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Research Article

Production of cookies from sorghum-pigeon pea flour under different processing methods

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Abstract

Consumption of sorghum has been linked to reduced risk of some cancers in humans. However, sorghum contains 60-80 % starch and thus needs to be fortified with affordable source of other essential nutrients needed particularly by children. In view of this, this research is to evaluate the nutritional and functional properties of sorghum-pigeon pea flour under different processing methods and to determine acceptability of cookies made from the composite flour. The composite flour of different ratio (100%, 90:10%, 80:20%, 70:30%, 60:40%) from blends of sorghum and pigeon pea flour are produced. At 5% level of significance, proximate analysis revealed that moisture content, ash content, fat content, crude fibre, protein content and carbohydrate content ranged from 7.66-10.23%, 2.24-2.94%, 4.18-8.13%, 1.64-2.12%, 9.23-18.94%, and 61.16-71.83% respectively; Mineral analysis of the composite flours pointed out that calcium, phosphorus, iron, zinc, magnesium and potassium content ranged from 92.20-137.62 mg/100g, 1.94- 2.81 mg/100 g, 3.02-5.61 mg/100 g, 2.03-3.41 mg/100 g, 120.41-149.63 mg/100 g and 124.14-290.11 mg/100 g respectively; and Functional properties of the flours showed that bulk density, water absorption capacity, oil absorption capacity, dispersibility, swelling power and water solubility index ranged from 0.50-0.65 g/ml, 160-190 g/ml, 141-171 g/ml, 70-76%, 5.15-8.47 g/g and 2.62-5.21% respectively. Consumer perception of the products indicated that cookies with up to 20% pigeon pea were most preferred and accepted.

Keywords: Composite flour, Processing, Analyses, Functional properties, Method, Acceptability

INTRODUCTION

Flour is a granular substance derived from cereals and other crops with high starch content. Composite flour is characterized by blend of flours originating from roots, tubers, cereals, and legumes with or without wheat flour (Adeleke et al., 2010). Foods undergo physical, chemical, structural, and sensory changes as a result of roasting. Roasting in foods aid development of flavour, color, and palatability and it also increases antioxidant activity by forming the maillard reaction in the products, which is one of the desired outcomes.

Several strategies have been employed to improve food quality such as germination, fermentation, roasting, boiling and irradiation. The physicochemical qualities of the grains and potential dietary applications could be affected by processing procedures. The inactivation of various Proteases, lipases, lipoxygenases, amylases and other oxidative and hydrolytic enzymes found in foods is improved by moderate heat treatment of the grains without development of harmful byproducts (Akubor, 2017).In pigeon peas boiling kills the protease inhibitors and cyanogens. The tongue feel of dishes has been believed to be improved by toasting and boiling of the grains. Foods that have been fermented have a longer shelf life have more flavour and have less anti-nutritional elements. The ability of seeds to absorb water and the protein solubility of winged beans seeds increases with germination. Millet flour's ability to bind oil has been reported to increase with germination, while flour's ability to absorb water reduces (Julianti et al., 2015).

Sorghum (*Sorghum bicolor L.*) is the fifth most significant cereal in the world. It shows greater resistance to drought

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than wheat and maize. Nigeria is the third largest world processor of sorghum after the United States and India, and the third-largest producer in Africa (Nwakalor et al., 2014). Investigation revealed that utilization of sorghum in complementary foods improves its phytochemical properties (Ocheme et al., 2015).

Pigeon pea (*Cajanus cajan L.)* is an important nourishing grain in the tropics. It is rich in protein (19-26%) and minerals (Adeola et al., 2017a). The anti-nutrients in pigeon pea are easily removed during processing. Although Pigeon pea is indigenous to many communities in south western Nigeria, it is grossly underutilized and it is virtually unknown to many of the young people in the communities. More importantly, the utilization of pigeon pea to improve protein quality of high starchy staple foods had been reported by (Muoki et al., 2012).

To boost the protein and micronutrient content of sorghum as a cereal, addition of Bambara groundnut, yam bean, African breadfruit and pigeon pea to the diet using standard formulation improves nutritional composition of the crop. Supplementation in food like this has been utilized in quality production such as weaning food (sorghum/pigeon-pea blends) and millet pigeon-pea blend biscuits (Mbaeyi et al., 2013). Legumes are rich in protein and can be used as substitute for animal protein which has become prohibitively expensive for the poor and low income earners. The flour made from legumes has been reported to be beneficial and useful in solving animal protein scarcity (Chinomnso et al., 2017). Increased consumption of dietary beans has also been encouraged by nutritionists. However, Many healthy dishes have been made in Nigeria from widely grown legumes such as cowpea because of its peculiar tends to overshadow the relevance of other legumes. Pigeon pea is underutilized, rich in minerals, amino acid lysine (19-26%) and thus, a good source of amino acid supplement with sorghum (Adeola et al., 2017b). Research revealed that anti-nutrients in pigeon pea are easily removed by processing.

Consumption of sorghum has been linked to reduced risk cancer in humans and promotion of cardiovascular health in animals (Awika et al., 2004). Sorghum contains 60-80% starch and thus needs to be riched with affordable source of other essential nutrients needed by children. Legumes generally have high protein content when compared to other plant food and because of its chemical and nutritional properties legume proteins are commonly employed in foodstuff formulas to supplement cereal grains (Okoye et al., 2018). In view of this, the aim of this research is to evaluate nutritional and functional properties of sorghum-pigeon pea flour under different processing methods and to determine acceptability of cookies made from the composite flour.

MATERIALS AND METHODS

Materials

Sorghum seeds and pigeon pea were bought in Oja Odan market in Yewa North Local Government in Ogun State, Nigeria. All the analyses were carried out in Food Technology Laboratory, Bells University of Technology, Ota, Nigeria between February and August, 2021.

Preparation of sample

The seeds were washed to remove foreign contaminants and stored in jute bags. The seeds were then subjected to five processing methods (raw, toasting, boiling, germination and fermentation) as described by (Akubor, 2017).

Preparation of raw sorghum and pigeon pea and flour

The sorghum and pigeon pea seeds were soaked in water at 30ºC for 60 minutes, then manually dehulled, oven dried at 60ºC for 3 hours and milled. The powder was filtered using a 60 mesh sieve (0.1 mm), packed in HDPF bags, and stored at 30ºC on a laboratory bench until needed.

Preparation of toasted sorghum and pigeon pea flour

In an air convection oven, the cleaned sorghum and pigeon pea seeds were roasted on trays at 120ºC for 30 minutes with occasional mixing. The kernels were processed in an attrition mill and passed through a 60 mesh sieve after the toasted seeds were manually dehulled (0.1 mm).

Preparation of boiled sorghum and pigeon pea flour

Sorghum and pigeon pea seeds were cooked for 60 minutes in boiling water at 100ºC, cooled, dehulled by hand, oven dried at 60ºC for 3 hours, ground in an attrition mill, and sieved through a 60 mesh sieve.

Preparation of germinated sorghum and pigeon pea flour

Surface sterilization of sorghum and pigeon pea seeds was achieved using a 1.5% sodium hypochlorite solution followed by a 20-minute soak in 70% ethanol. The seeds were carefully cleaned and steeped in tap water for 6 hours. In three duplicates, the hydrated seeds were placed uniformly on layers of wet jute bags in big petrish dishes and germinated for 5 days in the dark. At regular intervals, the jute bags were soaked. The seeds that did not germinate were discarded. The sprouting seeds were rinsed with tap water before being dried in the oven at 60ºC for 3 hours. The kernels were milled and filtered through a 60 mesh sieve in an attrition mill.

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Preparation of fermented sorghum and pigeon pea flour

As reported by a portion of the raw sorghum and pigeon pea flour was blended with water in a covered plastic dish at a 3:2 (water: flour) ratio. The paste was fermented for 5 days and then oven dried at 60ºC for 3 hours, attrition milled, and screened through a 60 mesh sieve. Prior to usage, all flour samples were stored in a 0.77 mm thick high density polyethylene (HDPE) bag.

Blend formulation of processed sorghum and pigeon pea flour

Five composite flours were prepared by blending the processed sorghum flour (SF) and Pigeon pea flour (PF) in the ratios of 100:0, 90:10, 80:20, 70:30 and 60:40 respectively. Where sample A is 100%pigeon pea flour, sample B is 90:10, sample C is 80:20, sample D is 70:30, sample E is 60:40 and sample F is 100% sorghum flour respectively.

Proximate analysis

Proximate analyses as described by technique were carried out to determine percentage of moisture, ash, protein, fat, crude fiber and carbohydrate content of the samples.

Moisture content determination

Moisture content was determined; 2 g of the sample was weighed into a previously weighed Petri plate and then transferred to a constant weight in an oven set at 100ºC. The sample was taken out and placed in a desiccator for 10 minutes to cool before being weighed.

Where W1= weight of empty crucible; W2= weight of crucible + sample before drying; W3= weight of crucible + sample after drying.

Ash content determination

The sample (2 g) was weighed into a weighted crucible that had previously been dried in an oven and chilled in a desiccator. It was then charred with an electric heater before being transported to a muffle furnace at 600°C for 6 hours. After cooling in the desiccator, the crucible with the sample was weighed.

Crude fat determination

1 gm of each sample was weighed and softly blocked with cotton wool in a fat-free extraction thimble. The thimble was fitted with a reflux condenser and put in the extractor. Soxhlet flask (250 ml) that had been dried in the oven and cooled in the desiccators was weighed and petroleum ether at boiling point 40ºC - 60ºC was added to 34% of the volume of the soxhlet flask. For condensation of the ether vapor, the flask, extractor, and condenser set were placed on the heater for 6 hours with constant running water from the tap. The set was then washed with ether leaks on a regular basis, and the heat source was adjusted to allow the ether to brill softly. The sample thimble was dried on a click glass bench top, the extractor and condenser were replaced, and distillation resumed until the flask was almost completely dried. The flask containing the fat and oil was removed, cleaned, and dried in the oven to a constant weight.

Where W0 = Initial weight of dry soxhlet flask; W1 = Final weight of oven dried flask + oil/fat

Crude protein determination.

To guarantee that all components reach the bottom of the tubes, in the kjeldahl digestion tubes, 0.5 g of each sample was carefully weighed. Before setting in the appropriate hole of the digesting block heaters in a fume cupboard for 4 hours, 1 kjeldahl catalyst tablet and 10 ml concentrated were added. After cooling the digest, it was carefully placed into a 100 ml volumetric flask; the digestion tube was thoroughly washed with distilled water. 5 ml of the digest was pipette into the distillation device, followed by 5 ml of 40 percent NaOH. The mixture was steam distilled for 2 minutes into a 500 ml conical flask containing 10 ml of 2% boric acid and mixed indicator solution, which was then put at the condenser's receiving top. In a 50 ml burette, the solution was titrated against 0.01 N HCl.

Crude fibre determination

Two (2) g of sample was weighed into a 600 ml long beaker, 200 ml of hot 1.25% was added, and the mixture was then placed in digestion equipment with pre-heated plates. To hydrolyze the carbohydrates and protein, this was allowed to boil and reflux for 30 minutes. After that, the filtrate was filtered through what man paper and the residue was washed with distilled water until it was neutral. The residue was transferred to the beaker and 200 ml NaOH was added before returning to the digesting apparatus to boil and reflux for 30 minutes (this affect the saponification of fat). The filtrate was filtered and washed with distilled water until it was neutral. After that, the residue was placed in the crucible and dried at 100ºC overnight. It was placed in the furnace at 600°C for 6 hours after cooling in the desiccators and weighed (A). It was weighed again as B after cooling.

Carbohydrate content determination

Carbohydrate content is determined by subtracting the sum of the moisture, crude protein, crude fat, crude fiber and ash content from 100.

Carbohydrate (%) = 100 – (% moisture +% protein + % fat + % fibre + % ash) … (6)

Mineral content determination

The mineral content of the flour and its composites was determined using (Mbaeyi et al., 2013) technique, 2.5 ml of 0.03 N hydrochloric acid was used to digest 1 g of dried materials (HCl). The digest was cooked for 5 minutes, cooled at room temperature before being transferred to 50 ml volumetric flask and diluted to the desired consistency. The resultant digest was then filtered through an ash less filter. Filter paper No.1 using an atomic absorption spectrophotometer, the mineral content of each sample's filtrate (calcium, iron, zinc, magnesium, potassium, and phosphorus) was determined using Buck scientific atomic absorption emission spectrophotometer model 200-A, 1992 (Mbaeyi et al., 2013). The true values were calculated using the standard curves as a guide. For each ion, the values obtained were corrected for HCl-extractability. All of the tests were carried out in triplicates.

FUNCTIONAL PROPERTIES

Water absorption capacity

One (1) g of flour was mixed with 10 ml of distilled water or oil in a centrifuge tube. The suspension was centrifuged for 15 minutes at 2200 rpm after one hour of agitation on a griffin flask shaker. The volume of water or oil in the sediment water was measured. The ability to absorb water and oil was measured in milliliters of water or milliliters of oil per gram of flour.

Swelling power and solubility

The approach outlined by (Adeleke et al., 2010) was used to determine swelling power and solubility. In a centrifuge tube, 1 g of composite flour was combined with 10 ml distilled water and cooked at 80ºC for 30 minutes. During the heating process, this was constantly shaken. The tube was taken out of the bath, wiped dry, cooled to room temperature (28ºC) and centrifuged at 2200 rpm for 15 minutes. To determine the solubility, the supernatant was evaporated and the dry residue weighed. The swelling power was determined by weighing the swollen sample (paste) obtained by decanting supernatant. The swelling power was calculated by dividing the paste weight by the dry sample weight.

Bulk density

Approach was used to determine bulk density. In a 50 ml graduated measuring cylinder, weighing a known amount of sample. From a height of 5 cm, by gently tapping the cylinder on the bench top, the sample was packed and the sample volume was measured (Adeleke et al., 2010)

Dispersibility

To reach a volume of 100 ml, 10 g of flour was suspended in a 100 ml measuring cylinder and it was filled with distilled water. The set up was aggressively agitated and allow the mixture to rest for 3 hours. From a total of 100, the volume of settling particles was measured and subtracted. The disparity was expressed as a percentage of dispersibility.

Sensory evaluation

The consumer study had a total of twenty untrained panelists. Pre-screening forms were handed out to each panelist that asked about their age, gender, level of education, frequency of cookies consumption, cookies shopping habits, and potential food sensitivities. Members of the panelist that had food allergy were requested to withdraw from the study. Informed consent forms were also signed by panelists to inform them of the study's goal and guidelines. Samples were placed on white paper plates and labeled with random three-digit codes. To eliminate prejudice, the panelists were instructed to test each sample in the sequence stated. Between samples, they were given unsalted crackers and distilled water to wipe their palates. The biscuit samples were judged on a 9-point hedonic scale (9= strongly like; 5= neither like nor dislike; 1= extremely dislike) to determine the degree of likening for five sensory attributes: Colour, texture, taste, aroma and overall acceptability.

Statistical analysis

With statistical package for social sciences version 16.0 for Windows, data was examined using analysis of variance (ANOVA) to identify difference sample means and Duncan's Multiple Range Test (DMRT) to separate the means at 5%.

RESULTS AND DISCUSSION

Processing methods on the proximate analysis

The effect of the combined processing methods on the proximate composition of sorghum and pigeon pea flour is presented on **Table 1**. The moisture content ranged from 7.66 to 10.23%, ash content ranged from 2.24 to 2.94%, fat content ranged from 4.83 to 8.13%, crude fibre ranged from 1.64 to 2.12%, protein content ranged from 9.23 to 18.94% and carbohydrate content ranged from 61.16 to 71.83% respectively.

There was significant difference in the proximate composition of the composite flour at 5% level of significance. The highest moisture level was found in sample F while the lowest was found in sample D. This is in accordance with result given by (Mbaeyi et al., 2010) whose moisture content ranged from 8.05 to 10.00%. Flour can be stored for a long time as long as the moisture level does not exceed 10% (Adebowale et al., 2005).

Low moisture content in flour inhibits mould growth and dampens moisture-dependent biological responses As a result dried products with reduced moisture content have a longer shelf life. The dry matter content of a food is determined by its moisture content. The highest protein

Table 1. Proximate composition of sorghum and pigeon pea flour blends.

Sample	Composition (%)					
	Moisture	Ash	Fibre	Fat	Protein	Carbohydrate
A	8.46 ± 0.05[c]	2.93 ± 0.05[a]	1.91 ± 0.01[b]	5.24 ± 0.01[d]	13.16 ± 0.04[d]	68.30 ± 0.05[b]
B	7.94 ± 0.02[d]	2.53 ± 0.01[b]	2.03 ± 0.01[a]	5.50 ± 0.05[c]	13.44 ± 0.02[c]	68.53 ± 0.04[b]
C	8.03 ± 0.05[c]	2.64 ± 0.01[b]	2.12 ± 0.05[a]	5.73 ± 0.01[c]	13.53 ± 0.01[c]	67.95 ± 0.01[c]
D	7.66 ± 0.05[d]	2.52 ± 0.05[b]	1.95 ± 0.05[b]	8.13 ± 0.05[a]	16.91 ± 0.05[b]	62.83 ± 0.05[d]
E	9.03 ± 0.05[b]	2.94 ± 0.01[a]	1.90 ± 0.01[b]	6.03 ± 0.01[b]	18.94 ± 0.05[a]	61.16 ± 0.05[d]
F	10.23 ± 0.03[a]	2.24 ± 0.01[c]	1.64 ± 0.05[c]	4.83 ± 0.02[e]	9.23 ± 0.01[e]	71.83 ± 0.03[a]

Values were mean ± standard deviation of triplicate determinations. Values with different superscripts within the same column are significantly different from each other (p≤0.05).

Legend: A = 100% Pigeon pea**;** B = 90:10 Sorghum Pigeon pea**;** C = 80:20 Sorghum Pigeon pea**;** D = 70: 30 Sorghum Pigeon pea; E = 60:40 Sorghum Pigeon pea; F = 100% Sorghum

content was found in sample E while the least value was found in F. This is closely related to 12.61 to 20.75% reported by (Adeniyi et al., 2014). The significant increase in protein content could probably be attributed to the high protein content of pigeon pea flour. In many regions of developing countries, like Nigeria, adequate protein intake is a serious nutritional issue because the cost of animal-based protein is high and out of reach for many poor and low income earners (Ekpo, 2011).

The high crude protein content of sorghum and pigeon pea flour indicates that the composite flour can be used as a low-cost protein source for Africans. However (Chandra et al., 2015). Recommended nutritional intake for infants aged 4 to 6 months (1.30 g/kg per day), 7-9 months (1.25 g/kg per day) and 10-12 months (1.15 g/kg per day), the various blends provided additional protein consumption. Proteins are necessary for children's growth and development because they assist the body in the formation of new tissues and the repair of worn-out tissues.

The Ash content was in accordance to (Olagunju et al., 2018). Whose ash content ranged from 2.56 to 3.68%. The fat content is in variance with (Adeola et al., 2017a) whose fat content ranged from 2.57 to 2.94%. This could probably be as a result of inclusion of pigeon pea flour and the combined processing method. Ash is used to identify mineral elements in food since it is the inorganic residue remaining after water and organic matter have been removed by heating in the presence of an oxidizing agent (Sanni et al., 2016). The crude fibre content differed from that of (Adeniyi et al., 2014) who reported a crude fiber content of 5.31 to 7.05%. This could be due to differences in crop varieties and processing methods. In order to lose weight and reduce fat, fibre-rich foods have been used. They help to regulate satiety, as well as reducing energy intake from food (Ekpo, 2011). According to scientific studies, one of the physiological functions of crude fibre in the human body is to maintain an internal pressure that allows the intestinal tract to move freely (Oduor et al., 2008) to avoids constipation (Groff et al., 2015).

The decrease in carbohydrate from sample B to E was as a result of increasing proportion in pigeon pea and the carbohydrate content of wheat-cassava and soy composite flour was similarly reported by (Oluwamukomi et al., 2011) to be 69.2 to 74.5%. These results showed that sorghum and pigeon-pea flour are good sources of carbohydrate.

Processing method on the mineral analysis

The effect of combined processing methods on the mineral analysis of blends of sorghum and pigeon pea flour is presented in **Table 2.** The result showed significant differences in the mineral composition of the composite flour at 5% level of significance. The Calcium, phosphorus, iron, zinc, magnesium and potassium content ranged from 92.20 to 137.62 mg/100 g, 1.94 to 2.81 mg/100 g, 3.02 to 5.61 mg/100 g, 2.03 to 3.41 mg/100 g, 120.41 to 149.63 mg/100 g and 124.14 to 290.11 mg/100 g. Sample F had the least value of iron, magnesium, calcium, phosphorous, zinc, and potassium content while sample E had the highest value of the minerals. The level of minerals in sample E might be as a result of blends and combined effect of the processing methods.

Mineral leaching into the water resulted in a drop in calcium, potassium, and magnesium (FAO/WHO, 2007). The activities of hydrolytic enzymes during the sprouting period may contribute to the release of additional free calcium from its organic complexes (Obizoba et al., 2014). The observed rise in phosphorous levels in the treated flours could be due to the nutrients being used for metabolic activities during sprouting, resulting in the preference. The mineral content increased as the proportion of pigeon pea increases while that of sorghum decreases.

Mineral concentrations were found to be higher in blended samples (B, C, D and E) than in 100% samples (A and F). A number of minerals form compounds with anti-nutritional agents, lowering their bioavailability and more minerals are released from their bound complexes with anti-nutrients when the metabolic enzymes of sprouting increased (Obizoba et al., 2014). Thus, Sprouting boosted the mineral levels in the treated samples. Zinc is a component of every living cell and plays an important role in body functions; enzymes reaction during blood clotting, wound healing and vision as reported by Mariam (2005). Potassium is necessary for maintaining total body fluid volume, electrolyte balance, acid balance, and appropriate cell activity (Sodipo et al., 2018). Magnesium is necessary for bone structure, nervous system function, and reproduction. In plant cells, it helps in Adenosine (Triphosphate ATP) production, glucose, fat, and protein storage, as well as Activity of nerves and muscles (Bello et al., 2017).

Processing methods on functional properties of sorghum and pigeon pea flour

Table 3. showed significant differences ($p \leq 0.05$) in the composite flour's functional properties. The bulk density ranged from 0.50 to 0.65 g/ml. Sample D and E had the lowest in the blends probably because of low proportion of sorghum flour while sample F had the highest. This is in accordance to (Adeniyi et al., 2014) who reported 0.46 to 0.74%. The dispersibilities of the flour blends ranged between 70 and 76% where sample F had the lowest and sample A had the highest. The result is closely related to who reported 64.67 to 70%. The swelling power values ranged between 5.15 to 8.47 g/g where sample A had the lowest and sample E and F had the highest. The water solubility index ranged from 2.62 to 5.21% where sample F had the lowest and sample E had the highest percentage. This is in agreement with (Adeola et al., 2017a) who reported 3.67 to 5.33%.

There was significant variation in the water absorption capacity of the flour blends. It ranged from 160 to 190 g/ml where sample F had the lowest and sample A had the highest while in the blends, sample B had the highest water absorption capacity. The oil absorption capacity ranged from 141 to 171 g/ml, while sample E had the lowest and sample A had the highest. The water absorption index of flour granules during heating is measured by swelling power (Adeleke et al., 2010). The swelling power of the mixes was nearly identical, which could be attributable to similar composition. The low swelling power in pigeon pea has been attributed to a high degree of intermolecular association and high amylase content compared to sorghum. Low solubility levels could suggest a low level of starch breakdown during flour milling. Water absorption capacity is a measure of granular integrity, which defines the strength of associative forces between starch granules and hence the number of molecular surfaces available for water molecule binding.

There was insignificant difference in the water absorption capacity of the blends and even then the water solubility

Table 2. Mineral analysis of sorghum and pigeon pea flour blends.

Sample	Mineral (mg/100g)					
	Ca	P	Fe	Zn	Mg	K
A	92.20 ± 0.03^{d}	1.94 ± 0.01^{d}	3.02 ± 0.03^{d}	2.03 ± 0.03^{d}	120.41 ± 0.05^{d}	124.14 ± 0.01^{e}
B	112.13 ± 0.01^{c}	2.22 ± 0.01^{c}	4.44 ± 0.0^{c}	2.43 ± 0.03^{c}	134.13 0.02^{c}	190.12 ± 0.01^{d}
C	125.93 ± 0.03^{b}	2.34 ± 0.04^{c}	5.03 ± 0.02^{b}	2.63 ± 0.01^{c}	142.74 ± 0.01^{b}	210.23 ± 0.03^{c}
D	130.32 ± 0.04^{a}	2.56 ± 0.01^{b}	5.13 ± 0.01^{b}	3.02 ± 0.03^{b}	144.02 ± 0.03^{b}	245.23 ± 0.01^{b}
E	137.62 ± 0.08^{a}	2.81 ± 0.02^{a}	5.61 ± 0.03^{a}	3.41 ± 0.03^{a}	149.63 ± 0.01^{a}	290.11 ± 0.01^{a}
F	65.34 ± 0.01^{e}	1.42 ± 0.01^{e}	2.04 ± 0.01^{e}	0.94 ± 0.02^{e}	113.02 ± 0.03^{e}	103.04 ± 0.01^{e}

Values were mean ± standard deviation of triplicate determinations. Values with different superscripts within the same column are significantly different from each other ($p \leq 0.05$).

Legend: A = 100% Pigeon pea; B = 90:10 Sorghum Pigeon pea; C = 80:20 Sorghum Pigeon pea; D = 70: 30 Sorghum Pigeon pea; E = 60:40 Sorghum Pigeon pea; F = 100% Sorghum

Table 3. Functional properties of sorghum and pigeon pea flour blends.

Parameter	Sample					
	A	B	C	D	E	F
Bulk density (g/ml)	0.53 ± 0.01^{b}	0.53 ± 0.07^{b}	0.51 ± 0.00^{c}	0.50 ± 0.03^{c}	0.50 ± 0.05^{d}	0.65 ± 0.01^{a}
WAC (g/ml)	190 ± 0.00^{a}	185 ± 0.00^{b}	175 ± 0.00^{c}	171 ± 0.01^{c}	163 ± 0.01^{d}	160 ± 0.03^{d}
OAC (g/ml)	171 ± 0.08^{a}	161 ± 0.05^{b}	152 ± 0.00^{c}	143 ± 0.01^{d}	141 ± 0.00^{d}	143 ± 0.01^{d}
Dispersibility (%)	76 ± 0.06^{a}	75 ± 0.03^{a}	73.5 ± 0.03^{a}	72 ± 0.02^{a}	70 ± 0.01^{a}	70.5 ± 0.01^{a}
Swelling power (g/g)	5.15 ± 0.02^{d}	5.70 ± 0.04^{c}	6.81 ± 0.01^{b}	8.42 ± 0.06^{a}	8.47 ± 0.01^{a}	8.47 ± 0.01^{a}
WSI (%)	4.36 ± 0.03^{d}	4.81 ± 0.03^{c}	5.08 ± 0.09^{b}	5.16 ± 0.05^{b}	5.21 ± 0.03^{a}	2.62 ± 0.03^{e}

Values were mean ± standard deviation of triplicate determinations. Values with different superscripts within the same column are significantly different from each other ($p \leq 0.05$).

Legend: A = 100% Pigeon pea**;** B = 90:10 Sorghum Pigeon pea**;** C = 80:20 Sorghum Pigeon pea**;** D = 70: 30 Sorghum Pigeon pea;

E = 60:40 Sorghum Pigeon pea; F = 100% Sorghum;WAC = water absorption capacity; OAC= Oil absorption capacity

WSI= Water solubility index

index among the blends did not vary widely. Water absorption varies depending on the polar amino acid in protein and polysaccharides. As a result, the water absorption capacity of the blends could be a reflection of their protein and carbohydrate composition.

Processing methods on sensory properties of the cookies

Effect of processing methods on the sensory attributes of cookies from blends of sorghum and pigeon pea flour is presented in **Figure 1.** The sensory rating for colour, texture, taste, aroma and overall acceptability of the biscuit samples is significantly different (< 0.05) with values that ranged from 6.2 to 7.7, 5.8 to 7.7, 5.4 to 7.2, 5.1 to 7.8 and 5.9 to 7.6, respectively. Sample F had the lowest in colour and texture and sample A had the highest rating for colour and texture. Samples E had the lowest rating for taste and sample A had the highest rating for taste. Sample E had the lowest aroma rating, while sample A received the highest aroma rating. Sample D had the lowest overall acceptability while sample A had the highest overall acceptability. However, processing method causes change in the physical and chemical properties of materials in blended foods and this can apparently alter sensory perception of the consumers.

Preparation of cookies

Four composite flours were prepared by blending the processed Sorghum flour (SF) and Pigeon pea flour (PF) in the ratios of 100:0, 90:10, 80:20, 70:30 and 60:40 respectively **Table 4.**

The various mixes were created by combining processed sorghum flour and processed pigeon pea flour with the same amount of other active components (sugar, baking powder, water, baking fat, egg and salt). The fats and sugar

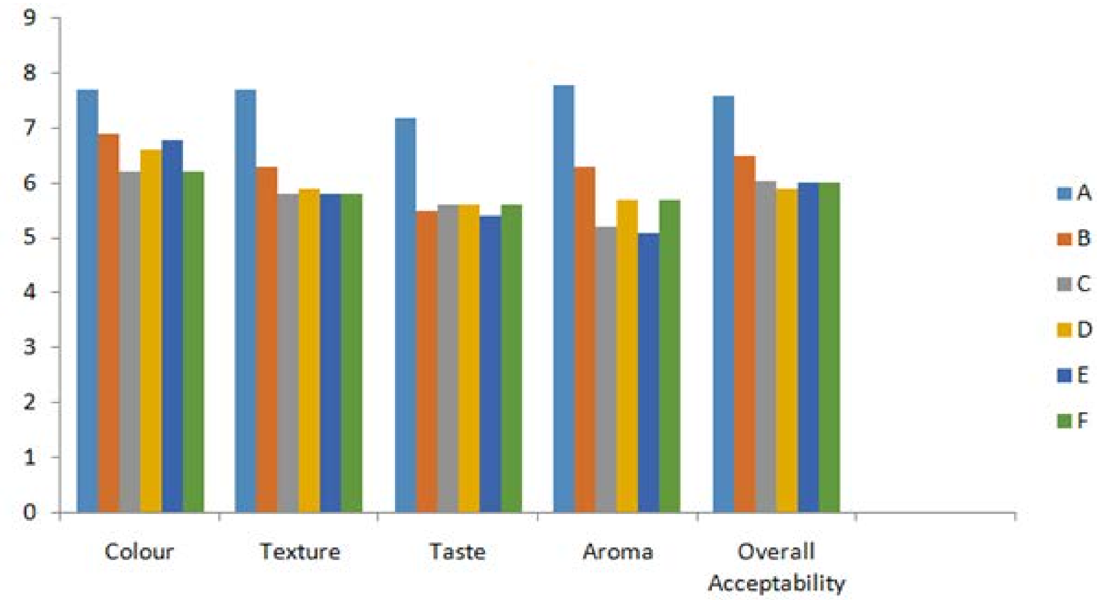

Figure 1: Sensory attributes of cookies from blends of sorghum and pigeon pea flour.

Legend: A = 100% Pigeon pea; B = 90:10 Sorghum Pigeon pea; C = 80:20 Sorghum Pigeon pea; D = 70: 30 Sorghum Pigeon pea

E = 60:40 Sorghum Pigeon pea; F = 100% Sorghum

Table 4. Recipe for the production of cookies.

Sample	Processed Sorghum Flour (%)	Processed Pigeon pea (%)	Fat (g)	Egg (g)	Sugar (g)	Salt (g)	Baking powder (g)
A	100	0	45	30	55	0.6	3.6
B	90	10	45	30	55	0.6	3.6
C	80	20	45	30	55	0.6	3.6
D	70	30	45	30	55	0.6	3.6
E	60	40	45	30	55	0.6	3.6
F	100	0	45	30	55	0.6	3.6

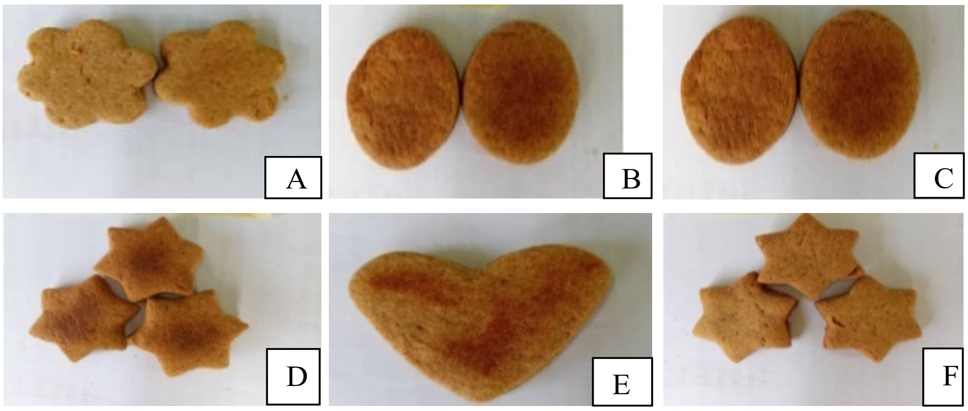

Figure 2: Pictoria diagram of cookiest produced from the blends of sorghum and pigeon pea. a) 100% Pigeon pea, b)90:10 sorghum and pigeon pea; (c) 80:20 sorghum and pigeon pea; (d)70:30 sorghum and pigeon pea; (e)60:40 sorghum and pigeon pea and (f)100% sorghum.

were creamed together until light and fluffy, and then the remaining Ingredients that were dry were added, followed by water until the batter texture was achieved. To achieve the proper thickness, the batters were kneaded on a rolling table. With the use of a biscuit cutter, the batters were cut into desired shapes. It was baked for 20 minutes at 200°C, cooled, and packaged in low density polythene bags before being stored in airtight containers for examination. During production, sample A and F have a lighter color shade when compared to sample B to E because as the proportion of composite flour increases (the pigeon pea increases and the sorghum decreases) the color of the cookies being mixed became darker. Sample E which is ratio 60:40 have an unattractive colour. The cookies are more expensive when compared to other cookies in the market because of the cost of pigeon pea and sorghum.

However the nutritional benefit is more than the conventional biscuit **Figure 2.**

CONCLUSION

Composite flour of different ratio (100%, 90:10%, 80:20%, 70:30% and 60:40%) from the blends of sorghum and Pigeon pea flour was developed. Proximate composition of the flour revealed that sample E had the highest ash and protein content, while samples C, D and F had the highest fibre, fat and carbohydrate content respectively. Mineral analysis showed that sample E had the highest calcium, phosphorus, iron, zinc, magnesium and potassium. Functional properties of the composite flour indicated that sample A had the highest water absorption capacity, oil absorption capacity and dispersibility; sample F had the highest bulk density; water solubility index was found to be highest in sample E while the highest swelling power was discovered in sample E and F. Cookies with satisfactory sensory attributes were made with up to 20% pigeon pea. This research demonstrates potential in pigeon pea inclusion in baked products to promote utilization of the crop. The cookies are therefore recommended for children, youth, young adult and the aged because of its nutritional benefit.

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