EFFECTS OF SOAKING, BOILING, AND TOASTING PROCESSING TECHNIQUES ON NUTRIENT COMPOSITION OF PIGEON PEA FLOURS AND ORGANOLEPTIC ATTRIBUTES OF THEIR PUDDINGS AND BALLS.

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ABSTRACT

This study evaluated the effects of soaking, boiling and toasting processing techniques on nutrient and phytochemical composition of pigeon pea flour and the organoleptic properties of their puddings and balls. Pigeon pea and cowpea seeds which served as control were purchased, processed into flour, used for the preparation of puddings and balls. The pigeon pea flour samples were subjected to proximate, vitamin and mineral analysis using standard methods. The data generated from organoleptic evaluation, proximate, vitamins and minerals analyses respectively, were subjected to statistical analysis with descriptive statistics SPSS version 20. One way ANOVA was used to compare mean at $p<0.05$ probability level. Findings show that the processing techniques significantly improved the nutrient properties of the pigeon pea flours. However, toasted pigeon pea flour had the highest folate (vitamin B_9) content of 644.530mcg/100g and phosphorus content. Boiled pigeon pea flour had the highest iron content of 2.205mcg/100g.. Boiled pigeon pea flour had the highest protein and iron content and soaked pigeon pea flour had the highest moisture, crude fiber and Vitamin B_3 contents. Hence, to improve micronutrient intake such as folate and phosphorus, toasting processing technique is highly recommended.

Key words: Peageon pea, Boiling, Toasting, Soaking, Flour

INTRODUCTION

Pigeonpea (*Cajanus cajan* L.) is the sixth most important legume crop in the world (Rachie, 2017). Worldwide, pigeonpea production averaged 4.89 million tons in 2014 (FAO, 2014). India and Myanmar are the major producers (83%) ahead of Malawi, Tanzania, Kenya and Uganda as major producers in Africa (14%) (FAO). In West Africa, pigeonpea is a minor crop, but it plays a key role in the subsistence of smallholders in Benin, Nigeria and Ghana. Pigeon pea seeds are highly nutritious (Saxena, Kumar, & Gowda, 2014). The mature seeds contain 18.8% protein, 53% starch, 2.3% fat, 6.6% crude fiber and 250.3 mg 100 g−1 minerals (Saxena & Kumar, 2014). As a perennial shrub, pigeon pea has many advantages over annual legumes in that several harvests are possible and the capacity to contribute to enhance soil fertility is much higher (Høgh-jensen, 2014). Pigeonpea has high tolerance to drought stresses, high biomass productivity, which is mainly used as fodder, and provides the most nutrient and moisture contributions to the soil (Odeny, 2017).

Pigeon pea is an under-utilized tropical legume in Nigeria. It is one of the most drought tolerant legumes with the potential of mitigating the impacts of climate change in the tropics (Odeny, 2017). It is described as the only crop that yields some grains during dry spells when other legumes as field beans have wilted and dried up (Odeny, 2017). Pigeon pea seed is a cheap, nutritious and healthy legume of various uses with healing and medicinal value. It is a rich source of protein, fibre, minerals and vitamins (Fasoyiro, Ajibaded, Omole, Adeniyan, & Farinde, 2016). Pigeon pea is also a good source of calcium, phosphorus, magnesium, iron, sulphur (Amarteifio, 2014).

Protein malnutrition is widespread among the poor in developing countries due to lack of sufficient animal proteins, thus the search for alternative sources of protein from lesser-known legumes is imperative. Legumes represent a major source of

energy and nutrients, including protein; particularly in vegetarians' diet (Ghadge, Vairagar & Prasad, 2018). The special contribution of food legumes to human diet lies in the quantity and quality of their protein content. Fasoyiro, (2015), reported that some foods have been neglected and underutilized in combating the protein energy malnutrition (PEM). People who consume too little protein and food energy are prone to developing protein – energy malnutrition (PEM). There is therefore an urgent need to find alternative sources of plant protein. Such alternatives must be easily available, cheap and contain a reasonable quantity of protein. Food legume such as pigeon pea contains just as much protein as meat, which is cheaper and readily available, can be used to prepare local dishes such as pigeon pea balls and pigeon pea puddings. However, pigeon pea like other legumes is deficient in methionine but high in lysine (Amarteifio, 2014). Like most tropical legumes, pigeon peas, especially the raw seeds contain antinutritonal substances such as trypsin inhibitors and tannins which affect their utilization (Igbedioh, Olugbemi & Akpapunam, 2015). They also contain flatulence causing oligosaccharides such as starchyose, raffinose and verbacose (Rao, 2016). Similarly, the characteristic problem of hard-to-cook phenomenon also hinders the extensive use of pigeon peas as food.

The dried seeds are hard and by the traditional processing methods, it takes 24 hours to prepare a meal of pigeon pea. It is therefore pertinent to find alternative processing techniques that could facilitate easy cooking, improve nutritional values as well as minimize the antinutrient components.

Purpose of the Study.

The main purpose of the study was to determine the effects of soaking, boiling, and toasting processing techniques on nutrient composition of pigeon pea flours.

Specifically the study:

1. determined the proximate (moisture, ash, crude fiber, fat, crude protein and total carbohydrates) of the flour produced from pigeon pea using soaking, boiling and toasting processing techniques;
2. determined the minerals(Fe, P) of the flour produced from pigeon pea;
3. determine the vitamins(B3, B9) of the flour produced from pigeon pea;
4. assessed the organoleptic attributes of pigeon pea puddings and balls.

MATERIALS AND METHODS

Procurement of raw materials

Mature pigeon pea seeds, Cowpea seeds and other ingredients needed for the preparation of pigeon pea pudding, cowpea pudding, cowpea balls and pigeon pea balls; vegetable oil, foil, fresh pepper, onions, salt, seasoning was obtained from Ogige market in Nsukka Local Government Area of Enugu State.

Sample preparation

Soaked Pigeon pea Flour

- The pigeon pea seeds were sorted and cleaned by removing damaged seeds and foreign materials such as sticks and stones, weighed and then washed up in clean tap water in a large bowl, while using a sifter to drain the water to avoid losing any quantity of the pigeon peas in the process. The water was changed as frequently as required.
- The washed pigeon peas are soaked in cold water in a deep bowl for 5hrs at room temperature and then washed and drained.
- The seeds was manually dehulled with hands, weighed and spread out the sun on a flat surface to dry for a period of 6-8hrs per day for 5days.
- The dried seeds was weighed, and milled to flour using a hammer mill, and stored in an air tight container.

Pigeon pea seeds =>Soaking => Dehulling => Drying => Milling => Pigeon pea flour =>Storage

Fig.1. Flowchart of soaked pigeon pea flour

Boiled Pigeon Pea Flour

- The pigeon pea seeds were sorted and cleaned by removing damaged seeds and foreign materials such as sticks and stones, weighed and then washed up in clean tap water in a large bowl, while using a sifter to drain the water to avoid losing any quantity of the pigeon peas in the process.
- The washed pigeon pea seeds were transferred into a neat pot, boiled for 20mins and drained. The drained seeds were left to cool before they were manually dehulled with hands, weighed

and spread out the sun to dry for 6-8hrs per day for 5days.
- The dried seeds was weighed, and milled to flour using a hammer mill, and stored in an air tight container.

Pigeon pea seeds => Sorting => Washing => Boiling => Dehulling => Drying => Milling => Pigeon pea flour => Storage

Fig.2. Flowchart of Boiled Pigeon pea Flour.

Toasted Pigeon pea Flour
- The pigeon pea seeds were sorted and cleaned by removing damaged seeds and foreign materials such as sticks and stones, weighed and then washed up in clean tap water in a large bowl, while using a sifter to drain the water to avoid losing any quantity of the pigeon peas in the process. The water was changed as frequently as required.
- A neat pan was preheated empty and the washed pigeon pea was transferred into it and allowed to cook with dry heat at low temperature while I continuously stirred every 15seconds to ensure that the seeds were evenly toasted for 30-45mins.
- The toasted seeds were allowed to cool before they were dehulled mechanically using
- The dehulled seeds were spread out to dry for 3-4hrs per day for 3days.
- The dried seeds was weighed, and milled to flour using a hammer mill, and stored in an air tight container.

Pigeon pea seeds => Sorting => Washing => Toasting => Dehulling => Drying => Milling => Pigeon pea Flour => Storage

Fig.3. Flowchart of Toasted Pigeon pea Flour

Soaked Cowpea Flour
- The cowpea seeds were sorted and cleaned by removing damaged seeds and foreign materials such as sticks and stones, weighed and then washed up in clean tap water in a large bowl, while using a sifter to drain the water to avoid losing any quantity of the cowpeas in the process. The water was changed twice daily.
- The washed cowpea seeds were soaked for 5mins before they were manually dehulled with hands, weighed and washed.
- The washed seeds were spread out in the sun for 6-8hrs per day for 5days.
- The dried seeds were weighed, and milled to flour using a hammer mill, and stored in an air tight container.

Cowpea Seeds => Sorting => Washing => Dehulling => Milling => Cowpea Flour => Storage

Fig.4. Flowchart of Cowpea Flour

Recipe for Cowpea Pudding
Ingredients
Cowpea flour 450g, red bell pepper 80g, seasoning cubes 16g, vegetable oil 120g, ground crayfish 100g, salt 25g teaspoon, onions 70g (Jemimah, 2019).

Method of Preparation
The foil to be used in cooking the pudding was prepared and set aside. The flour was put in a clean bowl, and lukewarm water added to form a thick paste. The onions, red bell pepper and crayfish were washed thoroughly and then ground using a blender. The blended paste was added to the thick cowpea paste and stirred using a wooden spatula until the liquids were properly mixed. Vegetable oil, seasoning cubes, salt and ground crayfish were added and then stirred until they were properly incorporated in the paste. Meanwhile, a medium sized pot was placed over high heat with 1-inch of water and was brought to a full boil. A measuring cup was used to measure 100ml of the cowpea pudding mix, into the foil and then properly wrapped. The wrapped cowpea pudding mix was gently lowered into the boiling water, covered and allowed to cook for 45mins until properly cooked (Jemimah, 2019).. The pigeon pea pudding was left to cool, before serving for organoleptic evaluation

Recipe for Cowpea Balls
Ingredients
Cowpea flour 100g, vegetable oil 200g, onions 50g, salt 8g. (Jemimah. 2019).

Method of Preparation
The cowpea flour was put in a neat bowl and water was added to form a thick paste. Onions was thoroughly washed and chopped into tiny bits and then added into the cowpea ball mix. Salt was added to taste and then stirred until properly mixed. The vegetable oil was heated in a 3inch medium sized

deep pan. The cowpea ball mix was scooped using tablespoon into the heated oil and fried for 3-5mins until it browns and flipped over until the other side is brown (Jemimah. S. 2019). The cowpea balls were transferred into an aluminium colander to drain excess oil and then put into a neat plate and allowed to cool before serving for organoleptic evaluation.

Organoleptic Evaluation

The formulated samples; Pigeon pea pudding, Cowpea pudding, Pigeon pea balls and Cowpea balls was served to 15 untrained panelists consisting of students of Home Science department of the University of Nigeria. A nine-point hedonic scale scoring from ranging from like extremely to dislike extremely (9-like extremely. 1- dislike extremely) was developed to serve as an instrument for the organoleptic evaluation. The samples were presented to the panelists in plate dishes appropriately labeled with codes: PPS, for pigeon pea pudding made from soaked pigeon pea seeds, PPT for pigeon pea pudding made from toasted, PPB for pigeon pea pudding made from boiled soaked pigeon peasflour, CPP for cowpea pudding made from soaked cowpea flour, PBS for pigeon pea ball made from soaked pigeon pea flour, PBT for pigeon pea balls made from toasted pigeon pea flour, PBB for pigeon pea ball made from boiled pigeon pea flour and CPB, for cowpea balls made from soaked cowpea flour and the samples were assessed for their appearance, flavor, taste, texture and overall acceptability. Water at room temperature was provided for each of the panelist to rinse their mouths before and after each sample to avoid carryover test.

Proximate composition Analysis

Proximate analysis refers to the determination of the major nutrients composition of foods and food products. For the purpose of this study, all the samples were analyzed for their proximate values using AOAC methods. The parameters analyzed include; crude fiber, crude fat, crude protein, moisture content, ash and carbohydrate.

Moisture Content Determination: Moisture content was determined using the AOAC (2010). The crucible was thoroughly washed, dried in a hot air oven and cooled in a desiccator. A weighing balance was used to check and record the weight of the dried crucible (W_1). Approximately 2g of the sample was introduced into the weighed crucible and the weight determined using a weighing balance (W_2). The crucible containing the sample was placed in a hot air oven at a temperature of 95-100^{o}c under pressure less than or equal to 100mmHg. The crucible and its content was cooled in a desiccator and weighed (W_3). The process was continued until a constant weight was obtained. The percentage moisture content due to drying (removal of moisture) can be calculated as follows:

$$\% \text{ Moisture} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Where: W_1 = weight of dry empty crucible

W_2 = Weight of dry empty crucible and initial weight of sample prior to drying

W_3 = Final weight of crucible and sample after drying.

Crude Fat Content Determination: The fat content of the samples was determined according to the specifications of AOAC (2010), using Soxhelet extraction method. A 500ml capacity round bottom flask was filled with 300ml petroleum ether and fixed to the Soxhelet extractor. Two grams of the sample was placed in a labelled thimble. The extractor thimble was sealed with cotton wool. Heat was applied to reflux the apparatus for 6 hours. The thimble was removed with care. The petroleum ether is recovered for reuse. When the flask was free of ether, it was removed and dried at 105^{o}C for 1 hour in an oven. The flask was cooled in a desiccator and weighed. The crude fat can be calculated using the formula below:

$$\% \text{ Fat} = \frac{\text{Weight of fat}}{\text{Weight of sample.}} \times 100$$

Crude Ash Content Determination: Ash content was determined using AOAC (2010) method. Sample of 2g was weighed into a crucible and charred on a Bunsen burner inside a fume cupboard where the smoke was driven off. The sample was transferred into a pre-heated Muffle furnace at 550^{o}C. At this temperature light grey ash will be obtained. The ashy sample was cooled in a desiccator, weighed and recorded using a weighing balance. The percentage ash content can be calculated as follows:

$$\% \text{ Ash} = \frac{\text{Weight of Ash}}{\text{Weight of sample}}$$

$$\% \text{ Ash} = \frac{W_3 - W_1}{W_2 - W_1} \times 100$$

Where: W_1 = weight of empty crucible

W_2 = Weight of crucible and weight of sample before ashing

W_3 = Weight of crucible + Weight of sample after ashing.

Crude Fiber Content Determination: According to the method of the AOAC (2010), 3g of the sample was weighed into a 50ml beaker and fat was extracted with petroleum ether by stirring, settling and decanting three times. The extracted sample was air-dried and transferred to a 600ml dried beaker. Then 200ml of 1.25% sulphuric acid and few drops of anti-foaming agent was added to the beaker. The beaker was placed on a digestion apparatus with pre-adjusted hot plate and boiled for 30minutes, rotating beaker periodically to keep solid from adhering to the side of the beaker. At the end of 30minutes period, the mixture was allowed to stand for one minute and then filtered through a Buchner funnel. Without breaking suction, the insoluble matter was washed with boiling water until it was free of the acid. The residue was washed back into the original flask by means of a wash bottle containing 200ml of 1.25% sodium hydroxide solution. It was boiled briskly for 30 minutes with similar precautions as before. After boiling for 30 minutes, it was allowed to stand for 1minute and then filtered immediately under suction. The residue was washed with boiling water followed 1% hydrochloric acid and finally with boiling water until it was free of acid. It was washed twice with alcohol, and then with ether for three times. The residue was transferred into ash dish and transferred and dried at 100^{o}C to a constant weight. Incineration of ash was done at 600^{o}C for 30 minutes, cooled in a desiccator and weighed. The difference in weight between oven dry weight and weight after incineration was taken as the fiber content of the sample. This was expressed as a percentage weight of the original sample taken for analysis. Crude fiber can be calculated as follows:

$$\% \text{ Crude fiber} = \frac{\text{weight of fiber}}{\text{Weight of sample}} \times \frac{100}{1}$$

$$\%\text{Crude Fiber} = \frac{\text{Oven Dried sample} - \text{Weight of sample incineration}}{\text{Weight of samples taken.}} \times 100$$

Crude Protein Content Determination: The micro Kjedahl method described by AOAC (2010) was use for crude protein determination. This involved three stages:

Digestion: One gram (1g) of each sample was digested with a mixture of concentrated 20ml sulphuric acid a pinch of copper sulphate and a sodium sulphate crystal to act as catalyst was added. The mixtures were heated till the black liquid is cleared. Heating was continued until the samples were completely digested. The digested samples were transferred into 100mls volumetric flask which was washed for distillation.

Distillation: Kjedahl distillation apparatus was used. Ten millilitres (10mls) of boric acid was combined with two drops of methyl blue and methyl red indicators in a conical flask of 100mls. The colonial flask was positioned into the receiving side of the distillation unit using a champ. Ten millilitres (10mls) of the digested samples was first introduced into the distillation unit followed by gradual addition of ten millilitres (10mls) of concentrated NaOH. The distillation process lasted for five to ten (5-10) minutes, during which ammonia (NH_3) was trapped in excess boric acid. The presence ofNH_3 changed the purple colour of boric acid to green which is the common characteristics of alkaline gas.

$$\%\text{Nitrogen} = \frac{\text{Titre} \times 0.01 \times \text{DF} \times \text{MWN} \times 100}{\text{Weight of the sample (mg)}}$$

Where: DF =Dilution Factor (100m/5ml) =20

Titration: NH_3 was trapped in boric acid indicator and was titrated using 0.1N HCL. Crude protein content of the sample was calculated using the formula:

MWN = Molecular weight of nitrogen= 14.01

Carbohydrate Content Determination by Differentiation: Using the Standard method of AOAC (2010), carbohydrate content of samples was determined by difference as follows:

% Carbohydrate = 100 – (% moisture + % fat + % ash + % crude protein + % crude fiber)

Vitamin Analysis

Determination of niacin (Vitamin B_3): Vitamin B3 was determined using the spectrophotometeric method described by AOAC (2010). Five grams **(**5g) of the sample was extracted with 100ml of distilled water. Five milliliter of this solution was drawn into 100 ml volumetric flask and made up to the mark with distilled water. Standard solutions of niacin was prepared and absorbance of sample and standard solutions measured at a wavelength of 385 nm on a spectrophotometer. Niacin concentration of the sample was thereafter estimated.

Determination of folate: The method described by AOAC (2005) was used. One gram of each sample was weighed into a 250ml volumetric flask. To the 250 ml volumetric flask, 100ml of distilled water was added and spinned or shaken for 45mins and made up to mark with distilled water. The sample mixture was filtered into another 250 ml beaker, rejecting the first 20ml that has been filtered. Another 20ml was collected. To the filterate, 5ml of 1% sodium Dithionite solution was added to decolorize the yellow colour. Standard folic acid of range 0-10 ug/ml was prepared from stock folic acid. A sample blank made up to distilled water was also prepared.

The absorbencies of samples as well as standard was read at a wavelength of 445nm on a spectrophotometer.

Vitamin B_9 (folic acid) = $\frac{\text{Absorbance of sample x Gradient Factor x Dil.Factor}}{\text{Wt. of Sample}}$

Mineral Analysis

Determination of iron: The AOAC (2010) method was used to determine the iron content of the sample. Organic matter in the sample was first destroyed by dry ashing and the resulting ash dissolved in hydrochloric acid and diluted to a known volume with water. Iron present in the aliquot of ash solution was then reduced with hydroxylamine hydrochloride and the Fe (II) determined spectrophotometrically as its coloured complex with α-dipyridryl, the solution being buffered with acetate buffer solution. Absorption of the resulting complex was read at 510 nm wavelength and calculated as thus:

Fe (mg)/100g sample =

$$\frac{\text{Quantity of Fe in aliquot ash solution}}{\text{Aliquot in ash solution taken for determination}} \times \frac{\text{Total volume of ash solution}}{\text{Weight of the sample taken for ashing}} \times \frac{100}{1}$$

Phosphorus determination: This was done by Spectrophotometric method (Pearson, 1976).

Procedure: Two point five (2.5) ml of filtrate was mask out into triplicate tubes. Then, 0.25 ml of dilute ammonia, 1 drop Nitric acid and 1.25 ml of vanadate moly date reagent were added, the mixture was made up 5 ml with distilled water. To prepare the blank, 2.5 ml distilld water, 0.25 ml of dilute ammonia, 1 drop Nitric acid and 1.25 ml of vanadate molybdate reagent were mixed together and made up to 5 ml with distilled water. The absorbance reading was taken at 470nm against blank.

Calculation is done using the following formula;

Std curve for P: Y = 0.5151x (mg/100ml).

$$P\ (mg/100g) = \frac{A \times D}{0.5151 \times W}$$

Where: A = absorbance reading

D = dilution factor (100)

W = weight of sample (g)

Test result was reported in mg P per 100 g sample.

RESULT

Table 1: Proximate Composition of Soaked, Boiled and Toasted Pigeon pea flours.

Parameter (%)	SP	BP	TP
Fat **(%)**	0.895^{a}±0.007	5.340^{b}±0.057	3.520^{c}±0.028
Protein **(%)**	24.470^{c}±0.028	32.545^{b}±0.035	21.320^{a}±0.282
Moisture **(%)**	8.485^{c}±0.120	5.135^{b}±0.495	2.545^{a}±0.636
Ash **(%)**	2.850^{a}±0.014	5.330^{b}±0.042	5.160^{c}±0.141
Crude fiber **(%)**	3.525^{c}±0.350	0.910^{a}±0.140	2.120^{b}±0.028
Carbohydrate **(%)**	59.775^{b}±0.205	50.740^{c}±0.198	65.335^{a}±0.163

KEYS: Values = Mean ± SD (SD = standard deviation) of duplicate determination. SP= Soaked Pigeon pea flour, BP= Boiled Pigeon pea flour, TP= Toasted Pigeon pea flour.

Table 1 shows the proximate composition of Soaked, Toasted and Boiled Pigeon pea flours. The fat content of sample BP was 5.340 while that of sample SP was 0.895 therefore Sample BP contains more fat compared to Sample SP. More moisture was found in sample SP than sample TP. The crude fibre content of sample SP was more than that of sample BP. The carbohydrate content of Sample TP (65.335%) was more than Sample SP (59.775%) and Sample BP (65.335%). Sample SP (2.850%) contains the least ash among Samples BP and TP.

Table 2: Vitamins and Mineral composition of Soaked, Boiled and Toasted Pigeon pea flours.

Parameter (%)	SPPF	BPPF	TPPF
Vitamin B_3(mg/100g)	2.920^{b}±0.030	1.980^{c}±0.021	2.542^{a}±0.034
Vitamin B_9(mcg/100g)		425.61^{c}±0.028	644.53^{a}±0.035
Iron(mg/100g)		2.205^{c}±0.007	1.935^{a}±0.021
Phosphorus(mg/100g)	33.240^{b}±0.057	33.450^{c}±0.042	36.505^{a}±0.025

KEY: Values = Mean ± SD (SD = standard deviation) of duplicate determination. SPPF= Soaked Pigeon pea flour, BPPF= Boiled Pigeon pea flour, TPPF= Toasted Pigeon pea flour.

Table 2 shows the Vitamins and Mineral composition of Soaked, Boiled and Toasted Pigeon pea flours. The Iron content of Samples SPPF, BPPF, and TPPF were 2.130, 2.2.5 and 1.935 respectively. The Phosphorus content of Sample SPPF and BPPF were on the same range 33.240 and 33.450. The folate content of Sample TPPF was higher than that of SPPF and BPPF. Sample TPPF has the highest folate content compared to Samples BPPF and SPPF

Table 3: Organoleptic Properties of Puddings and Balls made from Cowpea flour, Soaked Pigeon pea flour, Toasted Pigeon pea Flour and Boiled Pigeon pea Flour.

Sample	Colour	Flavour	Taste	Texture	General Acceptability
PPS	5.6^{bc}±2.410	5.40^{bc}±2.131	5.27^{bc}±2.086	5.13^{ab}±1.959	4.13^{a}±2.446
PPT	3.80^{a}±2.426	3.80^{a}±2.426	3.07^{a} ±2.434	3.00^{a}±2.390	3.00^{a}±2.390
PPB	5.13^{abc}±2.973	5.13^{abc}±2.973	5.07^{bc}±2.840	4.93^{ab}±2.604	4.53^{a}±1.727
CPP	7.67^{d}±1.799	7.67^{e}±1.799	7.73^{de}±1.870	7.53^{cd}±2.167	7.87^{c}±1.358
PBS	7.37^{cd}±1.223	7.27^{de}±1.223	7.53^{de}±0.915	7.07^{cd}±1.486	6.93^{bc}±1.100
PBT	4.47^{a}±1.642	4.47^{ab}±1.767	4.5^{b}±1.642	4.40^{a}±1.844	4.53^{a}±1.727
PBB	6.40^{bc}±1.121	6.07^{cd}±1.280	6.07^{bc}±1.534	6.40^{cd}±1.183	6.27^{b}±1.486
CPB	8.00^{d}±0.655	8.20^{e} ±0.775	8.20^{e}±0.775	8.27^{d}±0.884	8.07^{c}±0.884

Key: Values = Mean ± SD (SD = standard deviation) of triplicate determination. PPS=Soaked Pigeon pea flour Pudding, PPT=Toasted Pigeon pea flour Pudding, PPB=Boiled Pigeon pea flour Pudding, CPP=Soaked Cowpea flour Pudding (Control), PBS=Soaked Pigeon pea flour Ball, PBT=Toasted Pigeon pea flour Ball, PBB=Boiled Pigeon pea flour Ball, CPB=Soaked Cowpea flour Ball (Control).

Table 1 shows the sensory evaluation of Puddings and Balls made from Soaked Cowpea flour(Control), Soaked Pigeon pea flour, Toasted Pigeon pea Flour and Boiled Pigeon pea Flour. The colour and taste parameters of sample CPP was more preferred to that of PPS and PPB. The taste of sample PPT was least liked among sample PPS, PPB and CPP. The texture of sample PPS was neither liked

nor disliked. Sample CPP was more acceptable than PPS, PPT and PPB. The colour and taste of sample PBS and CPB were most liked than that of PBB and PBT. The texture of PBT was the least liked sample among PBS, PBB and CPB. Sample CPB was the most acceptable followed by samples PBS and PBB. The least acceptable was PBT.

Discussion

Proximate composition of Soaked, Boiled and Toasted Pigeon pea flours

The findings from this work showed that the proximate composition of flours produced from pigeon peas using soaking, boiling and toasting processing methods yielded varrying nutritional values. The variation can be attributed to the different processing methods used in producing the flours. Only toasting significantly ($P<0.05$) decreased the moisture and protein of the pigeon pea seed. According to King, Puwasterm (2019), and Akubor, (2019) decrease in fat content due to soaking could be due to the activities of lipases which were activated during soaking. The ash content in this study contradicts that of Akubor (2019) who reported that only toasting increased the ash content of the pigeon pea flour due to concentration effect. The carbohydrate contents of the soaked and boiled pigeon pea seed flours were slightly lower than that of toasting. The decrease in carbohydrate content could be due to alpha amylase activity which broke down complex carbohydrates into simpler and more absorbable sugars. Only toasting and soaking increased the crude fiber content of the pigeon pea seed flour. The increase in the crude fiber content of the pigeon seed on soaking may be attributed to the synthesis of more of the cell wall material. The protein content of boiling was found to be higher than that of toasting, contrary to Osita (2017), who reported that all the processing methods except boiling slightly increases the protein content of pigeon pea, while toasting may have concentrated the proteins in the pigeon pea seed. The protein content of boiling also contradicts Akubor and Obiegbunam (2019), who reported that soluble proteins of the pigeon pea seed may have leached into the boiling water during the boiling process. The results indicate that there is significantly compositional difference between soaked pigeon pea flour, boiled pigeon pea flour and toasted pigeon pea flour in their levels of proximate contents.

Vitamin and Mineral composition of soaked, boiled and toasted pigeon pea flours.

The ash content of a a food sample is an index of the mineral elements of such food sample. The general low or high content of vitamins and minerals in this study can be attributed to the ash content of the flours. Toasting may have concentrated the content of Phosphorus by loss of moisture. The relative decrease in the iron content due to toasting was probably caused by leaching of the minerals while heating. Iron is needed for the formation of haemoglobin and adequate iron in the diet will reduce the risk of iron defiency anaemia as insufficient iodine in diet also will lead to goitre (Short & Domagalski, 2013). Toasting significantly increased the folate concentration of the pigeon pea flour. The folate content was observed to be high in this study and toasting increased the concentration. The vitamin B_3 content of the results are in agreement with the reports that boiling leads to decrease in the vitamins while soaking leads to increase in vitamin content of pigeon pea seeds (Fadahunsi, 2019). Niacin (vitamin B_3) facilitates lipid catabolism and plays a key role in tricarboxylic acid cycle.

The sensory evaluation of the puddings and balls revealed that there were significant differences between the parameters. Pigeon pea flour from soaking and boiling processing methods were better utilized for pudding and balls preparation than toasted pigeon pea flour. These different reactions to the pudings and balls may be due to the different rates of preference and acceptable values of panelist and the quality of the puddings and balls that were produced. The mouth feel of any product, called texture is the sensory manifestation of the structure and is one of the most important parameter connected to product quality (Jemziya & Mahendran, 2015). The puddings and balls made from toasted pigeon pea flour showed the least mean value for texture, colour, flavour, taste and general acceptability thereby being the least liked among the samples. Taste is the primary factor that determines the acceptability of any product, which has the highest impact as far as market success of the product is concerned. Beside the cowpea puddings and balls which were used as control being the most preferred among the samples, puddings and balls made from Soaked and Boiled Pigeon pea flours were also liked. Pigeon pea balls made from Soaked pigeon pea flour were liked slightly in taste, texture,

color and flavour. The researcher believes that public enlightenment on the nutritional importance of puddings and balls made from soaked, toasted and boiled pigeon pea flours would enhance the acceptibility of it's usage in the production an d consumption of pastries, puddings, balls, composite flours.

Conclusion

Based on the findings of this study, it was found that the flours contain a high amount of protein, and folate (vitaminB_9) although limited in fibre content. The vitamins and mineral contents were of appreciable quantity when compared to that of a raw pigeon pea seed. According to Center for Disease Control and Prevention (CDC), The Recommended Daily Allowance for folate for men and women ages between 19 years and above is 400mcg, while pregnant and lactating women require 600mcg and 500mcg. The pigeon pea flours produced contain an appreciable amount of folate and therefore is highly recommended.

Recommendations

The following recommendations were made based on the findings of the study;

1) The pigeon pea should be used to make different snacks such as puddings and balls as well as utilized and incorporated into daily diets to improve the nutritional values of foods.
2) Pigeon pea flours should be incorporated in the production of pastries to promote food diversity and improve nutrition quality of pastries.
3) The use of toasting processing technique to improve the folate content of the flour, especially when preparing diets of women in low income families should be adopted
4) Nutrition education should be given to mothers and home makers by Nutritionists during women conferences and meetings, antenatal and postnatal classes to sensitize them on the nutrient organoleptic qualities the pigeon pea puddings and balls.

REFERENCES

Akubor PI, Obiegbunam J.E. (2019). Cereal chemical and functional properties of ungerminated and germinated milled flour. *Journal Food Science and Technology*, 3, 241-243.

Akubor, P.I., (2019). Evaluation of the chemical composition and sensory properties of complementary foods prepared from germinated cowpea and sweet potato flour blends. *Nigerian Journal of Nutritional Science,* 1, 11-19.

Amarteifio J.O, Muntali D.C, Karikar S.K, Morake T.K. (2014) The composition of pigeon pea (Cajanus cajan) grow in Botswana. *Plant Foods for Human Nutrition,* 57:175-177.

AOAC. (2005). Association of Official Analytical Chemists. Official methods of Analysis 17th Edn. Washington DC: AOAC International.

AOAC. (2010). Association of Official Analytical Chemists. Official methods of Analysis 17th Edn. Washington DC: AOAC International.

Fadahunsi, I. F (2019). The effects of soaking, boiling and fermentation with Rhizopus oligosporous on the water soluble vitamin content of bambara groundnut. *Parkistan Journal of Nutrition.* 8: 835-840.

Fasoyiro, S.B., Ajibaded, S.R., Omole, A.J., Adeniyan, O.N., & Farinde, E.O. (2016). Proximate, mineral and anti-nutritional factors of some under-utilized grain legumes in South-West Nigeria. *Nutrition Food Science*, 38, 18-23.

Fasoyiro, S.B., Akande, S.R., Arowora, K.A., Sodeko, O.O., Sulaiman, P.O., Olapade, C.O., & Odiri, C.E. (2015). Physico-chemical and sensory properties of pigeon pea (Cajanus cajan) flours. *African Journal of Food Science,* 3, 120 – 126.

FAO STAT, FAO Statistic Division, (2015). Doi: http://faostat.fao.org/faostat/collections?version=ext&hasbulko&subset=agriculture.

Ghadge, P.N., Vairagar, P.R., & Prasad, K. (2018). Some physical properties of chickpea split (Cicer arietinum L.). *Agricultural Engineering International: The CIGR Ejournal*, 10, 07-039.

Hogh-jensen H (2014). To meet future food demands we need to change from annual

grains to multipurpose semi-perenial legumes in Aladjadjiyan . A (editor). Food production-approaches, challenges and tasks . Rijek: In Technology: 1-24.

Igbedioh, S.O., Olugbemi, K.T., Akpapunam, M.A. (2015). Effect of processing methods on phytic acid level and some constituents in bambara groundnut and pigeon pea. *Journal of Food Chemistry*, 50, 147-151.

Jemziya, M. & Mahendran, T. (2015). Quality characteristics and sensory evaluation of biscuits produced from composite blends of sweet potato (Ipomoea batatas L.) and wheat (Triticum aestivum L.) flour. *Sri Lanka Journal of Food and Agriculture*, 2; 22-30.

King, R.D., Puwasterm. P. (2019). Effect of germination on the proximate compositon and nutritional quality of winged beans (Psophocarpus tetragolobus) seeds. *Journal of Food Science*, 51, 52-60.

Odeny, D.A. (2017). The potential of pigeonpea (Cajanus cajan (L.) Millsp.) in *Africa Natural Resources Forum*, 31, 297 – 305.

Osita, B.U., (2017). Amino acid, fatty acid and mineral composition of pigeon pea (Cajanus Cajan). *International Journal of Food Science and Nutrition*, 3, 181-191.

Rachie, K.O, & Wurster, R., (2017). The potential of pigeon pea (Cajanus cajan) as a horticultural crop in East Africa. *1 SHS Acts Hortict*ive, 21, 1-5.

Rao V.S., Vakie U.K., & Layam S.S. (2016). Pigeon pea as important food source. *CRC Critical Review in Food Science and Nutrition*, 23,103-141.

Saxena, K.B., Kumar, R.V & Gowda, C.L., (2014). Vegetable pigeon pea – a review. *International crops research institute for semi- arid tropics, Patanchenru, India*, 2, 91-98.

Short, M. & Domagalski, J. (2013). iron deficiency anemia: evaluation and management. *American family physician*, 2, 98-104.

SPSS. Statistical package for social sciences (SPSS) (2008). version SPSS 20.0. SPSS Inc., Chicago, IL, USA.

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Recommendations	Not adequate

Bibliography/References:	Rework

Others:	**See the pane for other observations**
Decision:	Publishable with minor corrections