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Effects of Malting on Nutritional Characteristics of Pigeon Pea (*Cajanus cajan*)

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Authors' contributions

This work was carried out in collaboration between both authors. Author NNU designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author AIA managed the analyses of the study. Author NNU managed the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

Background/Objective: Malting is a process that is not expensive and is technologically effective in improving the nutritional quality of food. The objective of this study was to determine the effect of malting on the nutritional characteristics of pigeon pea *(Cajanus cajan*).
Materials and Methods: The pigeon pea seeds were sorted and washed. The seeds were then steeped in water at 29°C for 24 hours. Changing of water at 6 hours interval was observed during steeping. The resultant steeped seeds were spread on jute bag and were covered with white cotton cloth to germinate for 72 hours. The sprouted seeds were oven dried at a temperature of 50°C for 1 hour and thereafter, the plumules were separated from the seed and the malted seeds were dried and milled into flour. Both the raw and malted samples were subjected to laboratory analysis for proximate, mineral element composition, anti-nutrients and functional properties. The results were determined in triplicate and subjected to statistical analysis using SPSS version 20.

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Results: The result of the proximate analysis showed that the samples were generally low in moisture which are 12.81±0.07 and 15.10±0.81%, protein content are 19.01±0.08 and 22.10±0.16%, Ash content are 2.27±0.23 and 3.18±0.47%, Fat content are 1.02±0.32 and 1.68±0.81%, fibre content are 0.45±0.52 and 1.23±0.63%, carbohydrate are 57.37±0.28 and 63.78±0.01% and energy were 300.32 and 326.20 Kcal/100 g for raw and malted sample respectively. The result of minerals are iron 0.13±0.12 and 1.03±0.08 mg/100 g, magnesium 50.30±0.01 and 68.24±0.45 mg/100 g, zinc 0.27±0.21 an 0.88±0.32 mg/100 g, phosphorus 13.10±0.57 and 18.30±0.32 mg/100 g, potassium 2.10±0.62 and 4.50±0.08 mg/100 g, sodium 6.10±0.31 and 9.33±0.07 mg/100 g and calcium 7.28±0.41 and 10.11±0.22 mg/100 g for raw and malted sample respectively. The anti-nutrients determined are phytate 19.86±0.03 and 7.22±0.78 mg/100 g, oxalate 1.78±0.03 and 0.02±0.42 mg/100 g, trypsin inhibitor 40.53±0.42 and 10.30 m±0.07 g/100 g, tannins 28.80±0.50 and 9.12±0.18 mg/100 g and hydrogen cyanide 1.63±0.68 and 0.68±0.04 mg/100 g, for the raw and malted pigeon pea respectively. The functional properties are Bulk density 0.62±0.81 and 0.98±0.01 g/cm^3, water absorption capacity 227.05±0.24 and 261.220.38%, oil absorption capacity 162.72±0.11 and 170.54%±0.42, foaming capacity 18.80±0.28 and 37.73±0.21% and swelling capacity 4.08±0.13 and 6.24±0.31%.
Conclusion: It was observed that highly nutritious flour can be produced from pigeon pea using malting.

Keywords: Malting; pigeon pea; dietary quality; legumes.

1. INTRODUCTION

Dietary quality is an important limiting factor to adequate nutrition in many resource-poor settings. One aspect of dietary quality with respect to adequacy of micro nutrient intake is bioavailability. Legumes are important sources of nutrients such as protein, carbohydrates, dietary fiber and minerals. Only a few of the known legume species are extensively promoted and used. Majority are still underutilized.

Pigeon pea is a marginally known legume, having the potential of reducing protein deficiency in developing poorer nations [1]. Pigeon Pea (*Cajanus cajan*) belongs to the order of *Fabaceae*. In Nigeria, it is grown extensively in Enugu, Anambra and Benue States. It is called “Fio-Fio” in Anambra State, “Agbubu” in Enugu State and “Waken Kurawa” or “Otile” in some parts of the Northern States [1]. Dry matured seeds are cooked whole until tender. They are mixed with cooked yam, maize and dried cocoyam grit (Achicha) or freshly cooked cocoyam, sweet potatoes in addition to vegetables, palm oil, salt and ground pepper. It is not often used to prepare steam gel (Moi-Moi) and fried cake (Akara). Pigeon pea seed has a hard coat with slight acrid taste [1]. The dried pigeon pea seeds are soaked overnight and cooked with salt spices.

One of the obstacles of the use of bean flour is the presence of anti-nutritional substances such as trypsin inhibitor which may decrease the bioavailability of nutrients in it. One of the efforts to overcome this is to give pretreatment before flouring to eliminate anti-nutritional substances. These pretreatment are malting, fermentation, soaking, boiling, roasting, decanting, germination etc. Pigeon pea has some problems that are associated with it. These include long time cooking for matured seeds which takes about 18-24hours before it becomes tender and edible, therefore malting can help reduce this challenge. The husks of pigeon pea are not easily removed. It must undergo long process before the husks are removed. This affects the flavor and odour of the ground pea [2].

Malting involves the sprouting of a seedling from a seed of an angiosperm or gymnosperm after steeping in water and drying of the sprouted seeds. Malting is also the process of converting legumes and cereal grains into malt (germinated and dried form) for use in brewing and distilling. The legumes are spread out on the malting floor in a layer of 8 to 12 cm (3 to 5 inch) depth. The malting process starts by immersing or steeping in water two or three times over two or three days to allow the grain to absorb moisture and to start to sprout [3]. Malting has been known as a process that is not expensive and is technologically effective in improving the nutritional quality of foods [4]. Malting is able to increase the nutrient content, digestibility and availability of free amino acids, dietary fiber and bioactive components.

The study aimed at utilizing the local legume in the production of processed food. It will reduce the high dependency on the imported flour. It will enhance better acceptability and utilization of pigeon pea in various food formulations. The flour could also serve as cheaper alternative to wheat flour. In addition, consumption of products produced from the flour would help to solve the problem of protein-calorie malnutrition in Africa. The thrust of this work is to determine the effect of malting on the nutritional characteristics of pigeon pea.

2. MATERIALS AND METHODS

2.1 Procurement of Raw Materials

The pigeon pea (*Cajanus cajan*) was obtained from Ogbete Main Market Enugu, Nigeria.

2.2 Processing of Samples

2.2.1 Production of raw and malted pigeon pea flour

The method used was as described by Nwosu et al. [2]. The pigeon pea seeds were sorted to remove dirt and other extraneous materials. Approximately 500 g of the clean seeds were winnowed and thoroughly washed. These seeds were then steeped in water at ambient temperature for 24 hours. Changing of water at 6hours interval was observed during steeping. The resultant steeped seeds were spread on jute bag and were covered with white cotton cloth to germinate for 72 hours. The sprouted seeds were oven dried at a temperature of 50°C in order to terminate enzyme activities. The plumules were separated from the seed and the malted seeds were dried and milled into flour with an attrition mill.

Table 1. Sample coding

Sample	Processing method
A	Raw pigeon pea flour
B	Malted pigeon pea flour

2.3 Proximate Composition

2.3.1 Determination of moisture content

The moisture content of the samples was determined using the air oven method of AOAC [5].

2.3.2 Determination of protein content

Crude protein content of the samples was determined using the automated Micro-Kjeldahl method as described by AOAC [5].

2.3.3 Determination of fat content

The fat content was determined using the Soxhlet extraction method [5].

2.3.4 Determination of crude fibre content

The crude fibre content of the samples was determined according to the procedure of AOAC [5].

2.3.5 Determination of ash content

The ash content was determined according to the procedure of AOAC [5].

2.3.6 Determination of carbohydrate content

Carbohydrate content was calculated by difference. The estimated percentages of crude protein, ash, fat, fibre and moisture was summed up and the value subtracted from 100%.

CHO = 100% - % (protein + fat + ash + fibre +moisture).

2.3.7 Determination of mineral element composition

The mineral contents, namely: Na, K, Ca, Mg,Cu, Mn, Hg and Pb contents were determined by the method described by Pearson [6] using a Pye Unicam SP9 Atomic Absorption Spectrophotometer (AAS) connected to an SP9 computer (Pye Unicam Ltd, York Street, Britain). Total phosphorus was determined by the spectrophotometric molybdovanadate [5].

2.3.8 Phytochemical screening

A small portion of the extract was subjected to the phytochemical test using Trease and Evans [7] and Harbourne [8] methods to test for alkaloids, flavonoids, saponins, lycopene, phenol and cardiac glycoside. The Folin-Denis Spectrophotometer method was used to determine the tannin content of the foods. The method was described by Pearson [6]. Cyanide was determined by Wang and Filled method [9]. Phytate was determined from duplicate samples of food using diluted HCL [10]. Oxalate determination was carried out as described by [11].

2.4 Determination of Functional Properties

2.4.1 Water Absorption Capacity (WAC)

Approximately (2.5 g) was suspended in 30 ml distilled water at 30°C in a centrifuge tube, stirred for 30 minutes intermittently and then centrifuged at 300 rpm for 10 minutes. The supernatant is decanted and the weight of the gel formed was recorded. The WAC was calculated as gel weight per gram dry sample Sosulski et al. [12]

WAC = Bound water (g) x 100

Weight of sample

2.4.2 Oil Absorption Capacity (OAC)

Flour samples (1 g) were suspended in 5 ml of water in a centrifugal tube. The slurry was shaken on a platform tube rocker for 1 minute at room temperature and centrifuged at 3000 rpm for 10 minutes. The supernatant was decanted and discarded. The adhering drops of water was removed and reweighed. OAC are expresses as the weight of sediment/initial weight of flour sample (g/g) [13].

2.4.3 Bulk density

Bulk density of the flour samples was determined according to the method of Udoro et al. [14]. A 10 ml graduated cylinder, was gently filled with the sample, the bottom of the cylinder was gently tapped on a laboratory bench several (about 50) times until there were no further diminution of the sample level after filling to the 10 ml mark. Bulk density was calculated as weight of sample per unit volume of sample (g/cm^3).

$$\text{Bulk density} = \frac{X1\ (g)}{X2\ (g)}$$

Where X1 = Weight of the sample
X2 = Volume of the sample

2.4.4 Swelling properties

The method used was as described by Okaka and Potter [15]. About 25 g of flour was measured into a 100 ml measuring cylinder. The measuring cylinder was then filled with water to 100 ml bench mark. The mixture was shaken several times and allowed to settle. The volume of the flour was recorded after 15 minutes. The percentage swelling in the volume was determined by the difference in volume divided by the initial volume. Thus

$$\% \text{ swelling properties} = \frac{C - B}{A}$$

where

A = initial volume (equivalent volume of the 25 g flour sample)
B = volume before swelling
C = Volume after swelling

2.4.5 Foam Capacity (FC)

The foam capacity (FC) and stability (FS) of the sample were studied by the method of Narayana and Narsinga Rao [16]. A 3 g of flour was transferred into clean, dry and graduated (50 ml) cylinders. The flour samples were gently level and the volumes noted. Distilled water (30 ml) was added to each sample; the cylinder was swirled and allowed to stand for 120 min while the change in volume was recorded every 10 min. The FC (%) value was calculated as follows:

$$FC\ (\%) = \frac{Vt - V0}{V0} \times 100$$

Where V0 (ml) is the original volume of sample and Vt is the total volume after different times (ml)

2.4.6 Viscosity

Viscosity (AV) The apparent viscosity of slurries were determined by the methods of Beuchat, [17] and was determined by placing Twenty grams of the sample in measuring cylinder of 100ml of water in an oiling water bath of 75 – 80°C. The slurry was constantly stirred and until boiling which was continued for five minutes. The slurry was cooled to room temperature 23 – 250°C and their viscosity were measured with a cannon viscometer.

2.5 Determination of Anti-nutrient

2.5.1 Determination of phytate

Phytate was determined using the method of AOAC [5]. The sample (0.5 g) was extracted with 100 ml of 2.4% HCl for 1 h at room temperature. The extract (5 ml) was pipette into a test tube and diluted with 25 ml of distilled water. 0.7 M sodium chloride (15 ml) was added and the

absorbance was read at 520 nm using UV/Vis spectrophotometer. The value was calculated from a prepared standard curve and blank.

2.5.2 Determination of oxalate

Oxalate was determined using the method of AOAC [5]. One gram of the powdered sample was weighed and put into a test tube and 47.5 ml of water and 2.5 ml of 6 N hydrogen chloride were added to the powdered sample. It was boiled for 1 h and made up to 62.5 ml with water. The solution was cooled at room temperature and filtered. Some filtrate (12.5 ml) was taken and the pH was adjusted to the range of 4.0 to 4.5 with dilute ammonia (NH3). The solution was heated up to 90°C, filtered and heated up again to 90°C. Then, 5 ml of calcium chloride was added to the solution with constant stirring. The solution was allowed to stand overnight. The solution was centrifuged for 5 min and the supernatants were decanted off. The precipitate was dissolved with 5 ml of 20% sulphuric acid. It was heated until about to boil. The solution was then titrated with 0.5 N standards. KMNO4 until a pale pink colour that persisted for 30 s was attained and the percentage oxalate was calculated.

2.5.3 Determination of saponin

The method used was also as described by AOAC, [5]. Twenty grams of the powdered sample was placed in 200 ml of 20% ethanol. The suspension was heated over water bath for 4 h with continuous stirring at 55°C. The mixture was filtered and the residue re-extracted with 200 ml of 20% ethanol. The combined extracts were reduced to 40 ml over water bath at 90°C. The concentrate was transferred into a 250 ml separator funnel and 20 ml diethyl ether was added and shaken vigorously. The aqueous layer was recovered while the ether layer was discarded. The purification process was repeated. 60 ml of n-butanol extracts were washed twice with 10 ml of 5% aqueous sodium chloride. The remaining solution was heated in a water bath. After evaporation, the sample was dried in the oven to a constant weight. The Saponin content was calculated in percentage.

2.5.4 Determination of tannin

Tannin content of the sample was determined Folin Denis Colometric method according to AOAC [5]. A measured weight of the processed sample (5.0 g) was mixed with distilled water in the ration of 1:10 (w/v). The mixture was shaken for 30 minutes at room temperature fittered to obtain the extract. A standard tannic acid solution was prepared, 2 ml of the standard solution and equal volume of distilled water were dispersed into a separate 50 ml volumetric flask to serve as standard and reagent blank respectively. Then 2 mls of each of the sample extract was put in their respective lapelled flask. The content of each flask was mixed with 35 ml distilled water and 1 ml of the Folin Denis reagent was added to each. This was followed by 2.5 mls of saturated Na_2CO_3 solution. There after each flask was diluted to the 50 ml mark with distilled water and incubated for 90 minutes at room temperature. Their absorbance was measured at 760nm in a spectrophotometer with the reagent blank at zero.

The tannin content was calculated as shown below:

2.5.5 Determination of hydrogen cyanide (HCN)

This was determined by alkaline Pikrate colorimeter method by AOAC [5]. About 1.02 g of this sample was dispersed in 50 ml of distilled water in a 25.0 ml conical flask. An alkaline Pikrate paper was hung over the sample mixture and the blank in their respective flasks. The set up were incubated overnight and each Pikrate paper was eluted (or dipped) into a 60 ml of distilled water. A standard cyanide solution was prepared and diluted to a required concentration. The absorbance of the diluted sample solution of the standard was measured spectophotometrically at 540 nm wavelength with the reagent blank at zero. The cyanide content was determined by the formular shown below:

$$HCN\ mg/kg = 1000 \times au \times CxD\ (W\ as\ 1)$$

Where W = weight of sample analyzed
Au= absorbance of test sample
As = absorbance of standard HCN solution
C = concentration of the standard in mg/dl
d = dilution factor where applicable.

2.5.6 Glycosides

The method of AOAC [5] was used. One gram of the sample was mixed with 20 ml of water. Some quantity (2.5 ml) of 15% lead acetate was added to the filtration and the solution was shaken vigorously. It was allowed to settle and the lower layer was collected and evaporated to dryness.

The residue was dissolved with 3 ml of glacial acetic acid. About 0.1 ml of 5% ferric chloride was added. Some 0.25 ml of conc H2SO4 was also added. The solution was vigorously shaken and put in a dark container for 2 h. The absorbance was read at 530 nm.

2.6 Statistical Analysis

All the analysis reported in this study was performed in triplicates and data obtained is reported as mean ± standard deviation. T-test, mean and standard deviation was performed on the generated data using SPSS software version 20.0.0 [18].

3. RESULTS AND DISCUSSION

3.1 Proximate Composition of Raw and Malted Flour

The result shown in Table 2 that the protein content of raw and malted pigeon pea are 19.01±0.08 and 22.10±0.16% respectively. There was higher protein in the malted sample than the raw sample. These values were similar to the findings of Saxena et al. [19] and Okpala et al. [20] with protein values of 18.8% and 21.43% for raw and malted pigeon pea respectively. This increase could be attributed to the proteolytic enzymes involved in the degradation of the malted samples which were activated during the process. The ash content of the malted sample (3.18±0.47%) was also higher than that of raw sample (2.27±0.23%). This was contrary to the findings of Pele et al. [1] that had higher ash content in raw sample (5.58%) than the malted sample (5.41%) of pigeon pea. The discrepancy in the results could be due to the processing method applied. The higher content in malted sample could be due to some left over prumule after winnowing during sample preparation. The result also showed that the fibre content of raw and malted pigeon pea were 0.45±0.52% and 1.23±0.63%. The malted sample had higher fibre than that of the raw sample. The fibre content of the malted sample agreed with the findings of Nwanekezi et al. [21] with the value of 1.63%. However, the raw sample was slightly lower than the findings of Nwosu et al. [2] that had 4.4% crude fibre in pigeon pea. The variation could be attributed to the location and the processing method of the sample. Crude fibre is a necessary nutrient that rejuvenates the immune system and burns cholesterol in the body. A number of studies have indicated that components of plants such as dietary fiber have beneficial effects in lowering blood cholesterol levels aside from the decreased intake of saturated fat and cholesterol that occurs with high intakes of plant foods [22]. Fibre cleanses the digestive tract, by removing potential carcinogens from the body and prevents the absorption of excess cholesterol [22]. There was decrease in fat content of the sample as raw sample had 1.68±0.32% while the malted sample had 1.02±0.52% respectively. This agreed with the findings of Saxena et al. [19] that had 1.9% for raw sample and Nwanekezi et al. [21] with 1.55% for malted pigeon pea sample. The higher fat content of the raw sample than the malted sample was because of the processing effect of malting. The higher crude fat in raw sample could be due to the fact that the pericarp and seed coat of pigeon pea which composed of the fatty component was not affected by processing [1]. Dietary fat functions in the increase of palatability of food by absorbing and retaining flavours. The low fat content of this vegetables are imperative since high fatty foods are associated with cardiovascular diseases such as cancer, high blood pressure and obesity. The moisture content of the malted sample (15.10±0.81) was higher than the raw sample (12.81±0.07%). The moisture value obtained was similar to the findings of Nwosu et al. [2] with 11.5% for raw sample and Pele et al. [1] had 13.65% for malted pigeon pea sample. The higher moisture content in malted sample could be due to sprouting. Although the moisture content of the malted sample was slightly above the recommended acceptable limit for dried sample which is 14% but can still possess acceptable shelf life [2]. The carbohydrate content of raw sample (63.78±0.28%) was higher than the malted sample (57.37±0.01%). The findings of Nwosu et al. [2] who worked on raw pigeon pea sample supported this claim with the value of 63.4% and Okpala et al. [20] that worked on the malted pigeon pea sample also agreed with this finding with the similar value of 57.77%. The percentage carbohydrate content of the malted samples was generally lower than that of the raw samples. This is mainly due to the reduction in the values of other nutrients as malting progressed. Also during malting, complex starch and protein are being broken down to disaccharides and amino acid by the action of amylase and protease enzymes [1]. The result showed that the raw sample (346.28 kcal) had higher energy than that of the malted sample (327.06 kcal). This finding was slightly lower than that of Okpala et al. [20] with 372.15 kcal/100 g in pigeon pea. The variation could be the age of the sample and the

analytical procedures. The higher energy value in the raw sample could be due to the higher carbohydrate as the malting process reduces the carbohydrate. Carbohydrate is the major energy source in food.

3.2 Mineral Composition of Raw and Malted Flour

The result shown in Table 3 that the iron content of the malted sample 1.03±0.08 mg/100 g was higher than that of the raw sample (0.13±0.12 mg/100 g). These values were lower than the findings of Saxena et al. [19] that had 3.0 mg/100 g iron in pigeon pea. The variation could be due to the location and the soil type where the raw material was planted. Iron (Fe) is an important constituent of Hemoglobin. Iron plays numerous biochemical roles in the body, including oxygen binding in hemoglobin and acting as an important catalytic centre in many enzymes such as the cytochrome oxidase [23]. The RDA for iron is 8 mg/day. Magnesium content was higher in raw sample (68.24 mg/100 g) than that of malted sample (50.30 mg/100 g) and was slightly lower than the findings of Saxena et al. [19] with the mean value of 122 mg/100 g in pigeon pea. The variation could also be due to the location and the nature of the sample used. The magnesium status of the body is greatly influenced by the health of both the digestive and renal systems. Any disorder of the gastro-intestinal tract that impair absorption processes, such as Crohn's disease, can limit magnesium absorption by the body leading to depletion in body magnesium stores which could, in extreme cases, lead to chronic magnesium deficiency which may include symptoms like erythemia, hyperaemia, neuromuscular hyper-irritability which increases if the deficiency is unchecked and may be accompanied by cardiac arrhythmia and generalized tremours [24]. Magnesium deficiency can be prevented by consumption of magnesium rich diets as well as supplementation of diets with magnesium if the diets are poor in magnesium content [24]. The zinc contents were (0.88±0.32 mg/100 g) and (0.27±0.21 mg/100 g). There was higher zinc content in malted sample than raw sample. Saxena et al. [19] observed the zinc content of 2.3 mg/100 g in pigeon pea which is slightly higher than the test samples. These variations may be due to the soil type where the raw materials were sourced as soil is the major source of minerals which usually influence crops. Zinc is needed for the proper growth and maintenance of the human body. It is found in several systems and biological reactions, and it is needed for immune function, wound healing, blood clotting, thyroid function, and much more. The presence of zinc in the composite flour is an indication that products from the flour will be good for pregnant women [25]. Study has investigated that zinc can be used for the treatment of diarrhea. The WHO has recommended the use of zinc for diarrhea treatment especially in children as it can decrease diarrhoea morbidity and mortality when introduced to diarrhea patients [26]. This research also found that there was decrease in phosphorus as the raw sample had 18.30±0.57 mg/100 g and the malted sample had 13.10±0.32 mg/100 g. These values were slightly lower than the findings of Arawande and Borokini [27] who reported a phosphorus content of 55.00mg/100g in pigeon pea. Calcium and phosphorus are related in their functions, they reciprocate each other. The complex these two element form gives rigidity to bones and teeth. Phosphorus helps in healthy bone formation, improved digestion, regulate excretion and help in protein formation [27]. The result of potassium showed that the malted sample recorded higher value than the raw sample with the values of 4.50±0.08 mg/100 g for malted sample and 2.10±0.62 mg/100 g for raw sample. The values obtained agreed with the findings of Arawande and Borokini [27] with mean value of 1.41 mg/100 g in pigeon pea. Potassium helps in fluid balance and regulation of nerve impulse conduction, regular heart beat and cell metabolism. Potassium is the major cation in intracellular fluid and functions in the maintenance of weight, regulation of acid-base balance, conduction of nerve impulse, muscular contraction (especially of the cardiac muscle), correct functioning of the cell membrane, regulation of the sodium-potassium adenosine triphosphatase (ATPase) system and the maintenance of fluid volume [28]. It also plays a vital role in the transfer of phosphate from adenosine triphosphate to pyruvic acid. The metabolism of potassium is regulated by the hormone, aldosterone. According to Institute of Medicine [29] the Recommended Daily Allowance (RDA) for potassium for both normal healthy males and non-pregnant females between the ages of 19 and 50 years is 4700 mg/day.

Table 2. Proximate composition of raw and malted flour

Sample	Protein (%)	Ash (%)	Fibre (%)	Fat (%)	Moisture (%)	Carbohydrate (%)	Energy (Kcal)
A	19.01±0.08	2.27±0.23	0.45±0.52	1.68±0.32	12.81±0.07	63.78±0.28	326.20
B	22.10±0.16	3.18±0.47	1.23±0.63	1.02±0.51	15.10±0.81	57.37±0.01	300.32
P-value	0.001	0.0023	0.001	0.7580	0.5130	0.003	0.001
T – test	(n=6)	(n=6)	(n=6)	(n=6)	(n=6)	(n=6)	

Values are mean ± standard deviation of 3 replication, P<0.05
Keys: Sample A = Raw pigeon pea; Sample A = Malted pigeon pea

Table 3. Mineral composition of raw and malted flour

Sample	Iron (mg/ 100 g)	Magnesium (mg/ 100g)	Zinc (mg/ 100 g)	Phosphorus (mg/100 g)	Potassium (mg/ 100 g)	Sodium (mg/100 g)	Calcium (mg/100 g)
Raw	0.13±0.12	68.24±0.01	0.27±0.21	18.30±0.57	2.10±0.62	6.10±0.31	7.28±0.41
Malted	1.03±0.08	50.30±0.45	0.88±0.32	13.10±0.32	4.50±0.08	9.33±0.07	10.11±0.22
P-value	0.004	0.0612	0.001	0.682	0.413	0.003	0.003
T – test	(n=6)	(n=6)	(n=6)	(n=6)	(n=6)	(n=6)	

Values are mean ± standard deviation of 3 replication, P<0.05
Keys: Sample A = Raw pigeon pea; Sample A = Malted pigeon pea

Table 4. Functional properties of raw and malted flour

Sample	Bulk density (g/cm^3)	Water absorption capacity (%)	Oil absorption capacity (%)	Foaming capacity (%)	Swelling capacity (%)
Raw	0.62±0.81	227.05±0.24	162.72±0.11	37.73±0.28	6.24±0.13
Malted	0.98±0.01	261.28±0.38	170.54±0.42	18.80±0.21	4.08±0.31
P-value	0.000	0.492	0.614	0.732	0.008
T – test	(n=6)	(n=6)	(n=6)	(n=6)	(n=6)

Values are mean ± standard deviation of 3 replication, P<0.05
Keys: Sample A = Raw pigeon pea; Sample A = Malted pigeon pea

Table 5. Anti-nutrient composition of raw and malted flour

Sample	Phytate (mg/100 g)	Oxalate (mg/100 g)	Trypsin inhibitor (mg/100 g)	Tannin (mg/100 g)	Hydrogen cyanide (mg/100 g)
Raw	19.86±0.03	1.78±0.03	40.53±0.42	28.80±0.50	1.63±0.68
Malted	7.22±0.78	0.02±0.42	10.30±0.07	9.12±0.18	0.68±0.04
P-value	0.734	0.004	0.932	0.681	0.000
T – test	(n=6)	(n=6)	(n=6)	(n=6)	(n=6)

Values are mean ± standard deviation of 3 replication, P<0.05
Keys: Sample A = Raw pigeon pea; Sample A = Malted pigeon pea

The result of the sodium showed that there was an increase in sodium content after malting. The raw sample had 6.10±0.31 mg/100 g while the malted sample had 9.33±0.07 mg/100 g. These values were slightly higher than the findings of Arawande and Borokini [27] that had 2.20 mg/100 g in pigeon pea. The variation could be the difference in the soil used in planting of the seeds. Sodium is an electrolyte and works hand in hand with potassium, calcium, and magnesium to keep electrolyte levels balanced. The result of the calcium content showed that malted sample had (10.11±0.22 mg/100 g) higher value than the raw sample with the values of 7.28±0.41 mg/100 g. This result obtained agreed with the finding of Ehimen et al. [25] that had calcium content of 7.34 mg/100 g in pigeon pea. Calcium plays a vital role in the development and sustenance of strong bones and teeth (especially in fetuses, infants, children, and the elderly), regulation of muscular contraction and relaxation, regulation of nerve function and absorption of cyanocobalamin (vitamin B12). Calcium may therefore be useful in the prevention of osteoporosis in the elderly. It also plays a key role in the coagulation of blood as it activates the process leading to the conversion of prothrombin to thrombin.

Pictures showing raw and malted pigeon peas

Plate 1. Raw pigeon pea

Plate 2. Sprouted pigeon pea

Plate 3. Dried sprouted pigeon pea

Plate 4. Malted pigeon pea flour

Plate 5. Raw pigeon pea flour

3.3 Functional Properties of Raw and Malted Flour

The essence of determining the functional properties of the composite flour was for identification of the usage of the flour for food application or product development. The result shown in Table 4 that the malted and raw samples had 0.98±0.01 g/cm^3 and 0.62±0.81 g/cm^3 level of bulk density respectively. The malted sample had higher bulk density than the raw sample. These values are similar to the findings of Nwanekezi et al. [21] that had bulk density of 0.53 g/cm^3 in pigeon pea. The bulk density of food materials is affected by the particle size and the density of the food. Bulk density is an important factor in food packaging. The Water absorption capacity (WAC) of the malted pigeon pea flour contained 261.28±0.38% while the raw sample had 227.05±0.24%. The WAC of the malted pigeon pea flour was higher than that of the raw sample. Therefore the value obtained in this study agreed with the values reported by Wayan et al. [30] that had 250.73 and 216.65% for malted and raw pigeon pea samples respectively. Water absorption capacity is an indication of the level of granular integrity which determines the weakness of associative forces between the starch granules, to allow for more molecular surfaces to be available for

binding with water molecules [31]. The water absorption capacity (WAC) is important in the development of ready to eat foods, and a high WAC may assure product cohesiveness, a low WAC product will be easily digestible. The oil absorption capacity of raw and malted pigeon pea flour were (162.72±0.11%) and (170.54±0.42%) respectively. They were slightly higher than that recorded by Nwanekezi et al. [21] with the value of 147.33% in pigeon pea. The variation in mean value could be due to the malting period and processing methods applied. Increased oil absorption capacity of pigeon pea malted flour can be caused by a decrease in fat content. The decreased level of fat was because fat is used as an energy source for the growth of sprouts. So the longer the germination, the more oil can be tied so that the oil absorption capacity is increasing. The foaming capacity of the raw sample was 37.73±0.28% which decreased after malting to 18.80±0.21%. These values were slightly higher than the findings of Ehimen et al. [25] with foaming capacity of 12.08% in pigeon pea. Previous studies had reported that malting lowered foaming capacity. Akubor [32] reported that malting decreases the foaming capacity of Pigeon pea and that the foaming capacity was dependent on the malting period. Foamability is related to the rate of decrease of the surface tension of air water interface caused by absorption of protein molecules. It is also a function of the type of protein and pH, processing methods. The treatments employed in this study may have increased the surface tension of the protein molecule, thus reduced the foamability of the flours. High foam stability is enhanced by native proteins, suggesting that the germinated pigeon pea flour had higher proportion of native proteins than the other flours. Foams are used to improve texture, consistency and appearance of foods. The high foaming properties of the raw and malted pigeon pea flour suggested that they may be suitable for food products where high porosity is required. This probably may be used in the preparation of *akara* balls in Nigeria [33]. However, the raw pigeon pea flour and malted pigeon pea flour may find application in baked and confectionery products [32]. The swelling capacity of the pigeon pea were 4.08±0.31 and 6.24±0.13%. Malting reduces the swelling capacity of pigeon pea flour. The smaller swelling volume (4.08%) was obtained from malted pigeon pea; while the higher swelling volume was obtained for the raw pigeon pea. The decreased capability of flour swelling volume was possibly due to the fact that, during germination, starch hydrolysis became simpler compounds. The bond of α 1-4 in a starch was damaged by amylase and subsequently by α-glycosidase. This reaction caused the starch to change into simpler sugar [30]. The decreased level of starch possibly caused swelling volume to decrease. Nwanekezi et al. [21] also observed a decreased in the swelling capacity of malted sample. In the raw pigeon pea flour, swelling capability was 5.3%, while in the malted flour; the swelling power became 4.23%.

3.4 Anti-Nutrient Composition of Raw and Malted Flour

Result of the anti-nutrient shown in Table 5 that the phytate content of the samples are 7.22±0.78 and 19.86±0.03 mg/100 g. There was significant reduction in the sample after malting as the raw sample had 19.86 mg/100 g while the malted sample had 7.22 mg/100 g. These values were higher than the findings of Pele et al. [1] that recorded 7.61 mg/100 g for raw and 5.27 mg/100 g for malted pigeon pea sample. The variation could be due to the malting period as it affects the phytate content tremendously. Thus, the value of phytate in pigeon pea might not pose any health hazard when related to a phytate diet of 10 – 60 mg/g consumed over a long period of time, which has been reported to decrease bioavailability of minerals in monogastric animals [14]. The oxalate content of the samples were 0.02±0.42 and 1.78±0.07 mg/100 g. Oxalate contents were higher in raw sample (1.78 mg/100 g) than the malted sample (0.02 mg/100 g) which also agreed with the research works of Ehimen et al. [25] with the value of 1.08 for raw pigeon pea and Nwosu et al. [2] with oxalate value of 0.097 mg/100 g for malted pigeon pea. This suggests that malting really reduced oxalate level of food. This could help release the minerals which are bond with the Oxalates and make the seeds more nutritional. The result showed that trypsin inhibitor decreased after malting from 40.53±0.42 TIU/g in raw sample to 10.30±0.07 TIU/g after malting. However, the value obtained in this research was slightly higher than the findings of Pele et al. [1] that had 5.09 mg/100 g for malted pigeon pea and lower than the work of Ehimen et al. [25] that had 125.86 TIU/g in raw sample. The variation in trypsin inhibitor could be as a result of the malting period of the sample. Higher trypsin inhibitor in food binds the protein in food and thereby making them unavailable. However this is low when considering the lethal dose of 2.50

g/kg indicating that the test sample might not pose risk to health [29]. The result indicated that tannin content of the sample reduced from 28.80±0.28 mg/100 g for raw sample to 9.120.18±mg/100 g after malted sample. A study by Pele et al. [1] agreed with the value of malted sample in this study with the mean value of 8.52 mg/100 g in pigeon pea but had a slightly lower value of 14.72 mg/100 g in raw pigeon pea. The results obtained showed that malting reduces the tannin content of food. The level of tannin in the sample was lower than 0.3% specified as maximum standard for legumes by Codex (1990). Tannins are phenolic compounds that precipitate protein and cause reduced protein digestibility. However, there are reports that phenolic compounds like tannins possess antioxidant and antimicrobial activities [34]. The result showed that the cyanide content in raw and malted samples were 1.63 mg/100 g and 0.68 mg/100 g respectively. Raw sample had higher cyanide content than that of the malted sample. These cyanide values were lower than the values obtained by Nwosu et al. [2] that had 7.180 mg/100 g and 5.170 mg/100 g for raw and malted pigeon pea sample respectively. The hydrogen cyanide for the both samples showed that malting is best processing method to reduce the HCN content of pigeon pea [35]. World Health Organization recommendation on cyanide level in food and water is 10 mg/kg. There is high prevalence of mortality after consumption of HCN concentration 270 ppm [26]. Therefore the cyanide content of these samples was within the safe limit.

4. CONCLUSION

The results obtained have shown that malting significantly improved the nutritional quality of pigeon pea and reduced the anti-nutritional composition of pigeon pea. Protein content of pigeon pea was significantly increased while the fat content was significantly decreased due to sprouting respectively. The tannin, HCN and phytic acid which compromises minerals absorption was also significantly reduced by malting. This result indicated that malting of pigeon pea greatly increased the availability of minerals (iron, calcium, potassium, sodium and zinc). The increased in minerals availability is likely due to the reduction in phytate and tannin content of the composite flour.

Conclusively, it was observed that highly nutritious flour can be produced from pigeon pea using malting.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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