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ACCEPTABILITY AND NUTRITIONAL CONTRIBUTION OF GRAIN AMARANTH RECIPES IN UGANDA

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ABSTRACT

Grain amaranth is a highly nutritious crop. It is high in proteins and its proteins are of high quality. Compared to common starchy staples, grain amaranth also contains higher levels calcium, zinc, iron as well as vitamins A, E and folic acid. Grain amaranth has also been reported to exhibit nutraceutical properties. Despite its high nutritional value and nutraceutical properties, grain amaranth consumption in Uganda is low. This study was undertaken to evaluate the acceptance of grain amaranth containing recipes and to determine their potential nutritional contribution. A 24 hour recall was conducted on a sample of 420 respondents drawn from nine sub-counties, three from each of three districts: The results of the 24 hour recall were used to calculate nutritional quality indices. The 24 hour recall results showed low nutritional quality indices for zinc, calcium, niacin, thiamin and lipids. In addition, diets for 74% of respondents were low in iron. A total of 17 recipes containing grain amaranth and other locally produced foods were then developed with the aim of producing products with enhanced zinc, calcium, niacin, thiamin, iron and energy content. Products prepared based on the developed recipes were subjected to proximate analysis and sensory evaluation while the recipes were assessed by farmer groups for acceptability. All the products developed were found to be highly acceptable, all scoring ≥7.5 on nine point scale. The presence of grain amaranth in the products enhanced the nutrient content of most foods, when compared to the traditional recipes without grain amaranth. The most marked positive changes attributable to presence of grain amaranth in the food formulations were observed in the levels of Zn, Fe and Ca. Grain amaranth markedly enhanced the nutrient content for the starchy staple dishes which dominate diets of low income households in the communities studied. These findings show that if incorporated into locally consumed dishes, grain amaranth would fill some of the dietary nutrient gaps. The high acceptability of the products containing grain amaranth and the recipes tested showed high potential for grain amaranth adoption once the recipes are disseminated.

Key words: Amaranth, dietary assessment, sensory evaluation

INTRODUCTION

Amaranth (*Amaranthus spp)* is an herbaceous annual plant with upright growth habit, cultivated for both its seeds, which are used as a grain, and its leaves which are used as vegetables. Both leaves and seeds contain protein of unusually high quality [1]. Amaranth is often called a pseudocereal because it is used much like cereal grains although it is not in the grass family. Grain amaranth belongs to the cosmopolitan *Amaranthus* genus of some 60 species [2]. The most important species include *A. hypochondriacus, A. cruentus* (grain type), and *A. tricolor, A. dubius, A. lividus, A. creuntus, A. palmeri* and *A. hybridus* (vegetable type) [3]. Grain amaranths and many other amaranth species show tremendous potential for human consumption and other uses, and are particularly promising as a remedy for hunger and malnutrition in developing countries [2].

Grain amaranth is a relatively new food crop in Uganda. To facilitate expansion in its consumption, there is need to develop locally acceptable recipes and formulations. Current staple diets for most of the resource poor people in Uganda are dominated by starchy staples. These staples are typically low in lipids, protein, vitamins and minerals. Grain amaranth has higher quality and quantity of protein than most staples and the amino acid composition of its protein compares with the protein standard for good health [4]. Amaranth grain contains twice the level of calcium in milk, five times the level of iron in wheat, higher potassium, phosphorous and vitamins A, E and folic acid than cereal grains [5]. Amaranth grain also consists of 6 – 10% oil, which is predominantly unsaturated and is high in linoleic acid [6], an essential fatty acid. Grain amaranth would, if adopted for consumption, therefore, enrich local diets in different parts of Uganda.

Consumption of grain amaranth has been reported to have nutritional and health benefits, ranging from a general improvement in well-being to prevention and improvement of specific ailments and symptoms including recovery of severely malnourished children and an increase in the body mass index of people formerly wasted by HIV/AIDS [7,8]. Some specific nutritional and health benefits of amaranth consumption have been elucidated. Amaranth oil has been shown, in animal studies, to lower total serum triglycerides and levels of low density lipoproteins (LDL) [9]. Similar effects have been reported in humans [10]. High levels of serum LDL are associated with coronary heart disease. The serum LDL lowering effect of amaranth has been attributed to the tocotrienols (unsaturated forms of vitamin E) and squalene in amaranth oil. These compounds affect cholesterol biosynthesis in humans [10]. They are also believed to have anti-tumor and anti-oxidative activity [11], pointing to potential anti-cancer effects. Supplementation of patients with coronary heart disease with amaranth oil has been shown to contribute to decrease in body weight, a decrease or disappearance of headaches, weakness, increased fatigability, shortness of breath during physical activity, edema of the legs towards evenings and feeling of intermission of heart function in most patients [10]. Animal studies have shown that supplementation of diets with amaranth grain and amaranth oil improves glucose and lipid metabolism [12]. The fasting serum glucose levels and the glucose tolerance of the diabetic rats were both improved.

The aim of this study was to identify forms of incorporating grain amaranth to local diets in Uganda to address current dietary deficiencies. Elsewhere, grain amaranth has been used as seeds or flour to make a wide variety of products, including cookies, cakes, pancakes, bread muffins, crackers, pasta and other bakery products [3].

MATERIALS AND METHODS

Determination of baseline dietary deficiencies

A baseline survey was conducted in three districts of Uganda which included Apac, Kamuli and Nakasongola to determine dietary nutrient gaps. The selected districts represent 3 different agro-ecological and socio-cultural settings. Apac, which is located in Northern Uganda, is dominated by mixed farming. The main foods grown and consumed in this district include millet, sesame, maize, beans, sweet potatoes, cassava and groundnuts. Nakasongola is located in the Central part of Uganda. Most of the people in Nakasongola district are pastoralists. Important food crops in Nakasongola include cassava, maize, sweet potatoes, sorghum and millet. Kamuli district is located in Southeastern part of Uganda. Crop production is the most important economic activity and the main crops grown include sweet potatoes, rice, beans, bananas, maize, millet, groundnuts, citrus fruits and mangoes. The nutrient intake levels were determined based on 24 hour recall [13] data. The nutrient intake levels were compared to recommended intakes and the proportion of subjects whose intake was lower than that recommended levels for the different nutrients were determined. The Hansen's nutritional quality indices (NQI) were also derived and used to identify nutritional deficiencies [14].

Development of grain amaranth containing recipes

Recipes were developed to produce foods with elevated levels of nutrients identified to be deficient based on the NQI values obtained and absolute nutrient intake levels. Locally available foods with high levels of nutrients found to be deficient in the diets (from the baseline dietary survey) were identified, based documented nutritional composition.

Maize, cassava, rice, beans and wheat, which are major staples in all the study areas, were used as base foods for complementation with identified nutrient rich foods. All these foods were combined with grain amaranth and other locally available foods in different ratios. Traditional preparation methods, including those already used in preparation of grain amaranth by local communities, were then used to produce different food products. The developed products were subjected to a nine-point hedonic scale acceptability analysis. Panels of five sensory analysts were used to undertake preliminary product analysis during recipe development. The final formulations used for the different food products are provided in Table 1.

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Sensory analyses of the developed products

Sensory evaluation was conducted using a panel of 54 (35 females and 19 males) untrained panelists selected from volunteers among the Makerere University student and staff community. Before the study, all panelists were briefed about the procedure and each had to verbally consent to participation. All participants were non smokers, fluent in English, self reported to have normal taste and smell sensitivity. Panelists were requested to refrain from eating or drinking for at least 1 hour before the scheduled time for product tasting. The panelists assessed the acceptance of the products using a nine point hedonic scale. Each of the recipes was also analysed by six farmer groups (two from each of the three participating districts) who scored both the products and the production recipes using a five point scale, with one as highly unacceptable and five as highly acceptable. The groups were required to derive the score through consensus, after trying out the recipes and testing the resulting products.

Determination of nutritional value

The crude protein, fat, total ash and moisture contents of the food products were determined using AOAC methods [15]. Moisture content, total ash, crude fat and crude protein were determined by oven method, hot furnace, Soxhlet and Kjeldahl (N x 6.25) methods, respectively. Carbohydrates were estimated based on the nitrogen free extract and energy was derived by calculation based on the energy values of the macro-components.

The dietary fiber content of the foods was determined by the gravimetric method [16]. About 0.5g of the sample was weighed into a 600 ml flask, 50 ml of acid detergent fiber were added and the mixture boiled for one hour. The mixture was then filtered over a Buchner funnel connected to a vacuum pump using a sinter glass. The sinter-glass crucibles were taken to the oven maintained at 100^{o}C for 45 minutes to drive off the moisture. Dietary fiber was obtained as the difference between the weight of the empty sinter-glass and that after removal from the oven.

The iron (Fe) and zinc (Zn) contents of the food were determined using Atomic Absorption Spectrophotometer, Perkin-Elmer 2380 [15]. Calcium was determined using flame photometry. All values were expressed in mg/100g of sample.

The grain amaranth used in the study was cleaned by passing through multiple size sieves to minimize contamination which is a problem is small seed crops. The other materials used were obtained from local markets. For all chemical analyses, 3 different experiments were undertaken and samples were analysed in triplicate.

Data Analysis

Data were analyzed using Statistical Package for Social Scientists Version 16. Descriptive statistics (means and standard deviations) were derived for the different products for all attributes measured. Sensory evaluation data were also subjected to analysis of variance. Mean separation was attained using the least square difference method.

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RESULTS

Dietary nutrient inadequacies based on Nutritional quality indices

The mean NQI for zinc, calcium, niacin, thiamin and lipids were as shown below (Figure 1), indicating a need for dietary enrichment with respect to these nutrients. It was also observed that 74.1% of households studied had diets deficient in iron (Figure 2).

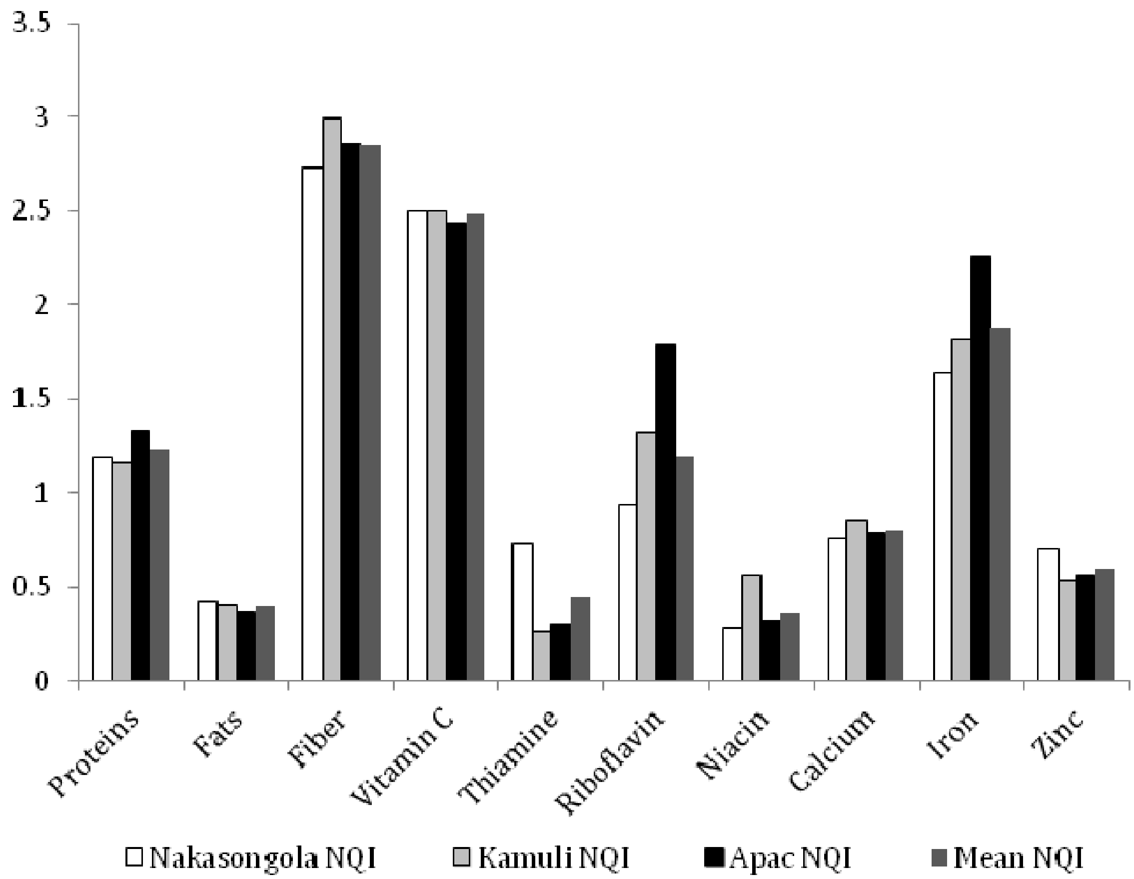

Figure 1: Nutritional quality index (NQI) of foods consumed by farmer households in Nakasongola, Kamuli and Apac districts based on 24 hour recall data

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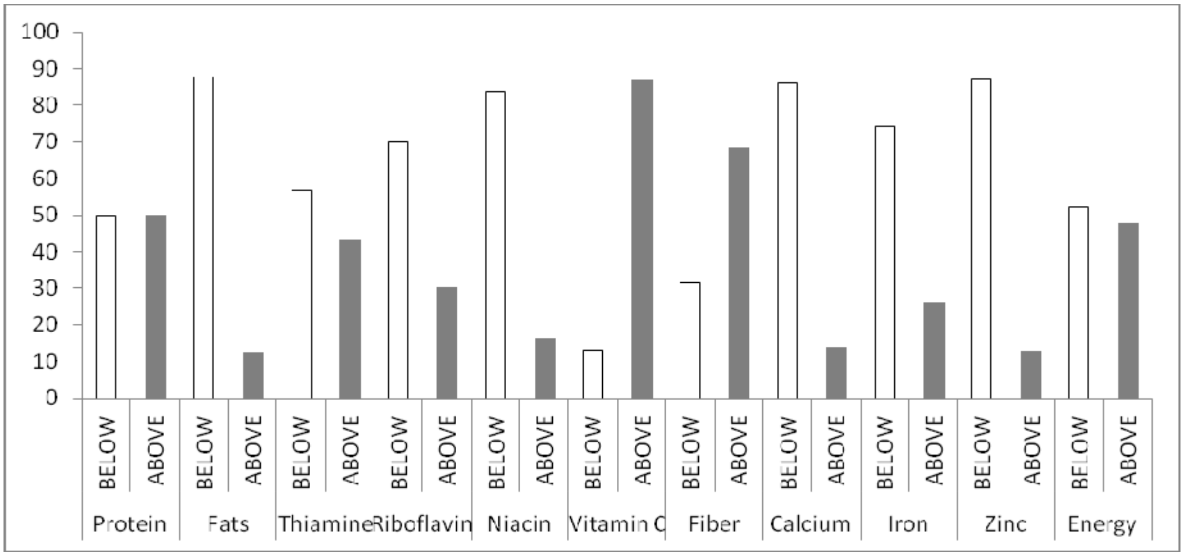

Figure 2: Distribution (%) of study population based on adequacy of the intake of the different nutrients

Based on the food availability in the districts and their nutritional profile, different foods were identified (Table 2) for enrichment of recipes with the identified deficient nutrients.

Sensory Evaluation of the developed products

All the products developed were found to be highly acceptable (Table 3), all scoring ≥7.5 on a nine point scale. This shows high potential for the adoption of the developed products.

Nutritional value of the developed grain amaranth containing products

Incorporation of the different foods identified as good sources of nutrients found to be deficient in diets of people in the three districts, generally led to products with enhanced levels of these target nutrients (Table 4). Sesame, soybeans and peanuts, in addition to contributing to nutrient enrichment, also enhanced the energy content of the foods to which they were added.

The presence of grain amaranth in the products led to a positive change in the nutrient content of most foods, when compared to the traditional recipes without grain amaranth (Table 5). The most marked positive changes attributable to presence of grain amaranth in the food formulations were recorded in the levels of the minerals (Zn, Fe and Ca). Grain amaranth markedly enhanced the nutrient content for cassava meal. It also generally enhanced nutrient content for maize, millet and rice albeit to a lower extent. This shows the value of incorporating grain amaranth in diets dominated by traditional starchy staples.

On the other hand, in sesame balls, grain amaranth incorporation was found to cause a reduction in the levels of all nutrients except protein. Generally the benefit of incorporating grain amaranth into oil seeds and pulses was lower than observed for starchy staples. Products containing sesame generally exhibited very high calcium content while GA tea masala, a product spiced with a locally sold ginger based spice normally used in tea, contained high levels of iron.

Recipe and food products community acceptance
A total of 15 of the 17 developed recipes were rated at ≥4 on a five point scale (Table 6) by farmer groups. The rice meal and bean sauce recipes were the only two to score below four. This shows that the recipes were generally acceptable to the communities in the three districts. There were no significant differences ($p>0.05$) in the scores given to the different recipes by farmer groups in the three districts.

The products made using the developed recipes were also found to be highly acceptable by the farmer groups, with 16 out of 17 scoring ≥4 on a scale of five (Table 7). The high acceptability of both recipes and products shows high potential for increased consumption of grain amaranth once the recipes are widely disseminated.

DISCUSSION

Malnutrition and nutritional deficiencies are serious problems for Uganda and this is to a large extent attributable to the poor quality of diets [17]. Dietary inadequacy with respect to iron, zinc, calcium and folic acid has previously been reported in a national food consumption survey [18]. A narrow range of staples, comprising cereals, plantain, roots and tubers dominate diets for most households in Uganda, accounting for approximately 70% of foods consumed [19]. These staples are largely deficient in important nutrients needed for normal human nutrition and health. Food based interventions ensure strong linkage between food production and consumption [20]. This helps to ensure sustained alleviation of malnutrition. There is, therefore, need to identify foods which can be used to alleviate malnutrition, especially among resource constrained communities. Grain amaranth is a fast growing, high yielding, stress resistant, nutritious crop with potential to contribute to the alleviation of malnutrition and nutritional deficiencies. Grain amaranth also fits well in the food habits of rural communities in Uganda since it can be used to make commonly consumed dishes such as gruels, stiff porridges, fried snacks and sauces. Results from this study show that grain amaranth is quite acceptable for consumption by communities in Kamuli, Nakasongola and Apac districts, Uganda and the products made with grain amaranth are of superior nutritional value compared to dishes without grain amaranth. Promotion of grain amaranth production and consumption should, therefore, be undertaken as an intervention towards alleviation of malnutrition. Such promotion should include nutrition education to inform the communities of the nutritional value of grain amaranth. It has been recognized that knowledge of the nutritional value of new crops promotes their adoption [21]. Methods that promote nutrient bioavailability from grains such as malting could be adopted to ensure even higher nutritional benefits from grain amaranth. Results for nutritional composition of the different products analysed revealed exceptionally high calcium content among those containing sesame. This is consistent with the fact that sesame is a rich source of calcium [22]. Ginger *masala* on the other hand had high values of iron (168 mg/100g). This may have resulted from contamination during milling of the *pilau masala*, an ingredient containing cardamom and a number of other spices which was purchased from local markets. There is widespread use of mills made of cast iron in Uganda. These could be a source of iron contamination in flours.

CONCLUSION

This study has demonstrated that grain amaranth has potential to contribute to the alleviation of dietary nutritional deficiencies. The recipes developed through this study were found to contain enhanced levels of the nutrients previously reported to be inadequate in the diets in the 3 study districts. These recipes were not only able to fill the nutritional gaps but were also found to be highly acceptable to the farmers in the rural households of three different districts in Uganda. Once widely disseminated and adopted, these recipes are likely to markedly contribute to improved nutrition in the three districts. Dissemination of the recipes is now on-going and this will be followed by evaluation of their adoption.

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Table 1: Formulation used for producing grain amaranth (GA) containing food products

Food products	Ingredients and their mixing proportions	Preparation method
Chapatti	Wheat flour (1400 g), popped powdered grain amaranth (600 g), water (1000 ml), grated carrots (156 g), grated onions (86 g), cooking oil (35 ml) and salt (15 g)	Ingredients mixed, kneaded into dough. Portions (95 g) of dough rolled into flat round shapes (about 12 cm diameter and <1 cm thickness), pan fried with gas flame while turning to have both sides heated.
Baggia	Cassava flour (500 g), water (1000 ml), roasted powdered soybean (300 g), popped powdered grain amaranth (200 g), ground fresh onions (43 g), ground fresh ginger (17 g) an salt (15 g)	Solid ingredients mixed using a wooden stirrer, water added gradually while stirring. Resulting paste cold extruded using *Baggia* machine and deep fried over a charcoal stove fire until golden brown and crunchy
Pancakes	Cassava flour (500 g), popped grain amaranth flour (250 g), freshly peeled sweet bananas (560 g), ginger (17 g) and cooking oil (1 litre)	Cassava flour and popped grain amaranth flour thoroughly mixed and sifted then blended with sweet bananas and ground ginger. The dough was rolled, shaped and deep fried
GA-sesame balls	Roasted sesame (100 g) popped G.A (100 g) and granular sugar (100 g).	Sugar was melted in a saucepan and the grains while stirring constantly using a metal spoon. Ladleful scoops of the grain-molten sugar mixture were hand-rolled into round balls and left to set
GA-bean Sauce	Dry beans (300 g), popped G.A flour (200 g).	Beans soaked in 3liters of clean cold water overnight. The testa were removed and the beans cooked, mashed and kneaded with GA flour. Resulting dough shaped and dried. Preparation of product done by boiling or frying and addition of spices and salt as desired
GA-sesame instant porridge	Sesame G.A (600 g), granular sugar (100 g) and water	The grain was milled and blended with sugar. The resulting flour was used to make porridge by mixing with water to desired consistency
GA-millet porridge	Roasted millet flour (500 g) and roasted G.A flour (500 g)	The two flours were mixed and porridge was made from the flour using conventional boiling method.

GA-maize porridge	Maize flour (500 g) and roasted GA flour (500 g).	The two flours were mixed and porridge was made from the flour using conventional boiling method
GA - Rice porridge	Rice kernels (500 g) and popped G.A flour (500 g)	The two flours were mixed and porridge was made from the flour using conventional boiling method.
GA -cassava meal	Cassava flour (500 g), roasted G.A flour (500 g)	The flours were mixed in a flour blender and the mixture used in preparation of stiff porridge using the conventional method
GA -cassava-millet meal	Roasted millet flour (800 g), cassava flour (400 g) and popped G.A flour (400 g)	The flours were mixed in a flour blender and the mixture used in preparation of stiff porridge using the conventional method.
GA-rice meal	Rice grain (500 g) and grain amaranth (500 g).	The mixture was boiled together, salted and spiced as desired
GA Tea Masala	Freshly ground ginger (300 g), 20 g pilau Masala,100 g popped G.A flour	Fresh ginger pounded in a motor to fineness, mixed with pilau masala and popped G.A flour molded into tiny fragments, dried under the sun for 2 days and later pounded to powder which was sieved to get a finer powder
GA soup	Roasted G.A	Roasted G.A was soaked in four times its weight of cold water for one hour. Salt and spices were added as desired and mixed to achieve uniform distribution. The mixture was prepared by boiling for 5 minutes on high fire and gently simmering for 20 minutes until most of the water was absorbed and the amaranth grains were puffed up. The cover was removed and the mixture was gently stirred to allow some of the remaining water to evaporate. Margarine was added melted into the now thick mixture. The mixture was then strained through a sieve to get a thick creamy soup as the final product
GA paste	Roasted sesame (1000 g), roasted groundnuts (500 g) and popped G.A flour (200 g)	Roasted sesame and roasted groundnut were mixed and milled into a thin paste to popped G.A flour was added to form a thicker paste for use as a spread
GA-peanut-bean snack	Roasted groundnuts (900 g), popped G.A flour (300 g),	Decorticated beans to which water, salt and spices had been added were boiled

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	decorticated beans (300 g) salt (30 g), water, margarine and assorted spices	ready. The excess water was removed and then the beans were cooled, mashed, while mixing with GA flour. Resulting mash was shaped into tiny fragments and dried. The dry product was prepared by deep frying until crispy
GA Leaf Powder-Peanut sauce	Dry GA leaf Powder (200 g), peanut paste (1 kg).	Ingredients thoroughly mixed with 250 ml of water in a clean saucepan and boiled at medium heat for 30 minutes with continuous stirring. Salt added to desired level.

Table 2: Foods identified to fill identified dietary gaps

Nutrient	**Foods**
Zinc	Sesame, soybeans, groundnuts, ginger
Calcium	Sesame, soybeans
Niacin	Peanut, millet
Lipids	Sesame, soybeans
Iron	Sesame

Table 3: Sensory scores for grain amaranth containing products developed

PRODUCT	SENSORY ATTRIBUTES (n= 54)				
	Texture	**Flavor**	**Appearance**	**Odor**	**Overall acceptability**
Chapatti	8	8.3	9	7.5	8.2
Baggia	8.3	7.3	8.8	8	8.1
Pancakes	7	8.8	8.3	7.8	7.9
Balls	8.8	9	7.8	8	8.4
Sauce	7.3	7.3	9	8.5	8
Sesame Instant porridge	8.8	8	7.3	8.8	8.2
Millet porridge	7.3	8.3	8.8	7.8	8
G.A-Maize porridge	7	7.3	7.3	8.5	7.5
G.A Rice porridge	7.5	7.5	7.3	8.8	7.8
G.A Cassava meal	8.5	8.8	7	8	8.1
G.A-Millet-Cassava meal	8	8.8	7.8	8.3	8.2
G.A Rice meal	7.5	8.3	8.8	7.8	8.1
G.A Tea Masala	9	8.5	8.3	9	8.7
G.A Soups	7.5	8.3	9	7	7.9
G.A Paste	7	8.8	8.3	8.9	8.2
G.A Snack	7.8	8	8.5	8.3	8.1
G.A Leaf powder-peanut sauce	8	7.3	8	7.5	7.7

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Table 4: Energy and nutrient content of developed, proximate and mineral composition per 100g of the developed products

Grain amaranth product	**Energy (Kcals)**	Protein (g)	Fat (g)	Carbohydrates (g)	Fiber (g)	Ash (g)	Moisture (g)	Zn (mg)	Fe (mg)	Ca (mg)
Chapatti	460.91	9.1	16.41	69.2	3.8	1.48	31.2	1.1	2.5	46.6
Baggia	499.81	8	34.63	39	3.82	2.25	6.48	1.25	1.94	55
Pancakes	453.36	3.38	38.8	22.65	2.94	1.8	24.38	0.7	1.8	34.8
Sesame balls	441	11.29	24	44.96	8.11	3.1	5.43	3.35	7.47	383
Bean sauce	453.59	17.05	4.13	87.1	4.72	6.06	3.72	1.26	3.05	68.1
Sesame Instant porridge	428.7	12.6	22.49	43.97	12.6	2.2	86	3.7	8.57	373.6
Millet porridge	394.26	12.2	5.64	73.7	9.07	2.9	85.2	2.87	7.61	86.5
Maize porridge	366	10.25	5.44	69	1.37	2.7	88	2.3	5	83
Rice porridge	400.5	9.76	4.22	80.9	1.7	1.1	89.4	1.84	3.98	84.5
Cassava meal	377.55	9.1	3.95	76.4	3.18	2.82	42	2.1	3.94	50.75
Millet-Cassava meal	399.22	9.11	3.95	81.81	8.07	2.7	40.3	2.12	3.94	50.75
Rice meal	388.12	9.76	4.22	77.8	1.19	2.6	45	1.84	3.98	84.5
Ginger Masala	363.24	9.985	7.29	64.4	7.83	4.4	7.58	3.6	168	125
Soup	395.42	0.45	0.54	97.2	0.58	1.25	90.26	2.6	8	17
Sesame-peanut Paste	543	18.39	42.6	21.5	2.76	3.4	2.49	5.45	10.2	603.3
Bean-peanut Snack	463.7	20.15	29.8	28.73	17.5	3.83	3.23	2.64	3.65	82.3
Peanut sauce	534	21.72	45.2	10.1	8.2	6	6.9	3.31	2.26	68.1

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Table 5: Nutrient changes due to grain amaranth incorporation

Grain amaranth product	Percentage change in Energy/Nutrients due to amaranth incorporation					
	Energy	**Protein**	**Fat**	**Zinc**	**Iron**	**Calcium**
Chapatti	11.9	9.64*	10.8	96.4	166	288.3
Baggia	45.8	6.7*	24.6	25.3	55.2	28.2*
Pancakes	19.5	293	32.4	250	445.4	284.5
Sesame balls	-7.35*	32.8	-4*	-6.9	0.95*	-22.6*
Bean sauce	215	86.14	282.4	18.9	23	9.84*
Sesame Instant porridge	-9.9	48.6	-6.25*	3.1*	15.7	-24.4*
Millet porridge	5.7*	13.1	32.7	9.1	93.1	517.9
Maize porridge	1.38*	47.8	40.9	32.95	110.1	1085.7
Rice porridge	9.4	64	197.2	129.4	1037.14	745
Cassava meal	136	569.1	1310.7	517.6	1359	217.5
Millet-cassava meal	32.2	19.5	34.8	13.4	44.9	245.9
Rice meal	6*	64	197.2	130	1037	745
Ginger masala	8.42	11.2	71.9	-1.09*	-15.2	9.65*
Sesame-peanut Paste	-5*	-4.2*	-12.3	-7.3	-3.8*	-10.9*
Bean-peanut Snack	0.8*	6.9*	-10.95	3*	56.6	45.1*
Peanut sauce	-8.72	-8.28*	-8.98*	3.4*	7.62*	26.1*

*Changes not significantly different at $\alpha = 0.05$

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Table 6: Farmer rating of grain amaranth containing recipes

Product	Score on 5 point Scale			
	Kamuli	Apac	Nakasongola	Overall
Chapatti	4.7	5	5	4.9
Baggia	4.5	4.3	4.5	4.4
Pancake	5	4.5	4.7	4.7
Sesame balls	5	5	5	5
Soup	3.5	4.5	4	4
Sesame instant porridge	5	5	4.5	4.8
Rice Porridge	4.5	4.5	4.5	4.5
Maize Porridge	5	5	5	5
Millet porridge	5	5	5	5
Peanut sauce	3.5	4	4.5	4
Bean sauce	4	4	3.5	3.8
Rice meal	3.5	3	3.5	3.3
Cassava meal	5	5	5	5
Millet-Cassava meal	5	5	5	5
Ginger Masala	5	4	4.5	4.5
Paste	4	4.5	4	4.2
Bean peanut snack	4.5	4	5	4.5

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Table 7: Farmer group acceptability scores for different grain amaranth products

Product	Score on 5 point Scale			
	Kamuli	Apac	Nakasongola	Overall
Chapatti	5	5	5	5
Baggia	4.5	4.7	4.5	4.6
Pancake	4.5	4.5	5	4.7
Sesame balls	5	5	5	5
Soup	3.5	4	4	3.8
Sesame instant porridge	5	5	4.5	4.8
Rice Porridge	5	4.5	4.5	4.7
Maize Porridge	4.5	4.5	4	4.3
Millet porridge	4.5	4.5	4.5	4.5
Peanut sauce	4	4	4.5	4.2
Bean sauce	4	4	4	4
Rice meal	3.5	4.5	4	4
Cassava meal	5	5	5	5
Millet-Cassava meal	5	5	5	5
Ginger Masala	5	4.5	5	4.8
Paste	4	4.5	4.5	4.3
Bean peanut snack	4	4.5	5	4.5

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