

IMPROVED WEANING/BREAKFAST DIETS FORMULATED FROM BAMBARA GROUNDNUT FORTIFIED MAIZE: SORGHUM MIX

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ABSTRACT

Weaning breakfast meals were produced by supplementing 1:1 maize-sorghum mix (MS) with raw, roasted and soaked cum steam cooked Bambara groundnut (*Vigna subterranean*). Supplementation brought about 5-7% increase in the protein levels of the compounded diets compared to the unfortified MS with crude protein 10.24%. The breakfast/weaning meals displayed a high dry matter content of 92.25-92.94%, crude fibre 3.65-4.78%, carbohydrate ranging from 72.82-77.03%. Mineral compositions of the meals showed ranges of P(11.03-18.27%), Ca(0.61-0.8%), K(10.9-23.0%), Na (1.53-3.07%), Fe (18.07-24.51 mg/kg) and Zn (5.8-11.48mg/kg). The meals showed profiles of oil absorption capacity, ranging from 63.33-73.33%, water absorption capacity of 90-96.67% and water oil absorption indices of less than 2. The water soluble vitamins comprised, in MS 5.0 and 56.7mg/l of thiamine and vitamin C respectively. Thiamine (10.30mg/l) in MS-raw bambara groundnut (rBG) decreased to 0.45 mg/l in MS- Roasted Bambara Groundnut (RBG) and 0.04 mg/l in MS-Cooked Bambara Groundnut (CBG), in MS-CBG were found 6.41, 4.85 and 3.22mg/L riboflavin, niacin, and pyridoxine respectively. Vitamin C in MS-RBG was considerably reduced to 86.56 and 1.78mg/L in MS-RBG and MS-CBG respectively. Organoleptic assessment of the meals MS and MS fortified with heat treated and untreated bambara groundnut were all acceptable. In overall acceptability, MS-CBG was significantly better than MS-RBG and MS-rBG.

Keywords: Bambara groundnut maize-sorghum, infant breakfast meals, absorption capacity, organoleptic assessment

Submitted: 04.03.2013

Reviewed: 24.04.2013

Accepted: 13.05.2013

1. INTRODUCTION

The cereal based diets of man will continue to undergo modifications to warrant a balance in essential nutrients. These diets comprise weaning infant and convalescent varieties which have long been traditionally adopted in parts of the world, especially tropical African regions. Balanced diets are normally meant to offset protein-calories malnutrition (Lawrence, 1991) that has long plagued African nations. Most cereals lack two main essential amino acids, tryptophan and lysine. Many cereal-legume combinations have been shown to provide supplementary/ complementary effect on protein/amino acid profile of the combined raw materials (McDonald and Greenhalgh, 1985). The economic meltdown, global warming and other climatic changes recently experienced world-wide have seemingly compounded our food insecurity, especially in African nations. These prevailing circumstances have also further accentuated

low level affordability of health sustaining food items, including meat/sea foods by over 50% of the African populations. This is indicating that for sometimes the most vulnerable proportions of the African people will still have to rely on cereal-legume diets for their sustenance.

Bambara groundnut (*Vigna subterranae*) has been reported to be a good source of fibre, calcium, iron, potassium, and methionine (FAO, 1987). Although maize constitutes the major cereal food in many parts of the world, it has been shown to be inferior to other cereals in biological value in terms of the poor protein content (protamin zein) consisting half the total protein whose hydrolysis yields little lysine/tryptophan (Ajenifuja, 1987). All types of maize, except the yellow varieties lack Vitamin A. Maize has been roasted, or cooked mixed with legumes, and also turned into other products and consumed culturally.

The objective of our study was to exploit the nutritive value of Bambara groundnut to fabricate a highly functional, widely acceptable

weaning/infant breakfast meal using combined cereal mix fortified with Bambara groundnut.

2. MATERIALS AND METHODS

All the raw materials (yellow maize, red sorghum and Bambara groundnut) were purchased from Bodija market, Ibadan, Oyo state, Nigeria. Raw materials were cleaned by removing insect damaged grains and other extraneous materials. Dry yellow maize and sorghum were treated according to method of (Agunbiade and Ojezele, 2010). Bambara groundnut was divided into three batches of 2.5 kg each. Batch one remained raw unprocessed. Batch two was roasted by the method of Agunbiade (Agunbiade, 1992) while the third batch was soaked overnight, cooked over kerosene stove for 45 minutes and sun dried for two days in wooden tray screened with wire mesh to prevent infestation and contamination. The three batches were each milled and sieved using 0.45 mm mesh sized and separately packaged and stored as raw bambara groundnut (rBG), roasted bambara groundnut (RBG) and cooked bambara groundnut (CBG) respectively.

Diet formulation.

Several MS supplemented with varied proportion of bambara were primarily test run to obtain optimum tolerable combinations in terms of organoleptic characteristics in comparison with MS. The diets which were finally adopted are as follows:

Diet:

MS – Maize-Sorghum mix as standard

MS rBG – MS: Raw bambara groundnut (80:20)

MS RBG – MS: Roasted bambara groundnut (80:20)

MS CBG – MS: Cooked bambara groundnut (70:30).

ANALYTICAL PROCEDURE

The proximate and mineral compositions of the cereal-based diets were carried out using the methods of Analysis of Official Analytical Chemists (A.O.A.C., 2004). Their functional properties (water and oil absorption capacity) were determined as described by Agunbiade

(Agunbiade, 1992) and Agunbiade and Longe, 1999. All selected water soluble vitamins were determined by the method of Desai and Machlin (Desai and Machlin, 1985).

Sensory Evaluation of Diets.

In our previous work it was established that MS is as good as Quaker oats as a breakfast meal. The aroma, taste, texture, colour and overall acceptability of the diets were carried out by the Scheme of Agunbiade and Longe (Agunbiade and Longe, 1996). The sensory scores were analysed statistically using analysis of variance and test of Significance.

3. RESULTS AND DISCUSSION

Table 1 shows the proximate composition of the cereal meals with or without supplementation with bambara groundnut flours. Both dry matter and carbohydrate levels were characteristically high, ranging from 92.25 – 92.94% and 72.82 – 77.03% respectively. The concentrations of ash and crude fat ranged 1.23 – 1.96% and 1.50 – 2.19% respectively. Incorporation of BG flour into MS caused increase of 0.35 – 1.13% crude fibre. The high dry matter, high carbohydrate, and 5 – 7.34% protein increase due to fortification is in consonance with previous reports (Agunbiade and Ojezele, 2010; Bookwalter, 1981; Plahar et al, 1997). The meals were also characteristically low in ash and oil for a food meal. A meal containing between 15 – 18% protein is considered adequate to offset any malnutrition.

Table 2 represents the mineral composition of the breakfast meals. The unfortified (MS) meal registered the highest Phosphorus concentration compared with legume fortified counterparts. Reduced mineral concentrations due to fortification were Phosphorus (4.51 – 7.25%), Sodium (1.14 – 1.54%) and Calcium (0.03 – 0.20%) while there were increases in Potassium (8.8 – 12.0%), Iron (2.0 – 6.44 mg/kg) and Zinc (1.35 – 6.6 mg/kg). Fortification of MS with RBG did not significantly affect the mineral composition of the cereal meal except Sodium. The decreases in Phosphorus, Calcium, and Sodium as well as

the increases in Potassium, Iron and Zinc were apparently due to fortification of MS with rBG, RBG and CBG, the former reflecting dilution effect while the latter showing concentration effect. In particular the increasing effect of Potassium and decreasing effect of sodium seem to be of high nutritional importance reflecting good Potassium – Sodium ratio in human intracellular composition. With significantly higher Potassium composition, hypertension commonly triggered off by high sodium diet, may be completely kept in check by the adoption of cereal – fortified with bambara groundnut. Zinc has been shown to be essential. Its deficiency results in abnormal immune function and higher rates of infectious diseases especially lower respiratory tract infection (Pneumonia) in children (Prasad, 1985; Bahl et al, 1998; Black and Sazawal, 2001). The level of dietary Zinc (7 – 11.48mg/kg) in the MS fortified with bambara groundnut, if adequate, may serve to suppress childhood infectious disease, morbidity and mortality. In event this level proves insufficient, the diets however may be supplemented to check the above physiological disorders. Of the total iron in human body (4 – 5g), 60 – 70% is a component of haemoglobin and 3 – 5% as myoglobin. During growth, pregnancy and lactation there is increased demand for iron by the body which comes through diet (Viteri, 1994).

The functional properties of the breakfast meals are found in Table 3. The water absorption capacities ranging from 90-96.67 are high. The fortification with Bambara groundnut flours apparently seemed to have lowered their Water absorption capacity (WAC) values, the MS – rBG being least for reason of non – gelatinization of the carbohydrate as a raw meal. Roasting and cooking have pre – gelatinized the other two meals and hence higher WAC. Oil absorption capacity (OAC) of the meals varied from 63.33 – 73.33g water/100g sample. The most important parameter is Ratio of water absorption capacity to oil absorption capacity (WOAI). This index which is very close to 2.0

is a major factor. If the index is lower than 2, the product is lipophilic and at 2 and above, the product is hydrophilic. However, the more hydrophilic the better [10].

Table 4 consists of meals' soluble vitamin composition as affected by heat treatments of bambara groundnut. Fortification of MS with rBG caused increased vitamin C of 46.58 in contrast to increase of 29.6 found in MS fortified with RBG i.e. in (MS – RBG). Highly significant reduction in vitamin C was observed when steam-cooked bambara groundnut was used to fortify MS. MS fortified rBG showed an increase 5.30 mg/l compared with drastic low levels of thiamin in MS – CBG (0.04) and MS – RBG (0.45mg/L). No vitamins B₂, B₃ and B₆ were detected in MS, MS – rBG and MS – RBG respectively. Upon fortification of MS with cooked bambara groundnut (MS – CBG), 6.41, 4.85, and 3.22mg/L of B₂, B₃, and B₆, were detected. All the increased vitamin concentrations in MS and MS – rBG were deemed derivable apparently from bambara groundnut. It has been observed in this study that dry heating (roasting) did not reduce vitamin B and C as much as cooking. This observation is in agreement with previous reports (Agunbiade and Ojezele, 2010).

The observed vitamin contents of MS-CBG may result from short duration fermentation supposedly accruing during the preceding soaking before cooking bambara groundnut. The importance of vitamin C as an antioxidant can never be over emphasized. In the presence of vitamin c, free radicals are removed to forestall the occurrence of diseases like cancer. Table 5 shows the evaluation of the sensory characteristics of the breakfast/weaning meals. The MS, mainly cereal, was significantly ($p < 0.05$) better than MS fortified with bambara groundnut flours. MS – CBG, except in texture, was significantly better than MS – fortified with rBG and RBG. MS – RBG was significantly ($p < 0.05$) better than MS – rBG only in taste. All the meals are, however, considered acceptable with sensory scores of 2 and above.

Table 1: Proximate composition of breakfast meals

SAMPLE MEAL	Composition in percentage (%)					
	Dry matter	Crude protein	Fibre	Ash	Fat	Carbohydrate
MS	92.44± 0.75	10.24±0.45	3.65±0.25	1.23±0.02	1.50±0.02	78.82±0.35
MS-rBG	92.34±0.72	15.55±0.52	4.78±0.40	1.96±0.01	2.19±0.03	75.52±0.40
MS-RBG	92.94± 0.65	15.24±0.50	4.00±0.35	1.81±0.03	1.65±0.03	77.03±0.45
MS-CBG	92.25± 0.76	17.58±0.53	4.30±0.41	1.80±0.03	1.54±0.03	75.08± 0.45

Values are means ± SD of Triplicate determinations.

KEY: MS = Maize – Sorghum mix (50:50)

MS-rBG = Maize – Sorghum : raw bambara groundnut (80:20)

MS-RBG = Maize – Sorghum : roasted bambara groundnut (80:20)

MS-CBG = Maize – Sorghum : cooked bambara groundnut (80:30)

Table 2: Mineral composition of breakfast meals fortified with graded, heat treated bambara groundnut.

Meal	P %	Mineral Composition				
		Ca %	K %	Na mg/kg	Fe mg/kg	Zn mg/kg
MS	18.27±1.05	0.81±0.02	10.90±0.61	3.07± 0.46	18.07±0.95	5.80±0.40
MS – rBG	11.03±0.72	0.61±0.01	23.00±1.14	1.93±0.25	24.46±1.04	11.42±0.54
MS – RBG	13.76±0.82	0.77±0.02	19.67±1.31	1.53±0.27	24.51±1.04	7.15±0.60
MS – CBG	11.61±0.70	0.78±0.02	20.26±1.26	1.60± 0.31	20.07±1.01	11.48±0.02

Values are means ± SD of duplicate determinations.

Abbreviated words, MS, MS-rBG, MS-RBG, MS-CBG, are as found under Table 1

Table 3: Functional properties of the breakfast meals.

Diet	WAC	OAC	WOAI
MS	96.67± 4.08	66.67± 4.08	1.45
MS – rBG	90.00±7.07	73.33± 4.08	1.23
MS – RBG	93.33±4.70	70.00±7.07	1.33
MS – CBG	93.33±4.70	63.33±4.08	1.47

Values are means ± standard error (SE) of triplicate determination.

KEY : WAC = Water absorption capacity measured as g sample/100ml water

OAC = Oil absorption capacity measured as g sample /100g oil absorbed

WOAI = Ratio of water absorption capacity to oil absorption capacity (Index).

Other abbreviated words are as found under Table 1.

Table 4: Water soluble vitamins of cereal – bambara nut formulated meals

Sample	Composition in mg/l				
	Thiamine (B ₁)	Riboflavin (B ₂)	Niacin (B ₃)	Pyridoxine (B ₆)	Vitamin C
MS	5.00±0.07	N.D	N.D	N.D	56.70±1.05
MS – rBG	10.30±0.07	N.D	N.D	N.D	103.28±1.03
MS – RBG	0.45±0.02	NIL	NIL	NIL	86.56±0.04
MS – CBG	0.04±0.01	6.41±0.01	4.85±0.02	3.22±0.01	1.78±0.03

Values are means ± SD of duplicate determinations

KEY: N.D = Not detected.

All other abbreviated words are as found under Table 1

Table 5: Sensory properties of the meals.

Diet	Aroma	Colour	Taste	Texture	Overall acceptability
MS	5.00 ± 0.00 ^a	5.00± 0.00 ^a	5.00 ± 0.00 ^a	5.00 ± 0.00 ^a	5.00±0.00 ^a
MS – rBG	3.20± 0.37 ^c	3.60±0.24 ^c	3.20± 0.37 ^d	3.40± 0.25 ^b	3.40± 0.22 ^c
MS – RBG	3.60± 0.24 ^c	3.20± 0.20 ^c	3.80±0.20 ^c	3.60± 0.25 ^b	3.80± 0.24 ^c
MS – CBG	4.20± 0.20 ^b	4.20±0.20 ^b	3.60± 0.25 ^b	3.60± 0.25 ^b	4.40±0.25 ^b

Values are treated as means ± standard error (SE)

Values along the column without a common superscript are significantly (p< 0.05) different.

The abbreviated words are as found under Table 1.

4. CONCLUSIONS

The MS has previously been found to be good enough as a breakfast meal when it was fortified with milk (Agunbiade and Ojezele, 2010). In the rural communities where people may be too poor to supplement this product with milk, alternatively supplementation with cooked bambara groundnut automatically makes it attractive as an infant meal. In addition increased concentrations of Fe, Zn and K against decreased Na concentration clearly showed the mineral needs of infants may be sufficiently met for normal body function. This formulation may positively address infant food insecurity as well as the economy of a nation as ours, especially if it is well packaged to serve as a means of foreign exchange.

5. ACKNOWLEDGEMENT

The authors acknowledge the technical assistance of Ayandale Maria

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