NUTRITIONAL COMPOSITION OF KENYAN SORGHUM-PIGEON PEA INSTANT COMPLEMENTARY FOOD

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Abstract
An instant complementary food product was developed by blending flours from two improved sorghum varieties, Gadam and Seredo, a local variety (kivila kya ivui) and one improved pigeon pea variety KAT 60/8. The effects of fermentation, germination and dehulling techniques on nutritional and anti-nutrient composition of the food were determined. Malted sorghum, fermented sorghum and steam cooked dehulled pigeon pea flours were prepared by appropriate processes. The flours were blended at three different ratios of 1:1, 2:1 and 5:1 (w/w, sorghum: pigeon pea). Untreated flour of both crops was also prepared and blended at the same ratios and used as control. Fermentation and malting increased the crude protein content significantly ($P < 0.05$). Fermented sorghum flour blend was found to be the highest with 14.11%. Crude protein content differed significantly among the formulations; flour blended at the ratio of 1:1 had the highest with 14.91%. The antinutrients content of the instant complementary food was significantly reduced by fermentation and malting. The tannin and phytate content was least in fermented and malted food which had 2.25 mg/100g and 207.5 mg/100g respectively. Blending flours at the ratio of 1:1 was found to be the most effective at reducing the antinutrients contents. The macro elements (Ca and Mg) were found to be highest in formulation 1:1 which had 29.81 mg/100g and 44.86 mg/100g respectively. Micro element (Fe) Iron was found to be highest in food formulated at the ratio of 5:1 which had 11.87 mg/100g. The results suggest that fermentation, as a processing technique and blending sorghum and pigeon pea flours at the ratio of 1:1 using Gadam variety, can be used to effectively enhance the nutritional status of sorghum- pigeon pea instant complementary food with concomitant reduction of its anti-nutritional factors.

Key words: Varieties, fermentation, malting, crude protein, anti-nutrients

1.0 Introduction

For proper growth adequate nutrition during infancy and childhood is fundamental. When breast milk alone is no longer sufficient to meet nutritional requirements of infants, complementary feeding commences with introduction of other foods along with breast milk. Breast feeding may continue beyond two years but the target range for complementary feeding is 6 to 24 months of age (Kathryn Dewey, 2001)

There is a direct connection between areas of high food insecurity and high rates of malnutrition in the areas studied in Kenya. Food insecurity is reported the highest in semi-arid regions of Kenya. Preventing malnutrition from affecting infants in semi-arid parts of Kenya requires various approaches including broadening the diet to incorporate a wider range of foods, increasing the utilization of conventional staples and boosting the nutritional quality of basic staples.

Due to high cost and unavailability of animal products such as milk, legumes are largely used as alternative sources of high quality protein. Cereals are relatively poor sources of protein but have been reported to supply over 70% of dietary protein in developing countries (Ijarotimi, 2006).

Pigeon pea (*Cajanus cajan* L.) accounts for about 5% of the world's pulse production. It's an important pulse in semi arid regions of Kenya (A. Opoku, 2003). One of the best solutions to protein energy malnutrition in developing countries is supplementing cereals with protein rich legumes. Pigeon pea flour has been tested and found to be suitable as a protein source for supplementing cereal food products due to its high level of protein and iron (Fe), (Harinder, 1999).

In many regions of Africa where the climatic conditions are unfavorable for the growth of other crops, sorghum (*Sorghum bicolor* (L.) Moench) is the major staple food (Eugene, 2011). Sorghum provides the staple food for a large population in the semi-arid parts parts of Kenya. It has a low protein content and compositing sorghum with pigeon pea flour improves its protein quality and could help alleviate protein energy malnutrition.

Fermentation, malting and dehulling techniques have been used to improve nutritional value of instant complementary mixes. Fermentation increases the protein content of sorghum flour after 48 hours (Mihiret, 2011). Malting has been shown to improve sorghum flour digestibility and quality of the protein, which generally increased with increased malting time (Dewar et al, 1997). Pigeon pea is dehulled to improve cooking and nutritional qualities and to reduce cooking time. Dehulling legume grains may lower the tannin content and improve their digestibility.

There is limited research work on value addition options for sorghum and pigeon pea. This is so because most farmers possess limited information on the processing techniques of both crop products. For instance, instant complementary food is a potential value added product of sorghum using pigeon pea; however, there is no proper documentation on information regarding the technological aspects of its production. The aim of this study is to determine the effects of food preparation techniques and formulation ratios on nutritional and anti-nutrient composition of sorghum-pigeon pea instant complementary food.

2.0 Materials and Methods

2.1 Research Design

This study examines the effect of three components of instant complementary food preparation on nutritional and anti-nutrient composition: the variety of sorghum (Gadam, Seredo, kivila kya ivui) the food preparation technique or treatment (fermentation, malting, control), and the formulation ratios of sorghum-to-pigeon pea flours (1:1:, 2:1, 5:1). Using all combinations of these three factors, a total of twenty-seven formulas of instant complementary food were prepared analyzed for their proximate (moisture, ash, fat, fibre, protein, carbohydrates), anti-nutrient (tannins, phytates) and mineral (Fe, Mg, Ca, Cu, Zn) composition. The experiment was replicated twice.

Seredo and the Local variety sorghum were obtained from farmers in Tharaka Nithi and Makueni Counties respectively. Gadam sorghum and KAT 60/8 pigeon pea varieties were collected from KARI-Katumani in Machakos County. The varieties selected were found to contain the highest crude protein content in a previous study (Kinyua, 2014) comparing three sorghum and three pigeon pea varieties across the three counties in Eastern Kenya (Table 1)

Table 1: Protein composition (%) of sorghum varieties grown in three counties in Kenya (Kinyua, 2014)

Variety	Protein	Variety	Protein
Sorghum		Pigeon pea	
Gadam		KAT 60/8	
Machakos	13.44±0.14[c]	Machakos	23.02±0.59[b]
TharakaNithi	8.71±0.31[a]	Tharaka Nithi	16.94±0.05[a]
Makueni	10.45±0.24[b]	Makueni	20.02±0.88[b]
Kivila kya ivui		Mbaazi II	
Machakos	11.92±0.18[b]	Machakos	22.27±0.62[c]
TharakaNithi	4.24±0.075[a]	TharakaNithi	19.11± 0.58[b]
Makueni	18.59±1.42[c]	Makueni	15.40±0.27[a]
Seredo		Ndombolo	
Machakos	7.05±0.41[a]	Machakos	13.62±0.14[a]
TharakaNithi	9.97±0.19[b]	TharakaNithi	19.08± 0.48[b]
Makueni	7.89±1.04[ab]	Makueni	17.87±0.88[b]

Values are means (± SE). Means with the same letter do not differ significantly at 5% significance level tests done by Duncan Multiple Range Test following ANOVA.

2.2 Preparation of Instant Complementary Food

2.2.1 Germinated Sorghum Flour

Sorted clean grains of sorghum weighing 500g were steeped in water (1:3 w/v, grain: water) for 4h. The steeped grains were then transferred to a wide container with cotton wool to allow for germination at room temperature (27ºC) for 5 days. The washed germinated seeds were dried in the oven at 35ºC for a total of about 10h to 12 h. The grains were then cleaned of sprouts and hulls by hand rubbing and winnowing, after which they were toasted in a shallow pan at 80ºC to a uniform light brown colour. The dried grains were ground to fine flour and passed through a 0.5 mm sieve (Elemo, 2011).

2.2.2 Fermented Sorghum Flour

To prepare the starter culture 300g of finely milled sorghum flour was mixed with 375ml of boiled and cooled water to a thick paste, covered and left to ferment at room temperature (25ºC) for 2days until it tasted sour (pH approximately 3.6). The starter culture was then used to prepare a larger amount of fermented sorghum flour. Half of the culture was mixed with 225g of finely milled sorghum flour, 300 ml of boiled cooled water and left to ferment at room temperature (25ºC) for 2days.The slurry was transferred to a metal pan and spread into a thin layer. The pans were put into an oven at 65°C for 24 hours. The dried material in the form of fermented cakes was allowed to cool before breaking into small pieces and milling using a hammer mill (Taylor, 1999)

2.2.3 Steamed Pigeon Pea Flour

Cleaned pigeon pea grains weighing 500g were soaked in water (1:2 w/v, grain: water) for 1h and dehulled by hand rubbing. The dehulled grains were steamed for 45 min until tender. The grains were then dried in an oven at 56ºC for 10 h. The dried grains were ground using a hammer and passed through a 0.5 mm sieve (Elemo, 2011).

2.2.4 Formulation of Complementary Food

The germinated sorghum flour and steamed cooked pigeon pea flour was blended at ratios of 1:1, 2:1 and 5:1 (w/w, sorghum: pigeon pea). The fermented sorghum flour and steam cooked pigeon pea flour were also blended at the same ratios.

2.2.5 Preparation of Untreated Formula (Control)

This was prepared from untreated sorghum and pigeon pea flour and blended in ratios of 1:1, 2:1 and 5:1 (w/w, sorghum: pigeon pea) and labeled control.

2.3 Laboratory Analysis

2.3.1 Proximate Analysis

Moisture, protein, carbohydrates, fat, ash and crude fibre were determined according to AOAC methods (AOAC, 1995)

2.3.2 Carbohydrates

The contents of total carbohydrates was calculated by subtracting the sum of moisture, protein, fat, ash and crude fibre from 100 (AOAC, 1995)

2.3.3 Tannins

Flour samples of about 5 g each were put inside a volumetric flask and 50 ml of distilled water was dispensed inside the volumetric flask, shaken for 30 min and filtered. About 2ml of the filtrate was measured into 50ml volumetric, Similarly, 2 ml of standard tannic acid solution and 2 ml of distilled water were measured with separate flasks to serve as standard and blank respectively. 2ml of follins-Dennis reagent was added to each of the flask followed by 2.5 ml of saturated sodium carbonate solution. The content of each flask was made upto 50 ml with distilled water and incubated for 90 min at room temperature. The absorbance of the developed colour was measured at 760 nm wavelength (Mehrotra, 1993).

2.3.4 Phytates

Determination of phytates was carried out using HPLC analysis according to Camire and Clydesdale, (1982), 50 mg of each sample being utilized. Extraction was carried out with 25 ml of 3% H_2SO_4 for 30 minutes on a shaker bath at medium speed for 30 min at room temperature. The slurry was filtered through fast filter and rinsed using a fine jet stream from a squeeze bottle, with a small volume of extracting solvent. The filtrate was transferred to 50ml centrifuge tubes and placed in boiling water bath for 5 minutes before addition of 3 ml of $FeCl_3$. The tubes were heated in boiling water bath to allow for the complete precipitation of the ferric phytate complex. Centrifugation was done at 2,500 rpm (Japan model H 2000C) for 10 min. and the supernatant discarded. The precipitates were washed once with 30m distilled water, centrifuged and the supernatant discarded again. Three (3) ml of 1.5N NaOH and a few ml of distilled water were added to the contents of the tubes. The volume will then be brought to approximately 30 ml with distilled water and heated in boiling water bath for 30 minutes to precipitate the ferric hydroxide. The cooled samples were centrifuged and the supernatant transferred to 50ml volumetric flasks. The precipitate was then rinsed with 10 ml distilled water, centrifuged and the supernatant added to the contents of the volumetric flask. Samples of 2 µl of the supernatant were injected into a HPLC (Shimazu model C-R7A plus) fitted with a 50377RP-18 (5 µl) column Cat. at an oven temperature of 30°C and RID-6A detector model. A stock solution of thestandard containing 10mg/ml of sodium phytate. Distilled water was prepared. Serial dilutions were made for the preparation of the standard curve. Results of the phytate content were obtained as per the calculations of (Vohraet, 1965)

2.3.5 Minerals

Five grams of sample were weighed in crucibles and transferred to hot plates in the fume hood chamber where they were charred to clear all the smoke from the organic material before transferring them to the muffle furnace. The charred materials were then incinerated at 550ºC until they were reduced to white ashes. The ash was cooled, 15 ml of 6N HCL added to each of them in the crucibles before transferring them to 100 ml volumetric flasks. Distilled water was used to top them up to the mark before mineral analysis (AOAC, 1995). Atomic Absorption Flame Emission Spectrophotometer was used for the Fe, Mg, Ca, Cu and Zn residue analysis of the alkali treated samples (Model A A-6200, Shimadzu, Corp., Kyoto, Japan).

2.4 Sensory Tests

Fermented sorghum (Gadam) flour and dehulled steam cooked pigeon pea flour blended at three different ratios of 1:1, 2:1 and 5:1 (w/w, sorghum: pigeon pea) was used in making the final product for sensory evaluation. Four table spoons (50 g) of the food was mixed with 100 ml of boiled hot milk to get a thick consistency. A tea spoon of sugar was added to increase the energy content. The following scale was used to express people’s attitude towards the products color, texture, appearance, taste, flavor and general acceptability. Like extremely 9, like very much, 8, like moderately 7, like slightly 6 neither like nor dislike 5, dislike slightly 4, dislike moderately 3, dislike very much 2 and dislike extremely 1. A panel of twelve mothers with infants in the complementary feeding age range was used in sensory evaluation of the product.

2.5 Statistical Analysis

The experiment was designed and analyzed as a three-way ANOVA with Variety, Treatment, and Ratio as the main factors. Each factor was considered fixed. Laboratory analyses were performed in triplicates. The ANOVA was repeated for each of the 13 nutritional and anti-nutrient characteristics. Post-hoc mean comparisons were made using the Duncan's Multiple Range Test when the main treatment effects were considered statistically significant at 5% following the ANOVA F-test. Sensory evaluation experiments were conducted in triplicate. The data obtained were analyzed using analysis of variance (ANOVA). Duncan multiple range was used in separating the means. Significant difference was accepted at 5% level. Statistical analyses were performed with genstat 14th edition.

3.0 Results and Discussion

3.1 Proximate Composition

The moisture content was found to be highest in control with 11.34%. Crude protein content differed significantly (P<0.05) among the three treatments and formulations (Table 2). Malting and fermentation increased protein content of the complementary food. Protein content for fermented and malted instant complementary food was found to be 14.11% and 13.84% respectively. These results are in agreement with previous studies, (Dewar et al, 1997) which indicated that malting, in addition to improving the malt quality characteristics, also improved the quality of the protein, which generally increased with increased malting time. Various studies have also shown that fermentation can increase the concentrations of vitamins, minerals and protein (Taylor et al, 2003). The increase in protein content for fermented food can be attributed to microbial synthesis of proteins from metabolic intermediates during their growth circles. The fiber content differed significantly (P<0.05) and ranged between 2.87% - 3.99% and 2.71% - 4.57% among the treatments and formulation respectively. Instant complementary food blended at the ratio of 2:1 had significantly higher amounts of ash, fat and fibre but lower amounts of carbohydrates than formulations of 1:1 and 5:1. The lower carbohydrate content is due the greater proportion of fat and fibre of formulation 2:1 compared with formulations 1:1 and 5:1. Significant difference was observed in interaction between treatment and formulation in moisture content. Fermentation had the highest moisture content of 6.15%.

Table 2: Proximate composition among the sorghum varieties, treatments and formulations

	Moisture	**Ash**	**Fat**	**Crude Fibre**	**Crude protein**	**Carbohydrates**
Variety						
Seredo	5.18±2.78[a]	2.21±0.53[a]	3.84±0.53[a]	3.49±0.74[a]	13.22±1.85[a]	71.23±3.3[a]
Gadam	5.19±2.77[a]	2.02±0.64[a]	4.02±0.93[a]	3.44±0.83[a]	11.84±2.8[a]	73.47±2.69[a]
Kivilakyaivui	4.73±2.78[a]	2.22±0.39[a]	3.52±0.72[a]	3.26±0.76[a]	12.93±1.98[a]	73.31±3.33[a]
Treatment						
Fermentation	2.01±0.74[a]	2.05±0.43[a]	3.85±0.69[a]	2.87±0.79[a]	14.11±2.21[b]	75.08±2.44[b]
Malting	1.75±0.8[a]	1.86±0.44[a]	3.79±0.87[a]	3.34±0.75[b]	13.84±1.59[b]	75.35±2.52[b]
Control	11.34±1.66[b]	2.53±0.58[a]	3.74±0.79[a]	3.99±0.64[b]	10.04±2[a]	67.58±2[a]
Formulation						
1:1	6.16±2.45[a]	2.06±0.39[a]	3.74±0.76[b]	2.71±0.72[a]	14.91±3.82[b]	70.35±2.2[a]
2:1	4.59±2.65[a]	2.75±1.02[b]	4.69±0.68[c]	4.57±0.51[b]	11.52±3.27[a]	71.86±2.51[a]
5:1	4.36±2.57[a]	1.63±0.86[a]	2.95±0.43[a]	2.92±0.57[a]	11.56±2.80[a]	75.80±3.42[b]

Values are means (± SE). Means sharing a common superscript letter in a column are not significantly different at (P<0.05)

3.2 Mineral Composition

Table 3 revealed that the complementary food differed significantly (P<0.05) in their iron (4.37-11.87mg/100g), zinc (1.02-2.34mg/100g), copper (0.28-0.61mg/100g), calcium (19.36-29.81mg/100g) and magnesium (33.21-44.86mg/100g) among the formulations. No significant differences were observed in all minerals for the treatments. Similar observations were made in study fermentation and malting does not have an overall effect on the contents of total minerals (Ejigui, 2005)

Table 3: Mineral composition (mg/100g) among the sorghum varieties, treatments and formulations

	Fe	Zn	Cu	Ca	Mg
Variety					
Seredo	$8.03±2.53^{a}$	$1.76±0.61^{a}$	$0.50±0.11^{a}$	$27.90±5.51^{a}$	$39.29±10.34^{a}$
Gadam	$6.72±1.62^{a}$	$1.37±0.27^{a}$	$0.42±0.12^{a}$	$21.01±3.96^{a}$	$36.66±6.05^{a}$
Kivilakyaivui	$8.43±2.37^{a}$	$1.83±0.41^{a}$	$0.55±0.25^{a}$	$24.24±7.51^{a}$	$43.08±7.95^{a}$
Treatment					
Fermentation	$8.44±2.74^{a}$	$1.65±0.38^{a}$	$0.53±0.26^{a}$	$23.31±7.85^{a}$	$42.25±9.72^{a}$
Malting	$6.89±1.71^{a}$	$1.86±0.51^{a}$	$0.48±0.12^{a}$	$23.62±5.05^{a}$	$38.56±8.01^{a}$
Control	$7.86±2.28^{a}$	$1.44±0.39^{a}$	$0.45±0.13^{a}$	$26.21±4.64^{a}$	$38.22±7.94^{a}$
Formulation					
1:1	$6.95±1.68^{b}$	$1.59±0.17^{b}$	$0.61±0.25^{b}$	$29.81±6.7^{b}$	$44.86±9.7^{b}$
2:1	$4.37±0.93^{a}$	$1.02±0.33^{a}$	$0.28±0.08^{a}$	$19.36±4.9^{a}$	$33.21±7.25^{a}$
5:1	$11.87±1.93^{c}$	$2.34±0.43^{c}$	$0.57±0.1^{b}$	$23.98±10.52^{ab}$	$40.97±7.45^{ab}$

Values are means (± SE). Means sharing a common superscript letter in a column are not significantly different at (P<0.05)

3.3 Anti-Nutrient Composition

Tannins and phytate content were reduced significantly (P<0.05) in fermented and malted instant complementary food compared with the control (Table 4). Fermented food had the least while untreated food had the highest tannin content with 1.85 mg/100g and 4.59mg/100g respectively. Malted food had the least phytate content which found to be 207.5 mg/100g. The results of this study are in agreement with those reported by (Makokha, 2002) who stated that fermentation of sorghum, produces significant loss in phytate. Reduction in tannin contents due to fermentation might have been caused by the activity of polyphenol oxidase present in food grain or micro flora (Fagbemi, 2005). The results revealed that fermentation enhances the removal of the anti nutritional factors which are believed to be responsible for unavailability of both proteins and divalent minerals.

Table 4: Antinutrients (mg/100g) among the sorghum varieties, treatments and formulations

	Tannins	**Phytates**
Variety		
Seredo	3.35±1.13[a]	264.6±35.31[b]
Gadam	2.41±0.52[a]	207.7±40.89[a]
Kivilakyaivui	3.20±2.41[a]	260.0±42.05[b]
Treatment		
Fermentation	1.85±0.35[a]	232.4±40.98[a]
Malting	2.25±0.46[a]	207.5±33.39[a]
Control	4.59±1.01[b]	392.4±41.61[b]
Formulation		
1:1	2.44±0.6[a]	202.4±37.16[a]
2:1	2.52±0.88[a]	234.3±42.03[a]
5:1	3.80±1.44[b]	295.6±34.56[b]

Values are means (± SE). Means sharing a common superscript letter in a column are not significantly different at (P<0.05)

Various studies have shown that malting reduces phytate content in sorghum. According to (wisal, 2005) the reduction is due to the action of endogenous phytases obtained during germination that degrade the phytate into organic phosphorus and inositol and its intermediate forms. The rate of reduction depends upon the age as well as the amount of malt. Significant differences were observed among the formulations and varieties for phytate content. Gadam and formulation 1:1 had the least phytate content with 207.7 mg/100g and 202.4 mg/100g respectively. Tannin content was least in food formulated at the ratio of 1:1 with 2.44mg/100g. Tannin content was lowest in Gadam variety for the interaction between varieties and treatments with 2.41 mg/100g. The level of phytate differed significantly (P<0.05) in interaction between varieties and treatments, Gadam variety had the least level with 207.7 mg/100g. The results indicate untreated pigeon pea significantly increases the levels of phytate and tannins in sorghum.

3.4 Sensory Properties of the Three Instant Complementary Food Blends

Mean sensory scores for the three blends of instant complementary food are shown in table 4. Significant (P<0.05) differences were observed in the scores for color, texture, taste, flavor, appearance and general acceptance. Significant differences were observed in color, texture, taste, flavor, appearance and general acceptance among the three ratios. Flour blended at the ratios of 1:1 and 2:1 had the preferred color, texture, flavor and appearance. It was stated instant complementary food blended at the ratio of 5:1 was thick for infants and had the least overall acceptability.

Table 5: Mean sensory scores for the three instant complementary food blends

Formulations	Color	Texture	Taste	Flavor	Appearance	General acceptance
1:1	6.83± 0.56[b]	7.50± 0.79[b]	8.5± 0.31[b]	7.5± 0.31[b]	7.66± 0.59[b]	8.33± 0.46[b]
2:1	7.16± 0.56[b]	7.33± 1.13[b]	7.33± 0.69[a]	7.5± 0.47[b]	7.33± 0.69[b]	7.66± 0.69[a]
5:1	5.33± 1.62[a]	5.33± 0.46[a]	5.66± 1.34[a]	5.50± 1.07[a]	5± 0.81[a]	5.33± 0.94[a]

Values are means (± SE). Means sharing a common superscript letter in a column are not significantly different at ($P<0.05$)

4.0 Conclusion

In conclusion, this research shows that, the use of fermentation and malting of sorghum as well as dehulling pigeon peas has reduced tannin and phytate content. It has also improved the protein content of the complementary blends compared to the untreated. Blending Gadam and KAT 60/8 flour at the ratio of 1:1 improved the protein content of sorghum and was effective at reducing the antinutrients content. Instant complementary food blended at the ratio of 1:1 had the preferred taste and the overall acceptance and identified as the best for feeding to infants.

Acknowledgements

This research was made possible through the Canadian International Food Security Research Fund (#106510). The Canadian International Food Security Research Fund (CIFSRF) is a program of Canada's International Development Research Centre (IDRC) undertaken with the financial support of the Government of Canada provided through Foreign Affairs, Trade and Development Canada (DFATD). We acknowledge the support of Lutta W. Muhammad and Gordon M. Hickey, Principal investigators of this CIFSRF project for the Kenya Agricultural Research Institute (KARI) and McGill University, respectively. We wish also to extend our thanks to the KARI-McGill Food Security Project manager Bernard Pelletier from McGill University for his constructive comments.

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