) content: Phenanthroline method as described in AOAC [8] was used for the determination of iron content. Phenanthroline solution was prepared by dissolving 100 mg I,10-phenanthroline molybdate in 100 ml distilled water by stirring and heating to 80°C. Hydroxylamine solution was prepared by dissolving 10 g in 100 ml of distilled water, while ammonium acetate buffer solution was prepared by dissolving 250 g in 150 ml distilled water. 5 ml of the digested sample put into a test-tube. Then, 3ml of phenanthroline solution and 2 ml of HCl were added. Hydroxylamine solution (1 ml) was added to the mixture and boiled in a steam bath at 600°C for 2 minutes. Then, 9 ml of ammonium acetate buffer solution was added and 35 ml diluted to 50 ml with water. The absorbance was taken at 510 nm. Calibration curve was prepared by pipetting 2, 4, 6, 8, and 10 ml standard iron solution into 100 ml volumetric flasks to prepare a solution of known concentrations. The curve obtained as used to read off the value of iron.

Determination of Magnesium (Mg) content: Determination of magnesium content was done according to the method of AOAC [8]. Ashe (2 ml) sample was transferred into 3 test tubes and 3 ml of water added. 2 ml of 10% sodium tung state and 2 ml of 0.67N sulfuric acid were added, centrifuged for 5 minutes. 5 ml of the supernatant was taken added 1ml water, 1 ml of 0.05% titan yellow and 1 ml of 0.1% gum ghatti. 2 ml of 10% sodium hydroxide was added and the absorbance taken at 520 nm against a blank.

Determination of Potassium (K) content: Potassium analysis of the sample will be done by the method of flame photometry. The same wet digested food sample solutions as used in AAS will be used for the determination of K. standard solutions of 20, 40, 60, 80, and 100 miliequivalent/L will be both used for K. the calculation for the total mineral intake involve the same as given in AAS.

2.5.3 Sensory evaluation

Acceptance test was carried out on the thick porridge *Madidi*, The samples were presented to 20 panelists that familiar with the product for sensory evaluation. The panelists rated the taste, color, texture, firmness, odour and overall acceptability of the products using Nine point Hedonic scale, (where 9 indicatelike extremely and 1 indicates dislike extremely).

2.6 Data Analysis

The experimental data generated were statistically analyzed using one way analysis of variance (ANOVA) using SPSS version 16.0. Duncan multiple range test was used to separate the means at $p<0.05$ significant differences.

3. RESULTS AND DISCUSSION

3.1 Proximate Composition of Madidi

The results of proximate composition of formulated madidi and the control are shown in Table 1. The protein content increased significantly ($p<0.05$) from 1.76 to 3.51% with increase in the percentage (0 to 20%) of bambara nut flour. The fat content increased from 0.26 to 1.22% with increasing concentration of bambara nut flour. The moisture content of the madidi increased from 75.44 to 81.75% with increasing concentration of bambara nut flour.

The ash content of the product decreased with no significantly differences ($p>0.05$) from 0.27 to 0.13% with an increased in the percentage of added bambara nut flour. The crude fibre of the product decreased from 0.27 to 0.18% with increased in bambara nut. The variation of ash and crude fibre was also observed by Ayinde and Olusegun [6].

Cellulose forms about one fourth of the dietary fiber in grains and fruits and one third in vegetables and nuts [12]. Cellulose has the ability to bind water which helps to increase faecal volume and thus, promote regular movements. The high cellulose contents of the peel and pulp flours make them suitable for these physiological functions. About 50% of cellulose is degraded by natural fermentation in the colon to produce significant amount of short chain fatty acids which feed the intestinal cells [13]. Insoluble fibres such as cellulose and lignin are mostly unfermentable by colonic micro floras and increase faecal bulk by their particle formation and water holding capacity [13]. About one third of the dietary fibre in vegetables, fruits, legumes and nuts consists of hemicellulose [14]. Hemicellulose promotes regular bowel movement by increasing hydration of the stool. Hemicellulose also directly binds to cholesterol in the gut and thus, prevent cholesterol absorption. The bacteria in the gut digest hemicellulose and increase the number of beneficial bacteria in the gut. These bacteria produce short chain fatty acids which colon cells use as fuel [13,12]. Hemicelluloses also decrease cholesterol [14].

5

Table 1. Proximate composition of millet based madidi supplemented with bambara nut flour (%)

Ogi slurry (%)	Bambara nut flour (%)	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Fibre (%)	Carbohydrate (%)
100	0	75.44 ± 0.01^e	0.27 ± 0.00^a	0.26 ± 0.00^d	1.76 ± 0.00^e	0.27 ± 0.01^a	22.54 ± 0.01^a
95	5	77.94 ± 0.01^d	0.25 ± 0.01^b	0.27 ± 0.01^d	1.98 ± 0.00^d	0.23 ± 0.01^b	19.79 ± 0.0^b
90	10	77.97 ± 0.01^c	0.15 ± 0.00^c	0.34 ± 0.01^c	2.19 ± 0.00^c	0.22 ± 0.00^c	$19.57 \pm 0.^{02c}$
85	15	79.94 ± 0.01^b	0.14 ± 0.00^d	0.82 ± 0.00^b	2.64 ± 0.01^b	0.21 ± 0.00^c	16.67 ± 0.01^d
80	20	81.75 ± 0.01^a	0.13 ± 0.00^c	1.22 ± 0.00^a	3.51 ± 0.01^a	0.18 ± 0.00^d	13.57 ± 0.01^e

Mean ± Standard Deviation. Means in column with different superscript alphabet are significantly different ($p < 0.05$)

Table 2. Mineral composition of millet based madidi supplemented with bambara nut flour

Millet (%)	Bambara nut flour (%)	Potassium (Mg/100)	Magnesium (Mg/100)	Phosphorous (Mg/100 g)	Iron (Mg/100 g)
100	0	$0.36 \pm .46^a$	$0.17 \pm .13^a$	$0.39 \pm .00^a$	$0.44 \pm .15^a$
95	5	$0.12 \pm .00^a$	$0.09 \pm .00^{ab}$	$0.34 \pm .00^b$	$0.43 \pm .01^a$
90	10	$0.07 \pm .00^a$	$0.03 \pm .00^b$	$0.26 \pm .00^c$	$0.39 \pm .00^a$
85	15	$0.04 \pm .00^a$	$0.03 \pm .00^b$	$0.26 \pm .03^c$	$0.35 \pm .00^a$
80	20	$0.03 \pm .00^a$	$0.03 \pm .00^b$	$0.22 \pm .00^d$	$0.33 \pm .00^a$

Mean ± Standard Deviation. Means in column with different superscript alphabet are significantly different ($p < 0.05$)

Table 3. Sensory quality of millet based madidi supplemented with bambara nut flour

Millet (%)	Bambara nut flour (%)	Taste	Color	Texture	Firmness	Odour	Overall acceptability
100	0	6.45 ± 1.146^b	7.15 ± 1.348^a	6.90 ± 1.651^a	6.60 ± 1.392^b	6.40 ± 1.353^a	6.90 ± 1.334^a
95	5	7.15 ± 1.309^{ab}	7.00 ± 1.170^a	7.15 ± 1.137^a	7.15 ± 1.424^{ab}	6.25 ± 1.164^a	6.75 ± 1.164^a
90	10	7.00 ± 1.076^{ab}	7.30 ± 1.261^a	7.30 ± 1.218^a	7.50 ± 1.000^a	6.95 ± 1.146^a	7.00 ± 1.124^a
85	15	7.15 ± 0.688^{ab}	7.60 ± 0.681^a	7.40 ± 0.940^a	7.30 ± 1.031^{ab}	6.85 ± 1.268^a	7.45 ± 1.099^a
80	20	7.50 ± 1.182^a	7.25 ± 1.552^a	7.70 ± 1.031^a	7.05 ± 0.945^{ab}	6.40 ± 1.818^a	7.15 ± 1.268^a

Mean ± Standard Deviation. Means in column with different superscript alphabet are significantly different ($p < 0.05$)

The carbohydrate content of the product decreased from 22.00 to 13.21% with increase in the percentage of bambara nut flour. The increase in protein contents of the samples could be due to the addition of bambara nut flour which from previous research has been observed to contain high protein content [15,16]. The protein has been confirmed to contain some amino acids of great importance to the body.

The increase in fat content could be a good source of energy supply to the body when eaten since in human body [16]. The increase in moisture is relatively low and could be due to the increase in the carbohydrates content [17]. This relative low moisture content could be an advantage in extending the keeping quality (shell life) of the product as most spoilage organism may not be able to thrive, and the biochemical and enzymatic reactions could be minimal [18]. The decrease in carbohydrate content could be due to relatively low carbohydrate content of added bambara nut [19].

3.2 Mineral Composition of Madidi

Table 2 showed the mineral properties of the added bambara nut flour blends. The result indicates that magnesium and phosphorous significantly (p<0.05) influenced the mineral properties of all the samples; however potassium and iron were not significant affected (p>0.05). (100% millet) 0.17 was significantly high in magnesium (p<0.05) followed by (95% millet and 5% bambara nut) 0.09 ± 0.00^{ab}. The phosphorous composition increased as the bambara nut flour increases, which ranged from 0.17 – 0.22. The data for potassium (0.36 – 0.03) are similar to that obtained by Amartelifio et al. [20]. Also the iron content is in agreement with previously reported data [21].

Magnesium is present in the mitochondria and other enzymes important in energy transfer. Magnesium is an activator of enzyme systems which maintains electrical potential in nerves [22]. Some minerals are components of antioxidants enzymes. Superoxide dismutase depends on Mn, Cu and Zn; catalase depends on Fe and glutathione peroxidase on Fe. Copper and iron are required in mammalian nutrition to prevent anemia [22].

3.3 Sensory Quality of Madidi

Table 3 shows the result of sensory evaluation. The mean scores for color ranged from 7.00 to 7.60, texture 6.90 to 70, odor 6.25 to 6.85 and overall acceptability 6.90 to 7.45. The result showed that there was no significant difference (p < 0.05) in color, texture, odor and overall acceptability. The addition of bambara nut has contributed positively to the acceptability of the product. Sample D (85% millet ogi, and 15% bambara flour) was rated high in all the parameters investigated (as shown in Table 3). Table 3 also shows that the mean scores for taste ranged from 6.45 to 7.50 and firmness 6.60 to 7.50. These indicate that there were significant differences observed for taste, firmness. It then means that an acceptable "madidi" can be produced from millet ogi slurry with the addition of 15% bambara nut flour. The addition of bambara nut will improve the nutritional quality and enhance the taste of the product.

4. CONCLUSION

The addition of bambara nut flour to the millet based madidi product have relatively improve its nutrient content in term of protein and minerals (phosphorous, magnesium, potassium and iron) and the acceptance of this product by consumers could improve their nutrient intake.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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