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EFFECT OF COOKING METHODS ON TIME AND NUTRIENT RETENTION OF PIGEON PEA (*CAJANUS CAJAN*)

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ABSTRACT

Protein malnutrition is widespread among the rural poor in developing countries and legumes serve as a major source of dietary protein where animal protein is very expensive. Pigeon pea is an important legume with high amount of protein, but its consumption is limited due to its hardness and time-consuming process of cooking. This study was carried out to determine effect of cooking methods on time and nutrient retention of pigeon pea as a means of promoting dietary diversity. Pigeon pea seeds were purchased from *Oja Oba* market in Ado-Ekiti, Ekiti State, Nigeria, cleaned, sorted, and divided into five portions. One portion was labelled as raw sample. The second portion was washed and cooked with distilled water on an electric cooker at 300ºC for 2 hours and labelled as Sample 2. The third portion was washed and cooked at 300^0C for two hours, with decanting and replenishing the water, and labelled as sample 3. The fourth portion was washed and pressure-cooked with distilled water at 300ºC for 1hour and labelled as Sample 4; while the fifth portion was pressure-cooked at 300ºC for 45 minutes, decanting and replenishing the water, cooked for 15 minutes, then labelled as sample 5. The five samples were analysed in triplicates for proximate, minerals and selected vitamins composition using standard methods of AOAC. Raw pigeon pea contained 11.9g moisture, 22.1g crude protein, 3.4g fat, 3.4g ash, 59.0g carbohydrates, 47.76mg sodium, 1025.63mg potassium, 100.25mg calcium, 377.87mg phosphorus, 13.01mg iron, 11.95mg zinc, and yielded 315.8kcal energy/100g sample. Boiling, and decanting the boiling water, and pressure cooking led to significant reduction in all macronutrients ($p<0.05$), the reduction being most pronounced in samples with cooking water decanted. Pressure-cooked samples retained more macronutrients with highest retention recorded in pressure-cooked sample without decanting the water ($p<0.05$). Boiling without decanting the water had highest retention of minerals, followed by pressure-cooked sample without decanting the water, while boiled sample with decanted water retained least minerals. Pressure cooking the pigeon pea significantly reduced cooking time ($p<0.05$), thereby reducing cost of electricity. Pigeon pea is a good source of protein, energy, potassium, calcium, phosphorus, iron and zinc, and can contribute significantly to meeting nutrient needs of consumers; hence, its consumption should be encouraged as a means of dietary diversity among the populace where it is available.

Key words: Protein malnutrition, Pigeon pea, Cooking methods, Nutrient retention, Micronutrient potential

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INTRODUCTION

Protein malnutrition is widespread among the poor in developing countries [1] due to lack of sufficient animal proteins, hence the search for alternative sources of protein from lesser-known legumes in lieu of expensive and scarce animal protein [2]. Legumes represent a major source of energy and nutrients, including protein; particularly in vegetarians' diet [3]. The special contribution of food legumes to human diet lies in the quantity and quality of their protein content.

Among many species of legumes in the plant kingdom, only very few are consumed as food. African yam bean (*Sphenostylis stenocarpa* Hochst ex A Rich), Lima bean (*Phaseolus lunatus*), Bambara groundnut (*Vigna subterranean*), Sword bean (*Canavalia gladiata*), Jack bean (*Canavalia ensiformis*), Pigeon pea (*Cajanus cajan*), and Lablab (*Lablab purpureus*) are under-utilized legumes that possess high crude protein content between 22 and 37% ([4, 5]. The low consumption or underutilization of some of these legumes are likely due to hard-to-cook characteristic of the legumes, lack of information regarding their nutritive values, presence of anti-nutrients, taboos and cultural beliefs, and low production [6].

Pigeon pea (*Cajanus cajan*) is an important food legume that its cultivation has been reported in more than seven countries including Nigeria [7, 8], and is a useful fallow and fodder plant with edible seeds doing best on medium good soils [9]. It is still under-utilized as food in Nigeria due to its tough texture, long cooking duration and lack of education on its nutritional potentials [8, 10, 11]. Women cook it using firewood overnight for about 8 - 12 hours. This consequently leads to high loss of nutrients [12]. The seed, apart from being hard to cook is hard to dehull, thus the drudgery process of dehulling the seed is also limiting its utilization into other form of products [13].

Figure 1: Pigeon Pea Seeds

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In spite of the fact that chemical composition of pigeon pea has been investigated, little or no information exists in the literature on the effect of cooking methods on its nutrient retention. Adepoju *et al*. [14] reported reduction in micronutrient content of products from cassava due to processing methods. This study was therefore carried out to determine the effect of cooking methods on nutrient retention and micronutrient potential of pigeon pea.

MATERIALS AND METHODS

Sample Collection and Preparation

Pigeon pea seeds were purchased from two stalls at *Oja Oba* market in Ado-Ekiti, Ekiti State, Nigeria and thoroughly mixed to obtain composite sample. *Oja Oba* market is a major market where farm produce from different parts of the state are brought for sale, hence the samples bought were believed to be representative of pigeon pea seeds from the State and its environ. The seeds were sorted manually to remove the bad ones, stones, damaged and immature seed, and divided into five portions of 150 g each. The first portion was ground in a blender and labelled as raw sample (Sample 1) and part of it was used in determining the moisture content, while the rest was oven dried at 60^0C for 18 hours and then stored in a plastic container at room temperature until when needed for analysis.

One hundred and fifty grammes (150 g) of each of the remaining four portions was washed with distilled water. The first washed portion was cooked in 750 ml of distilled water on an electric cooker (Stuart SB160) set at 300ºC for 2 hours to give undecanted sample which was labelled as Sample 2. Another 150 g of the washed portion was cooked using 500ml of distilled water on an electric cooker at 300ºC for 2 hours, with the cooking water decanted at the end of 90 minutes before the seed got softened, and another 250ml of distilled water added to complete the cooking. This was labelled as Sample 3.

Another 150 g of the washed portion was pressure-cooked using 750 ml of distilled water at 300ºC for 1hour and labelled as Sample 4. The last 150 g washed portion was also pressure-cooked at 300ºC for 45 minutes using 500ml distilled water, decanted, and then 250ml of distilled water added and cooked for 15 minutes and labelled as Sample 5. Four samples (samples 2 – 5) were cooked within the stated times till they became tender [15], mashed and oven dried at 60ºC overnight (18 hours) after determining their moisture content. The oven-dried samples were ground using a warring blender and stored in plastic containers at room temperature for chemical analysis.

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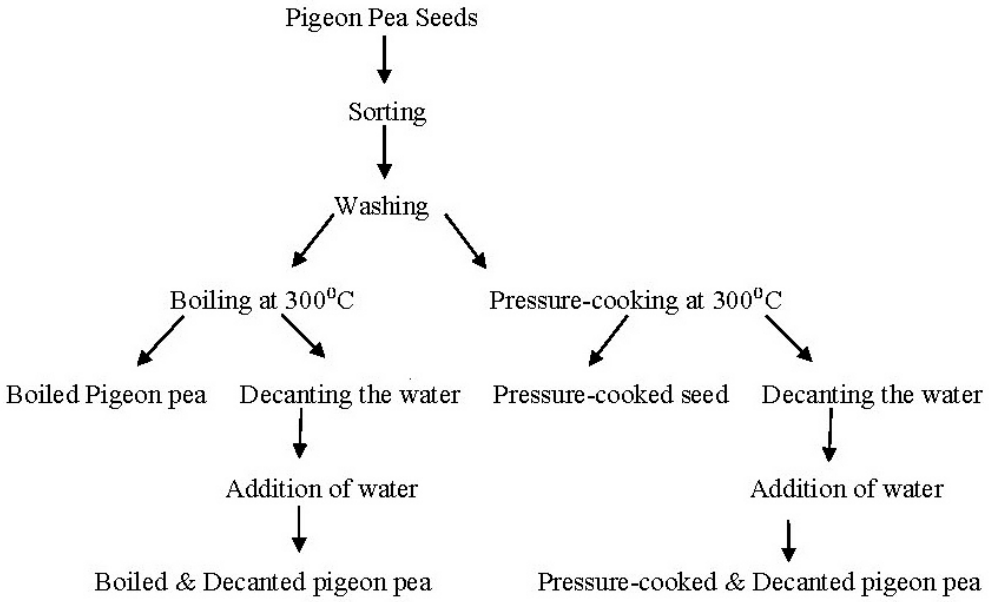

Figure 2: Flow chart for preparation of the pigeon pea product samples

Figure 3: Raw Pigeon pea (Sample 1)

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Figure 4: Cooked undecanted Pigeon pea (Sample 2)

Figure 5: Cooked and decanted Pigeon pea (Sample 3)

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Figure 6: Pressure-cooked undecanted Pigeon pea (Sample 4)

Figure 7: Pressure-cooked and decanted Pigeon pea (Sample 5)

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Chemical Analyses

Proximate Composition

Moisture content of the samples was determined by air oven at 105^0C (Plus 11 Sanyo Gallenkamp PLC UK) for 4 hours. The crude protein of the samples was determined using micro-Kjeldahl method [16] and amount of crude protein calculated using the conversion factor of 6.25. Crude lipid was determined by weighing 5 g of dried sample into fat free extraction thimble and plugging lightly with cotton wool. The thimble was placed in the Soxhlet extractor fitted up with reflux condenser [16]. The dried sample was extracted with petroleum ether and the crude lipid estimated as g/100g dry weight of sample, and then converted to g/100g fresh sample weight. The ash content was determined by weighing 5g of sample and heated in a muffle furnace (Gallenkamp, size 3) at 550^0C for 4 hours [16], and ash calculated as g/100g original sample. Total carbohydrate content was obtained by difference. Gross energy content of the samples was determined using ballistic bomb calorimeter (Cal 2k – Eco, TUV Rheinland Quality Services (Pty) Ltd, South Africa).

Mineral Analysis

Potassium and sodium content of the samples were determined by digesting the ash of the samples with Perchloric acid and nitric acid, and then taking the readings on Jenway digital flame photometer/spectronic20 [16]. Phosphorus was determined by vanado-molybdate colorimetric method [16]. Calcium, magnesium, iron zinc, manganese and copper were determined spectrophotometrically by using Buck 200 atomic absorption spectrophotometer (Buck Scientific, Norwalk) and absorption of the sample mineral compared with absorption of standards of these minerals [16].

β-Carotene Determination

The β-carotene content of the samples was determined through ultraviolet absorption measurement at 328 nm after extraction with chloroform. Calibration curve of β-carotene standard solutions was made and the sample β-carotene concentration estimated as microgram (µg) of β-carotene/100g sample [16].

Thiamine (Vitamin B_1) Determination

Thiamine content of the samples (raw and cooked) was determined by weighing 1g of each sample into 100ml volumetric flask and adding 50ml of 0.1M H_2SO_4 and boiled in a boiling water bath with frequent shaking for 30 minutes. Five millilitre of 2.5M sodium acetate solution was added and flask set in cold water to cool contents below 50^0C. The flask was stoppered and kept at 45-50^0C for 2 hours and thereafter made up to 100 ml mark. The mixture was filtered through a No. 42 Whatman filter paper, discarding the first 10ml. Ten (10 ml) was pipetted from remaining filtrate into a 50ml volumetric flask and 5ml of acid potassium chloride solution was added with thorough shaking. Standard thiamine solutions were prepared and treated same way. The absorbance of the sample as well as that of the standards was read on a fluorescent UV Spectrophotometer (Cecil A20 Model) at a wavelength of 285nm.

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Riboflavin (Vitamin B_2) Determination
One gramme (1g) of each sample (raw and cooked) was weighed into a 250ml volumetric flask, 5ml of 1M HCl was added, followed by the addition of 5ml of dichloroethene. The mixture was shaken and 90 ml of de-ionized water was added. The whole mixture was thoroughly shaken and was heated on a steam bath for 30 minutes to extract all the riboflavin. The mixture was then cooled and made up to volume with de-ionized water. It was then filtered, discarding the first 20ml of the aliquot, and 2ml of the filterate obtained was pipetted into another 250ml volumetric flask and made up to mark with de-ionized water. Sample absorption was read on the fluorescent spectrophotometer at a wavelength of 460nm. Standard solutions of riboflavin were prepared and readings taken at 460nm, and the sample riboflavin obtained through calculation.

Niacin (Vitamin B_3) determination
5g of sample was extracted with 100ml of distilled water and 5ml of this solution was drawn into 100ml volumetric flask and make up to mark with distilled water. Standard solutions of niacin were prepared and absorbance of sample and standard solutions were measured at a wavelength of 385nm on a spectrophotometer and niacin concentration of the sample estimated.

Ascorbic Acid Determination
Ascorbic acid in the sample was determined by titrating its aqueous extract with solution of 2, 6-dichlorophenol-indophenol dye to a faint pink end point [16].

Apparent Nutrient Retention of Cooked foods
The % apparent retention (AR) of nutrients was calculated by the formula of Murphy *et al*. [17]:

$$\% \text{ AR} = \frac{\text{Nutrient content per g of cooked food on dry basis}}{\text{Nutrient content per g of raw food on dry basis}} \times 100$$

All determinations were carried out in triplicate and data obtained interpreted statistically using Analysis of Variance (ANOVA) and Post Hoc Test at $p<0.05$.

RESULTS AND DISCUSSION

Proximate Composition
The results of proximate composition of raw and cooked pigeon pea are shown in Table 1. The moisture content of the raw sample was low (11.9±0.31 g/100g), while that of cooked samples were very high ($p<0.05$), with sample 3 (boiled decanted sample) having the highest value, followed by sample 5 (pressure-cooked decanted sample), and the pressure cooked undecanted sample (Sample 4) had the lowest value. There were significant differences ($p<0.05$) between the moisture content of the cooked samples.

The raw sample was high in crude protein content, while highly significant reduction ($p<0.05$) was recorded in protein content of the cooked samples when compared with the raw one. Pressure-cooked undecanted sample (sample 4) had the highest value of crude protein while the boiled and decanted sample (sample 3) had the lowest. There was also

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a significant difference in protein content of sample 4 and the rest of cooked samples ($p<0.05$), while there was no significant difference in its value for samples 2 and 5, which were significantly higher than that of sample 3.

Raw pigeon pea sample was very low crude lipid, and the cooked samples still recorded further significant reduction in value ($p<0.05$). The cooked decanted sample had the lowest crude lipid value while the pressure-cooked undecanted sample had the highest value. A significant reduction in lipid content was observed in the cooked samples ($p<0.05$). The ash content of raw and cooked samples differed significantly ($p<0.05$). There was no significant difference in ash values for samples 2, 3, and 4, while sample 5 had the lowest ash content which was significantly lower than the rest ($p<0.05$).

The raw sample was high in total carbohydrate content compared to the rest of the nutrients. There was a highly significant reduction in its value in the cooked samples ($p<0.05$). There were significant differences in carbohydrate content of the cooked samples ($p<0.05$), the pressure-cooked undecanted sample (Sample 4) having the highest value while the boiled and decanted sample (Sample 3) had the lowest value. There was no significant difference (($p>0.05$) between the boiled and decanted sample (Sample 2) and the pressure-cooked and decanted sample (Sample 5).

The gross energy content of the raw sample was high, while the cooked samples were significantly lower ($p<0.05$). The pressure-cooked and decanted sample had the highest value and the boiled undecanted sample having lowest value among the cooked samples. The value obtained for the moisture content of the raw sample was well within the range reported by Amarteifio *et al.* [18], while Abdel *et al*. [19] reported a lower value of 8%. The observed variation in the moisture content could be attributed to the degree of dryness and length of storage of the pea, as stored products do lose moisture during storage. The moisture content of the cooked samples was higher than that of raw sample due to absorption of water during cooking which had a dilution effect on all other nutrients [20].

The crude protein value of the raw sample was within the range reported in the literature [21, 22, 23], higher than the 21.0% reported by Abdel [19], and lower than the 27.15% reported by Onu and Okongwu [24]. The disparity observed might be due to varietal differences or geographic variation. The protein content of pigeon pea is slightly higher than that of commonly consumed beans (*Vigna unguiculata* and *Vigna angustifoliata*) reported by Bamigboye and Adepoju [25]. Its protein value qualifies it as a good source of plant protein which can contribute to meeting the daily protein dietary requirements of consumers.

Cooking resulted in significant reduction in the protein content of the products of pigeon pea. This finding is in agreement with that reported in the literature [4, 24], that reported a decrease in crude protein content of pigeon pea seeds with boiling. The reduction in crude protein value of pigeon pea could be associated with increase in moisture content of the samples, and leaching of soluble protein part of the seeds into the boiling water. This is supported by the lower protein values recorded for samples 3 and 5, in which the cooking water was decanted and replaced with fresh ones.

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The crude lipid value of the raw sample was similar to the one in the literature [3], but higher than the one reported for *Vigna unguiculata* and *Vigna angustifoliata* [25]. The significant reduction in crude lipid content observed in the cooked samples was believed to be due to increase in moisture content of the samples, as well as decantation of the cooking water. The ash content of the raw pigeon pea was in agreement with that of Abdel *et al*. [19], but lower than the range reported by Amarteifio *et al*. [18]. The substantial reduction in ash content of boiled samples was believed to be due to increase in the moisture content of the samples, as well as leaching of both micro and macro minerals into the decanted water.

The total carbohydrate content of the raw sample in this study was in agreement with the values reported by Adeparusi [26], but slightly lower than 61.40% reported by Abdel *et al*. [19] and Amaefule and Obioha [11]. However, the cooked samples had a significantly lower content of total carbohydrates than the raw form. The significant reduction in carbohydrate value in cooked samples was believed to be due to the increase in moisture content of the cooked samples.

The gross energy value obtained for raw pigeon pea in this study is within the range reported by Adebowale and Malik [2], but significantly lower than the value (369.38 kcal/100g) reported by Arawande and Borokini [27]. Various cooking methods increased the gross energy content of pigeon pea.

Mineral Composition

Pigeon pea was very high in potassium, phosphorus, iron and zinc, high in calcium, manganese and copper, but low in sodium and magnesium (Table 2). There were highly significant reductions in all mineral contents of the cooked pea samples compared to the raw ($p<0.05$), the reductions being more pronounced in the samples where the cooking water was decanted. The cooked undecanted sample (sample 2) retained more potassium, sodium, phosphorus, iron, zinc manganese and copper, while pressure-cooked undecanted sample (sample 4) retained more magnesium.

The value obtained for sodium content in raw sample (sample 1, Table 2) is in line with the finding of Bamigboye and Adepoju [25], which revealed that pulses are generally low in sodium content. The low sodium content of pigeon pea is an advantage for its suitability for consumption by all. The high potassium content of the pea can be beneficial to patients who take diuretics to control hypertension and those who suffer from excessive excretion of potassium through body fluids. The daily potassium requirement for the adults is 2,000mg [28], and 100 g portion of raw pigeon pea can supply half of this daily requirement.

The calcium content of the raw sample was higher than the values recorded for *Vigna unguiculata* and *Vigna angustifoliata* [25], which are commonly consumed in Nigeria. The magnesium content of the raw sample was in agreement with the range reported by Meiner *et al*. [29]. The iron, zinc, copper, and manganese content also were in agreement with that of Nwokolo [30] who reported these minerals in pigeon pea meal. However,

the values of these minerals were higher than that of *Vigna unguiculata* and *Vigna angustifoliata* [25].

The different processing methods such as boiling, boiling and decanting, pressure-cooking, pressure-cooking and decanting significantly reduced the mineral content of cooked samples (samples 2 – 5). This observation is in line with the assertion of Meiner *et al*. [29] who stated that the mineral content in cooked legumes was about one-third to one-half of the values in raw legumes.

Selected Vitamins Composition

The legume was low in β-carotene, thiamine, riboflavin, niacin and ascorbic acid (Table 3). Various cooking methods significantly increased the vitamin content of the samples, the decanted samples being higher in value ($p<0.05$). Pressure-cooked decanted sample (sample 5) had highest retention value for the cooked products.

The result of the thiamine, riboflavin, and niacin content of the raw sample (Table 3) was in close agreement with the values reported by Faris *et al*. [31]. However, the beta carotene and the ascorbic acid content of the raw sample in this study were different from the values reported by Faris *et al*. [31]. The observed variation in values may likely be due to yearly and geographic variation. However, cooking generally enhanced the vitamin content of the cooked samples significantly ($p<0.05$), the decanted samples (Samples 3 and 5) being significantly higher than the undecanted samples (samples 2 and 4). Pressure cooked samples were significantly higher in vitamins than the cooked samples. No possible explanation can be given for the trend being observed in the vitamin content of the cooked samples. The higher nutrient value of all the cooked samples above the raw is an indication that application of heat on pigeon pea releases more nutrients from their bound state to make them more readily available.

Nutrient Retention

Cooked undecanted sample (sample 2) retained more minerals than the rest of the samples (Table 4), cooked decanted sample (sample 3) retained more carbohydrates, ash, β-carotene and calcium, pressure-cooked undecanted sample (sample 4) retained more riboflavin, while pressure-cooked decanted sample (sample 5) retained more lipid, thiamine and niacin.

There was no specific pattern of nutrient retention among the various cooking methods used (Table 4). However, pressure-cooked undecanted sample (sample 40 retained more macronutrients, signifying a better method of cooking and retaining more nutrients in the cooked pea. All the cooking methods retained more than two-third of all nutrients studied. Boiled sample without discarding the cooking water retained highest amount of minerals, followed by pressure-cooking without decanting the water. This was expected, as decanting will lead to loss of soluble minerals in the decanted water [14]. The result of this study is at variance with the report of Murphy *et al.* [17] who compared the apparent and true retention of nutrients in different cooked foods, including legumes and found the highest retention for crude fibre and lowest retention for ash. Decanting seems to enhance the values of the water-soluble vitamins in the samples. Possible explanation for this may be due to the removal of masking effect of some components of the pigeon

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pea which are removed by decanting, thereby allowing fresh water to penetrate and facilitate the release of the vitamins. Beta carotene was retained most in all the samples, while the lowest retention was observed in riboflavin in all the samples.

CONCLUSION

Pigeon pea is rich in potassium, calcium, phosphorus, iron, zinc, manganese and copper, and could be a good source of these minerals. Boiling, boiling and decanting led to significant nutrient loss in the cooked samples compared to the raw samples. However, cooking without decanting the cooking water retained more nutrients for both boiled and pressure-cooked samples. The use of pressure cooker in cooking pigeon pea can reduce the problem associated with time and energy consumption in its of cooking. Consumption of this variety of pulses should be encouraged to promote dietary diversity and ensure adequate dietary intake, as well as contribute substantially to good health and well-being of consumers in the areas where this type of pulse exists.

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Table 1: Proximate composition of raw and cooked pigeon pea (g/100g)

Parameter	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Moisture	11.9±0.311^{a}	61.9±0.15^{b}	65.7±0.19^{c}	60.0±0.26^{d}	63.6±0.26^{e}
Crude Protein	23.1±0.14^{a}	9.1±0.06^{b}	7.9±0.08^{c}	10.1±0.05^{d}	8.8±0.11^{b}
Crude Lipid	3.4±0.02^{a}	1.4±0.01^{b}	1.3±0.02^{c}	1.6±0.02^{d}	1.5±0.02^{e}
Ash	1.7±0.02^{a}	0.7±0.02^{b}	0.7±0.01^{b}	0.7±0.02^{b}	0.6±0.01^{c}
*Total carbohydrates	59.9±0.16^{a}	27.0±0.12^{b}	24.4±0.10^{c}	27.6±0.19^{d}	25.1±0.14^{c}
Gross Energy (kcal/)	315.0±0.60^{a}	318.5±0.31^{b}	320.3±0.16^{b}	321.1±0.25^{b}	326.4±0.30^{c}

Values with the same superscript on the same row are not significantly different while values with different superscripts are significantly different
*Total carbohydrates = Available carbohydrates + fibre

Sample 1 = Raw pigeon pea, Sample 2 = Boiled undecanted pigeon pea, Sample 3 = Boiled and decanted pigeon pea, Sample 4 = Pressure cooked undecanted pigeon pea, and Sample 5 = Pressure cooked and decanted pigeon pea.

Table 2: Mineral composition of raw and cooked pigeon pea (mg/100g)

Parameter	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Sodium	47.76±0.37^{a}	18.52±0.34^{b}	14.52±0.24^{c}	15.93±0.21^{d}	11.67±0.27^{c}
Potassium	1025.63±3.18^{a}	449.12±3.83^{b}	381.98±1.39^{c}	433.81±3.97^{d}	393.90±3.41^{c}
Calcium	100.25±0.34^{a}	46.35±0.33^{b}	43.41±0.26^{c}	46.29±0.50^{b}	44.16±0.37^{d}
Magnesium	84.31±0.32^{a}	39.66±0.67^{b}	35.05±0.21^{c}	40.62±0.38^{b}	37.36±0.22^{d}
Phosphorus	377.87±3.39^{a}	161.77±0.59^{b}	143.06±1.79^{c}	151.67±2.51^{d}	132.86±2.34^{c}
Iron	13.01±0.20^{a}	5.37±0.12^{b}	3.91±0.12^{c}	4.21±0.15^{d}	3.27±0.65^{c}
Zinc	11.95±0.35^{a}	4.99±0.08^{b}	3.62±0.04^{c}	3.89±0.09^{d}	3.37±0.09^{c}
Manganese	7.01±0.18^{a}	2.84±0.08^{b}	2.34±0.07^{c}	2.45±.04^{d}	1.96±0.12^{c}
Copper	3.31±0.13^{a}	1.23±0.16^{b}	0.85±0.07^{c}	0.84±0.07^{c}	0.66±0.08^{d}

Values with the same superscript on the same row are not significantly different while values with different superscripts are significantly different

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Table 3: Vitamin composition of raw and processed pigeon pea (mg/100g)

Parameter	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
β-carotene (µg/)	23.31±0.04[a]	28.92±0.05[b]	27.66±2.85[c]	26.91±0.04[d]	31.25±0.03[c]
Thiamine	0.25±0.02[a]	0.32±0.01[b]	0.36±0.02[c]	0.4±0.03[d]	0.54±0.02[c]
Riboflavin	0.09±0.02[a]	0.07±0.03[b]	0.16±0.03[c]	0.14±0.03[d]	0.24±0.02[c]
Niacin	2.30±0.20[a]	2.77±0.31[b]	3.13±0.25[c]	3.33±0.25[d]	3.87±0.25[c]
Ascorbic acid	1.71±0.03[a]	1.89±0.03[b]	2.06±0.02[c]	2.13±0.02[d]	2.63±0.03[c]

Values with the same superscript on the same row are not significantly different while values with different superscripts are significantly different

Table 4: Percent nutrient retention by different cooking methods

Parameter	Sample 2	Sample 3	Sample 4	Sample 5
Crude protein	81.40	77.32	89.57	87.75
Crude lipid	95.39	93.77	103.25	105.15
Carbohydrate	102.52	103.79	100.86	100.23
Ash	107.67	111.25	98.21	96.93
β-carotene	74.59	92.50	88.51	86.11
Thiamine	46.30	59.26	66.67	74.07
Riboflavin	37.50	29.17	66.67	58.33
Niacin	59.43	71.58	80.88	86.05
Ascorbic acid	65.02	71.86	78.33	80.99
Sodium	85.77	74.42	71.43	57.33
Potassium	96.87	91.19	90.57	90.12
Calcium	102.27	106.02	98.67	103.36
Magnesium	105.21	101.79	103.16	103.99
Phosphorus	94.70	92.70	85.96	82.51
Iron	91.40	73.63	69.23	59.65
Zinc	89.83	72.23	68.08	64.59
Manganese	89.61	81.81	74.94	65.84
Copper	82.64	63.36	54.27	46.83

Sample 2 = Cooked undecanted water, Sample 3 = Cooked and decanted water, Sample 4 = Pressure-cooked undecanted water, Sample 5 = Pressure cooked and decanted water

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