

Nutrient Composition and Sensory Attributes of Pigeon Pea (*Cajanus Cajan*) Enriched Millet (*Pennisetum Glaucum*) Complementary Food

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ABSTRACT

Background: Pigeon pea, a leguminous plant, is going extinct because most people no longer consume it. Incorporating it in the production of complementary foods may diversify its utility as well as increase some key nutrients, such as protein and fat.

Objective: The work was designed to evaluate the chemical and sensory attributes of complementary foods produced from millet and pigeon flour blends.

Methods: Complementary foods were produced using standard methods; blend formulation was based on protein content. The blend formulated comprised millet: pigeon pea in the ratios of 50:50, 60:40, 70:30, and 80:20, respectively. The samples were subjected to chemical and sensory evaluation using standard procedures. The proximate compositions of the products were evaluated using AOAC methods. Minerals were determined using wet acid digestion. Means and standard deviations were calculated. Analysis of variance (ANOVA) was used to separate the means. Significant difference was accepted at $p < 0.05$.

Results: Protein (16.07 – 19.06%), fat (6.52 – 7.23%), calcium (10.45 - 16.53mg/100g), and zinc (2.02 – 2.32mg/100g) were significantly ($p < 0.05$) higher in pigeon pea-enriched millet foods. Other nutrients found in significant amounts in the products were thiamin (0.21 – 0.42mg/100g) and riboflavin (0.04–0.08mg/100g). Scores for colour and texture 80% millet: 20% blend were comparable to those of 100% millet pap.

Conclusion: Supplementing millet with pigeon pea for the complementary food production enhanced most of the key nutrients of the foods.

Keywords: Nutrient composition, Sensory attributes, Millet, Pigeon pea, Complementary food

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INTRODUCTION

Complementary foods are liquid and semi-solid foods that are introduced to children from the age of 6 months; for complementary food to be termed adequate, it has to provide 6 – 11g protein per 100g of complementary food eaten

by infants (6 – 23 months), 202kcal for infants 6 - 8months, 307 kcal for infants 9 -11 months and 548kcal for infants in the 12 – 23 months brackets (1). The complementary food should also be able to supply 225µg iodine, 500mg calcium, 27.5mg iron, 12.5mg zinc, and 500µgRE (2).

In Nigeria, complementary foods are mostly cereal-based. A study showed that commonly used cereals for the production of complementary foods in Nigeria include sorghum, maize, and millet (2). Cereals have an incomplete amino acid profile, which is why their supplementation with legumes (such as groundnuts and soybeans) as a means for alleviating protein-calorie malnutrition (3) has been advocated for. Alleviation of hunger and malnutrition, particularly among the rural populace and urban poor, is under threat because of the hike in food prices of commonly utilized foods in the country. There is therefore a need to seek out cheaper, underutilized indigenous crops and diversify their usage in order to curb preventable deficiencies in children.

Millet belongs to the grass family *Poaceae* and are considered one of the oldest cultivated crops (4). Pearl millet (*Pennisetum glaucum*) and finger millet (*Eleusine coracana*) are the two major millets used for food and feed worldwide (4). Pearl millet is said to have originated from sub-Saharan Africa, while finger millet is from the sub-humid uplands of East Africa sub-Saharan Africa (4). Pearl millet is considered the sixth highest produced crop, after maize, wheat, rice, barley, and sorghum (4). Nutritionally, it contains about 11.6% protein, which is higher than the 7.2% protein found in rice, 11.5% found in barley, 11.1% found in maize, and 10.4% found in sorghum (5). It contains higher energy compared to rice and wheat (5). It also has a significant amount of thiamine, niacin, and riboflavin (5). The amount of its calcium, iron, and phosphorus is similar to that found in other cereals (5). In addition to its nutritional values, millets are believed to have nutraceutical health benefits (4).

Cajanus cajan (L.), commonly called pigeon pea of the family *Fabaceae*, is one of the most prevalent fast-growing and adaptable pulse crops (6). It is the world's fifth-most well-known pulse crop, produced in the world after common beans, chickpeas, field peas, cowpeas, and lentils (7). Records showed that India, Myanmar, Malawi, Kenya, and Tanzania are the top producers of pigeon pea in the world (8; 9). Pigeon pea is called by various names such as red gram, congo pea, gungo pea, and no-eye (10). In Nigeria, it is predominantly grown in the guinea savannah agro-ecological zones of northern and southern parts; it is known as agugu among the Idomas and Fiofio amongst the Igbos. Nutritionally, pigeon pea contains about 20–22 % protein (11); its protein is two to three times higher than the protein found in cereals, and it is specifically

rich in lysine (12). Records showed that it has significant amounts of dietary fiber, vitamins, and minerals (13; 14). The seeds can be either eaten fresh (immature) or dried (mature) (15; 16). Pigeon pea has the potential of being used as an ingredient in the production of pasta, biscuits, noodles, cookies, sausages, and bread (17; 18). Legumes, such as groundnut and soybean, commonly used to enrich cereal-based complementary foods, are now expensive and beyond the reach of many poor families. It is therefore imperative to find affordable alternatives that can substitute the former. The work was designed to evaluate the chemical and sensory attributes of complementary foods produced from millet and pigeon pea flour blends.

MATERIALS AND METHODS

Purchase and preparation of ingredients

The millet (pearl variety), pigeon pea, crayfish, and sugar were purchased from Ubani market in Umuahia, Abia State. The millet, pigeon pea, and crayfish were identified in the Department of Biological Sciences, Michael Okpara University of Agriculture, Umudike. Millet was winnowed, and unwholesome seeds and other extraneous objects were handpicked. The grain was steeped in tap water for 24 hours at room temperature to ferment, after which the water was decanted. The grain was washed twice with tap water and then dried using a hot air oven at 60 °C for 8h, milled using a laboratory Hammer mill (Thomas Willey, model Ed-5), and sieved through a 1mm pore sieve. The sample was placed in a tight, closed sample container and placed in the refrigerator at a temperature of 20 °C until needed.

Cleaned pigeon pea was soaked for 24 h in tap water, after which it was boiled for 30 minutes and oven dried for 12h at 55 °C using a hot air oven (Hareus B 504). The dried peas were dehulled using a disc mill prior to milling. The crayfish was manually cleaned and sundried for 12h and then milled using an electric blender (Moulinex, model 278, made in France). The milled ingredients were packaged separately in polyethylene bags for further studies.

Formulation of blends

Blends were formulated on protein basis (protein contents were calculated using Nigerian Food Composition Table) and coded as follows: Sample A (100% millet), Sample B (80% millet: 20% pigeon pea), Sample C (70% millet: 30% pigeon pea), Sample D (60% millet: 40% pigeon pea) and Sample E (50% millet: 50% pigeon pea).

Production of complementary foods

Slurry was made by mixing 100g of the millet flour with 200ml of water, allowed to rest on laboratory table for 10min at room temperature (29 – 30°C) for proper water absorption. The slurry was then gradually poured into a pot of boiling water (500ml) with continuous stirring until thick paste was formed. The above method was also used to prepare pap from the slurry of millet and pigeon pea flour blends in the ratios of 50:50, 60:40, 70:30 and 80:20.

Chemical analyses of the samples

The proximate compositions of the complementary foods were determined using standard AOAC (19) methods. Moisture content was determined gravimetrically. The crude protein content was determined using the microKjeldahl method, and 6.25 was used as the nitrogen conversion factor. The crude fat content was determined using the Soxhlet extraction method. The ash content was determined by incinerating the samples at 600°C in a muffle furnace. Carbohydrate was obtained by difference, while energy was calculated using the Atwater Conversion factors. Mineral was determined using the wet-acid digestion method for multiple nutrients, AOAC (19). The digest was used for the determination of calcium (Ca) and magnesium (Mg) using the ethylene diamine tetraacetic acid (EDTA) Versenate complexometric titration method. Potassium (K) and sodium (Na) were evaluated using the flame emission spectrophotometric method, and phosphorus (P) by the vanadomolybdate spectrophotometric method (Model 3030, Perkin Elmer, Norwalk, USA). Microminerals (zinc (Zn), and iron (Fe)) were determined by an atomic absorption spectrophotometer (Model 3030 Perkin Elmer, Norwalk, USA). The vitamins (riboflavin and thiamin) of the products were determined spectrophotometrically (AOAC 19), and ascorbic acid by the titration method (AOAC 19). The gravimetric method was used to determine alkaloids, oxalate, and flavonoids. The Tannin content of the sample was determined spectrophotometrically, while phenol was determined by the folin-ciocatean spectrophotometry method (19).

Sensory evaluation

Sensory evaluation of the products was carried out by a group of 20 semi-trained panelists randomly selected from students who undertook a course in sensory evaluation of foods in the Department of Human Nutrition and Dietetics, Michael Okpara University of Agriculture,

Umudike, Abia State. The evaluation was carried out in the food laboratory of the Department. The panelists evaluated the products using a nine-point hedonic scale where 9 = like extremely and 1 = dislike extremely. Panelists scored the sample for four sensory attributes – colour, flavor, taste, and overall acceptability. A cup of potable water was given to the panelists to rinse their mouths after each tasting.

Statistical analysis

The data generated from duplicate analysis were analyzed using Statistical Package for Social Sciences (SPSS version 20). Means and standard deviations of the proximate, minerals, vitamins, phytochemicals, and sensory attributes were calculated. Mean separation was done using the Duncan multiple range test because the samples analysed were more than two in number. All calculations were done at 5% level of significance.

RESULTS

Proximate (%) and energy (kcal/100g) composition of complementary foods made from millet and pigeon pea flour blends dry weight basis

The proximate and energy composition of the complementary foods made from millet and pigeon pea flour blends revealed significant variations. The moisture content ranged from 11.65% to 14.33%, with the 100% millet product having significantly higher moisture content ($p > 0.05$). The protein and fat contents of the blends were significantly higher than those of the 100% millet product. The fiber content was highest in sample E (50% millet: 50% pigeon pea), while the carbohydrate content was highest in sample A (100% millet). The ash content of samples D and E was similar but significantly higher than the other products. The energy content of the products ranged from 350.4 to 361.4 kcal, with no significant differences between them.

Mineral composition of complementary foods made from millet and pigeon pea flour blends on a dry weight basis (mg/100g)

The mineral composition analysis revealed significant differences between the 100% millet product and the pigeon pea-supplemented complementary foods. The blends had higher values of calcium (10.45-16.53mg/100g), magnesium (32.53-38.95mg/100g), phosphorus (0.46-0.97mg/100g), and potassium (10.78-16.98mg/100g) compared to the 100% millet product, which had values of 6.93mg/100g,

30.96mg/100g, 0.24mg/100g, and 6.93mg/100g, respectively. Sodium values ranged from 5.03 to 5.93mg/100g, with the 100% millet product having the highest value (5.93mg/100g), while sample E (50% millet: 50% pigeon pea) had the lowest sodium value (5.03mg/100g). Iron values varied among the products, with the 100% millet product having the

highest iron value (6.82mg/100g) and sample E having the lowest (5.18mg/100g). Zinc values (2.02-2.32mg/100g) of pigeon pea-supplemented complementary foods were not significantly higher than the amount (1.98mg/100g) of zinc found in 100% millet complementary food.

Table 1: Proximate (%) and energy (kcal/100g) composition of complementary foods made from millet and pigeon pea flour blends dry weight basis

Sample	Moisture	Protein	Fat	Fiber	Ash	CHO	Energy
Sample A	14.33 ^a	13.21 ^e	6.17 ^e	2.13 ^c	0.91 ^d	63.2 ^a	361.4 ^a
Sample B	13.32 ^b	16.07 ^d	6.52 ^d	2.16 ^c	1.38 ^c	60.5 ^b	365.2 ^a
Sample C	12.84 ^c	17.78 ^c	6.55 ^c	2.17 ^c	1.52 ^b	59.1 ^c	366.7 ^a
Sample D	12.31 ^d	18.95 ^b	6.85 ^b	2.22 ^b	2.04 ^a	57.6 ^d	367.9 ^a
Sample E	11.65 ^e	19.06 ^a	7.53 ^a	2.47 ^a	2.08 ^a	57.2 ^e	350.4 ^a

Values are means of duplicate samples; a-e means with similar superscripts in the same columns are not significantly different from each other

Key: Sample A – 100% millet, Sample B – 80% millet: 20% pigeon pea, Sample C – 70% millet:30% pigeon pea, Sample D – 60% millet:40% pigeon pea, Sample E – 50% millet:50% pigeon pea

Table 2: Mineral composition of complementary foods made from millet and pigeon pea flour blends on dry weight basis (mg/100g)

Nutrient	Sample A	Sample B	Sample C	Sample D	Sample E
Calcium	6.93 ^e	10.45 ^d	11.97 ^c	13.96 ^b	16.53 ^a
Magnesium	30.96 ^e	32.53 ^d	34.81 ^c	36.04 ^b	38.95 ^a
Phosphorus	0.24 ^e	0.46 ^d	0.52 ^c	0.54 ^b	0.97 ^a
Potassium	6.93 ^e	10.78 ^d	12.83 ^c	13.67 ^b	16.98 ^a
Sodium	5.93 ^a	5.83 ^a	5.81 ^a	5.31 ^b	5.03 ^c
Iron	6.82 ^a	6.28 ^b	5.87 ^c	5.74 ^d	5.18 ^e
Zinc	1.98 ^a	2.02 ^a	2.12 ^a	2.15 ^a	2.32 ^a

Values are means of duplicate samples; a-e means with similar superscripts in the same row are not significantly different from each other

Key: Sample A – 100% millet, Sample B – 80% millet: 20% pigeon pea, Sample C – 70% millet:30% pigeon pea, Sample D – 60% millet:40% pigeon pea, Sample E – 50% millet:50% pigeon pea

Vitamin composition of complementary foods made from millet and pigeon pea flour blends on a dry weight basis (mg/100g)

The vitamin composition of the complementary foods revealed significant differences among the products. Thiamine content was highest in sample E (50% millet: 50% pigeon pea) at 0.42mg/100g, significantly higher than the other products (0.12-

0.28mg/100g). Riboflavin content was significantly higher in samples D and E (0.07 and 0.08mg/100g, respectively) compared to the other samples (0.03-0.05mg/100g). In contrast, vitamin C content was significantly lower in the pigeon pea-supplemented foods (6.22-8.43mg/100g) compared to the 100% millet complementary food (10.09 mg/100g).

Table 3: Vitamin composition of complementary foods made from millet and pigeon pea flour blends on a dry weight basis (mg/100g)

Nutrient	Sample A	Sample B	Sample C	Sample D	Sample E	RDI FOR INFANTS
Thiamin	0.12 ^d	0.21 ^c	0.24 ^c	0.28 ^b	0.42 ^a	0.30
Riboflavin	0.03 ^b	0.04 ^b	0.05 ^{ab}	0.07 ^a	0.08 ^a	0.50
Vitamin C	10.09 ^a	8.43 ^b	7.53 ^c	6.75 ^d	6.22 ^e	50.0

Values are means of duplicate samples; a-e means with similar superscripts in the same row are not significantly different from each other

Key: Sample A – 100% millet, Sample B – 80% millet: 20% pigeon pea, Sample C – 70% millet:30% pigeon pea, Sample D – 60% millet:40% pigeon pea, Sample E – 50% millet:50% pigeon pea,

Phytochemical composition of complementary foods made from millet and pigeon pea flour blends on a dry weight basis (mg/100g)

Tannin and alkaloid contents (0.53mg/100g and 1.01mg/100g) of complementary food produced from 100% millet were significantly higher than tannin and alkaloid values (0.23 – 0.41mg/100g and 0.58 - 0.75mg/100g) obtained from pigeon pea-supplemented products. The same

observations were made for flavonoids and oxalate, where flavonoids and oxalate values (1.04mg/100g and 0.57mg/100g) obtained for sample A were significantly higher than the values of flavonoids and oxalate found in pigeon pea supplemented products. The phenol contents (0.23 – 0.32mg/100g) of pigeon pea supplemented products were, however, significantly higher than the value obtained for sample A.

Table 4: Phytochemical composition of complementary foods made from millet and pigeon pea flour blends on a dry weight basis (mg/100g)

Phytochemical	Sample A	Sample B	Sample C	Sample D	Sample E	Safe level
Tannin	0.53 ^a	0.41 ^b	0.32 ^c	0.27 ^d	0.23 ^e	* <1500mg
Alkaloids	1.01 ^a	0.75 ^b	0.62 ^c	0.58 ^d	0.51 ^e	*20mg
Flavonoids	1.04 ^a	0.83 ^b	0.72 ^c	0.62 ^d	0.51 ^e	NE
Phenols	0.11 ^d	0.23 ^c	0.27 ^b	0.31 ^a	0.32 ^a	NE
Oxalate	0.57 ^a	0.52 ^b	0.43 ^c	0.22 ^d	0.15 ^e	*2.20mg

Values are means of duplicate samples; a-e means with similar superscripts in the same row are not significantly different from each other. NE- Not Established

Sources of safe levels: * Ene-obong (20)

Key: Sample A – 100% millet, Sample B – 80% millet: 20% pigeon pea, Sample C – 70% millet:30% pigeon pea, Sample D – 60% millet:40% pigeon pea, Sample E – 50% millet:50% pigeon pea

Sensory attributes of complementary foods made from millet and pigeon pea flour blends

The scores for colour ranged between 4.15 – 5.85. Sample A (100% millet) was the most acceptable in terms of colour (5.85), followed by sample B (80% millet: 20% pigeon pea). Sample E (50% millet: 50% pigeon pea) was the least

accepted (4.15) in terms of colour. The texture of sample B (4.95) was comparable to that of the control (100% millet) (5.15). The scores for taste ranged between 4.10 – 5.25. The product made from 100% millet had the highest (5.25) score for taste, followed by the product made from %50 millet: 50% pigeon pea, which had a 4.25 taste score.

Table 5: Sensory attributes of complementary foods made from millet and pigeon pea flour blends

Sample	Colour	Texture	Taste	General acceptability
Sample A	5.85 ^a ± 0.57	5.15 ^a ± 0.97	5.25 ^a ± 0.94	5.50 ^a ± 1.75
Sample B	5.55 ^b ± 1.50	4.95 ^a ± 1.18	4.09 ^c ± 1.24	4.86 ^b ± 1.41
Sample C	4.60 ^c ± 1.19	4.65 ^b ± 0.93	4.10 ^c ± 0.91	4.45 ^c ± 1.31
Sample D	4.45 ^d ± 1.43	4.65 ^b ± 0.94	4.15 ^c ± 1.03	4.42 ^{cd} ± 1.34
Sample E	4.15 ^e ± 0.49	4.50 ^c ± 0.96	4.25 ^b ± 1.16	4.30 ^d ± 0.99

Values are means of duplicate samples; a-e means with similar superscripts in the same column are not significantly different from each other

Key: Sample A – 100% millet, Sample B – 80% millet: 20% pigeon pea, Sample C – 70% millet: 30% pigeon pea, Sample D – 60% millet: 40% pigeon pea, Sample E – 50% millet: 50% pigeon pea S

DISCUSSION

Moisture was low in all the samples, and the low moisture value obtained in the samples was expected because the samples were analysed on a dry weight basis. Studies have shown that pigeon pea flour has a higher water absorption capacity than millet flour (21). It was, however, noted that the moisture content of the 100% millet

product was significantly higher than the supplemented products. This observation could be attributable to the effect of processing. When compared with a similar work, the moisture composition of the supplemented products in this study was higher than 8.60 – 9.71% reported for complementary foods made from sorghum, pigeon pea, and soybean flour blends (22). The difference in moisture content could be attributed

to the difference in processing methods. Notable nutrients that increased with an increase in pigeon pea supplementation were protein and fat. Protein increased by 21.6 – 44.3% and fat value increased by 5.6 -18.06%. Though the protein quality test was not carried out on the products, the protein values of the supplemented products fell within values recommended for infants (23). A sufficient amount of fat in the diet during the complementary feeding period is needed for the provision of sufficient energy density of the diet (24). It is impressive to note that consumption of a hundred grams of the supplemented products in this work can supply infants with about 72 – 84% of their daily fat needs. The carbohydrate value obtained in the product with 100% millet was significantly higher than the carbohydrate value obtained from the other products. Higher carbohydrate content found in 100% millet product could be attributable to the fact that millet is a richer source of carbohydrate than pigeon pea (25). Recommended energy for infants ranged between 202 - 307 kcal (1), with at least 20% of the energy coming from a fat source (24). It is worth noting that the fat obtained in this study can contribute about 15 – 21% of the total energy obtained. Significant increase in fibre was only observed at a 40-50% increment in pigeon pea supplementation. Though fibre is said to have a positive impact on the gastrointestinal and metabolic system of man (26) by preventing constipation and chronic digestive disorder (27), a high load of fiber in the diet may negatively affect the efficiency of the absorption of important nutrients from diets with marginal nutrient contents. Energy is an index of protein, fat, and carbohydrate content of food; this could account for the high value of energy obtained in the products. The values of energy obtained were, however, comparable with values (346.9 – 357.7kcal/100g) (28) in a similar study. Similarity in values of the two studies could be because the products were both analysed on a dry weight basis.

Most of the minerals analysed (except for iron and zinc) increased with an increase in pigeon pea supplementation. Calcium obtained in this study was higher than the value (2.0 – 6.05mg/100g) reported for complementary food formulated from millet, pigeon pea, and seedless breadfruit (29). The difference in calcium content could be attributable to the differences in blend formulation. Other minerals obtained in significant amounts with an increase in supplementation include phosphorus and

potassium. An increase in these nutrients will be beneficial to those will consume these products, as minerals are important components of nutrients needed in the body.

Vitamins are essential nutrients needed in small amounts for the proper regulation and function of the body. The products developed were poor sources of riboflavin and vitamin C but good sources of thiamine. Values of riboflavin and vitamin C obtained in the supplemented products could supply 10-20% and 20.7 -28% respectively, of the RDI needs of children 7 – 12 months, while the thiamine obtained will supply about 70 – 140 of % thiamine RDI needs of the same age group. Thiamine in these products may be high; consumption of this vitamin beyond daily need may not have any adverse effect, as the nutrient can be readily excreted via the kidneys.

Phytochemicals are plant chemicals that have either health benefits or anti-activities in humans. Most of the phytochemicals analysed, except for phenol nutrient appeared to reduce with the increase of the supplement. The result also showed that tannin, alkaloids, and oxalate contents of the products fell below the permissible limit, and this implies that the products are safe for consumption. Low values of phytochemicals found in this study could be due to the effect of processing. The products have an appreciable level of flavonoids and phenols. Phytochemicals such as flavonoids and phenols are associated with health benefits.

Results from the evaluation of the sensory attributes showed that the value of the acceptability of the texture of sample B (80% millet: 20% pigeon pea) compared favourably with that of sample A (100% millet). This acceptance could be because the amount of millet in that product must have masked the texture of its pigeon pea content, thereby making it acceptable to the panelists. The colour and taste of the 100% millet product were more acceptable than those of the supplemented products, which could be attributed to the fact that the panelists may be more familiar with products made from 100% millet.

CONCLUSION

The study showed that key nutrients such as protein, fat, calcium, and zinc increased with an increase in pigeon pea supplementation. All the phytochemicals, with the exception of phenol, decreased with the increase of pigeon pea supplementation. The sensory evaluation test

showed that the product produced with 100% millet was more acceptable.

AUTHOR'S CONTRIBUTION

1. Dr. Helen Ochanya Okudu developed the concept and design of the study.
2. Dr. Kuyik, S. A., and Dr. Adeoye-Agomoh, Q.C. drafted the article.
3. Virginia Uchenna Okolie and Ojinnaka, Monica C, revised the work critically for important intellectual content.
4. The statistical analysis was done by Dr. Kuyik, S.A.

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