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Proximate and Functional properties of Pigeon Pea (*Cajanuscajan*) and Sorghum (*Sorghum bicolor*) flour Blends.

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Abstract

The main purpose of this study was to assess the proximate and functional properties of pigeon pea seeds and sorghum grain flour blends. Specifically the study determined the proximate composition and functional properties (bulk density, water absorption capacity, oil absorption capacity, foaming capacity, emulsion capacity, wettability, swelling index, gelation time and gelation temperature) of the flour blends. Composite flour was formulated by blending the pigeon pea and sorghum flour in the ratios of 4:1, 1:1, 3:2 respectively using 100percent wheat flour as the control. The proximate and functional properties were determined using standard methods. Data were analyzed using means and standard deviation. Results for proximate composition of the flour samples show,among others, that moisture content ranged from 6.93-9.13 percent, ash 1.02-3.29percent, fat 1.84--2.81percent. Sample B which is made from100 percent pigeon pea flour was higher than the other samples in terms of ash, fat, protein, and fiber. Results for functional properties, ranged from 0.71-0.85percent, 0.83-1.37percent, 0.67-1.13percent, 17.95-25.16percent, 33.95-45.89percent, 35.33-71.00percent, 1.76-2.23percent, 12.91-23.53percent and 66.00-78.17percent respectively. This finding show that there were variations among the flour samples, however the flour blends possessappropriate functional properties that could make them suitable for use in development of food products.

Key words: Pigeon pea, Sorghum, Composite, Flour, Proximate, Functional, Properties.

Introduction

Legumes are considered as one of the best protein sources in the plant kingdom. They comprise of high nutritional values, extended storage times and are relatively cheaper compared to animal products(Sanchez, Jimenez Davila, Alvarez, &Madrigd 2015). Pigeon pea (*Cajanuscajan (L)* Millsp) is known as *gungo* pea, red gram, no-eye pea and Congo pea which belongs to the Leguminosae (fabaceae) family and is an important grain legume crop (Fuller, Murphy &Nalk, 2019). Pigeon peas thrive well in different kinds of soil, are very resistant to drought and are able to produce a high yield in very low favorable conditions. According to Arukwe &Nwanekezi (2022),Pigeon pea can survive and produce seeds under hash climatic conditions. Pigeon pea is known for its high adaptation in different soil types and production system at varying latitudes and altitudes and it is attributed to genetic tolerance to various biotic and abiotic stresses particularly insects and drought (Saxena et al 2021). Globally pigeon pea is cultivated on 5.4 million hectare land area with an annual production of 4.49 million tons. In Nigeria pigeon is predominantly grown in the Guinea Savannah agro ecological zones of the Northern and Southern parts of Nigeria (Fatokimi&Tanimonure 2021). Olanipekun, Levbare, Oyelade & Adelakun (2021) noted that pigeon pea is widely cultivated in Nigeria. According to Akubor (2017), presently different varieties of pigeon pea are grown in western and northern states of Nigeria. In Nigeria little consideration has been given to the potential of pigeon pea to contribute to food and income security to poor farming households whose diet is starch based with insufficient income (Esan & Ojemola 2018, Fatokimi &Tanimonure 2021). Recently, National Agricultural Quarantine Service (NAQS) reported that there is an offer of 100billion dollars secured by Nigeria from India to export legumes including pigeon pea and this would help to generate appreciable revenue due to its potentials and nutrition security for households (Ayenan, Danquah, Ofori 2017, Fatokimi&Tanimonure 2021).Despite its significant level of nutrients and strong medicinal properties, pigeon pea is still underutilized (Fatokimi&Tanimonure 2021, Falola, Mukaila, Lawal&Akinsuyi 2022).It is very essential and noted for cheapest sources of protein for majority of people living in developing countries (Maltas, *et al.*, 2011, Soris & Mohan 2011).In Nigeria pigeon pea production has been largely at the subsistence level despite the good and ecological and edaphic conditions of the country which can support its production in higher quantities for consumption and commercialization (Ezeaku et al. 2016).The nutritional components of pigeon pea are considered crucial for human nutrition when compared to other legumes and pulses like Africa yam beans, cowpea, soya beans, and kidney beans. It has been reported to possess high anti-nutritional factors, strong biological, pharmacological activities including antioxidant, antibacterial, anti-diabetic, anti-inflammatory and anti-carcinogenic properties (Adebe, 2022).Pigeon pea can be used as a supplement to cereal-based diet that are deficient in protein, vitamin B and beta carotenes. Medically, it is used to treat measles, hepatitis, diabetes and liver dysfunction (Mashifane, Chiulele&Gwata 2024).

Similarly, sorghum (*sorghum bicolor)* belongs to the grass family. It is the fifth most important cereal in the world after rice, wheat, maize, corn and barley (Okeyo,Hezronand Njeru 2020, Naik, Ahmed and Pati, 2016, Adebo, 2020). Sorghum grains have 95% to 98% of the nutritional value of maize. In Nigeria, sorghum is utilizedin different ways, tuwo a delicacy consumed mostly in the Northern areas, sorghum balls, fura balls, fura (ogi), local beverages anddrinks (Abah, Ishiwu, Obiegbena&Oladejo 2020).It is very versatile in the continent serving as a staple and main meal for millions of people (Adebo, 2020).According to FAO(2019), Nigeria produces sorghum in high quantities 6.9 million tons and 5.4 million hectares of land. Sorghum is the largest staple cereal crop accounting for 50percent of the total output and occupying about 45percent of the total land area devoted to cereal crops production in Nigeria. Sorghum is resistant to drought and heat and can produce marginal soil than other soil playing an important role in food security (Arukwe&Nwanekezi 2022).Utilization of indigenous crops like pigeon pea seeds and sorghum grains as composite flour will help in diversification of our local food crops for sustainability.

Composite flours refers to a mixture of any two or more of these flour obtained from any other local crops like maize, rice, yam, water yam, plantain, cocoyam, millet, kidney beans and so on with or without wheat flour in proper portions to make economic use of locally cultivated crops to produce high quality snacks (Anozie, China & Beleya, 2014). However, in order to improve the utilization of composite flour from locally available food material, it is necessary to carry out evaluation on proximate composition and functional properties analysis on the composite blends.

Proximate composition refers to the six components of food nutrients; they include nitrogen free extract moisture, crude protein, crude fat, crude fiber, crude ash and carbohydrate which are expressed as the content percentage respectively (China 2019). According to Awuchi, Igwe & Echeta (2019), functional properties are physiochemical properties of food that determine how food ingredients behave during processing and cooking, they include water and oil absorption capacity, bulk density, swelling capacity of the particles, solubility and least gelation concentration.. The knowledge of utilization of indigenous crops like pigeon pea seeds and sorghum grains as composite flour will help in diversification of our local food crops for sustainable and healthy households in Nigeria.

Purpose of the study

The general purpose of this study was to assess proximate composition and functional properties of various blends of pigeon pea seeds and sorghum grains flour. Specifically, the study determined:

1. proximate composition of 100 percent (100 %) pigeon pea flour; 100 percent (100 %) sorghum flour, composite flours 4:1 of pigeon pea flour and sorghum, 1:1of pigeon pea and sorghum, 3:2 of pigeonpea and sorghum (Ratios 4:1, 1:1 & 3:2) with 100 percent(100 %) wheat flour as control.
2. functional properties ofthe pigeon pea and sorghum composite flour (bulk density, water absorption capacity, oil absorption capacity, foam capacity, emulsion capacity, wettability swelling index, gelation time and gelation temperature).

Materials and Methods

Design of the Study: The study adopted an experimental research design.

Procurement of Materials: Pigeon pea (*Cajanuscajan)* and sorghum (*sorghum bicolor*) grains and wheat (control) were purchased at Orieugba market, Umuahia, Abia State Nigeria. Chemicals were obtained from the Food Science Laboratory College of Applied Food Science and Tourism,MichaelOkpara University of Agriculture Umudike (MOUAU).

***Sample Preparation*:** Pigeon pea (*Cajanuscajan)* was sorted to remove impurities. It was washed properly and soaked for 24 hours, dehulled, rinsed, drained and oven-dried for 60^{0}C for 24 hours to remove moisture. The dried samples were milled into flour using Nutri-blender and sieved with a US70 (180um diameter) sieve. The flour obtained was stored in an airtight plastic polyethylene bag at room temperature 37^{0}C).Sorghum and wheat were similarly cleaned, oven dried at 50 -55^{0}C for 4 hours, milled, sieved and packaged.

***Sample Formulation*:** Composite flour blends were formulated from processed seeds of pigeon pea, sorghum grains using the following three formulated ratios shown below:

A. 100 percent (100%) Wheat flour was used as the control
B. 100 percent (100%) Pigeon pea flour.
C. 100 percent (100%) sorghum flour
D. 80 percent (80%) Pigeon pea flour and 20percent (20%) Sorghum flour: 4:1
E. 50 percent (50%) Pigeon pea flour and 50percent(50%) Sorghum flour: 1:1
F. 60 percent (60%) Pigeon pea flour and 40percent (40%) Sorghum flour: 3:2

***Determination of Proximate Composition*:** The AOAC (2016) method was used to determine nutrient contents of the various compositions of the six samples (A, B, C, D, E and F). The contents determined for each sample include moisture, ash, fat, crude fibre, curde protein and carbohydrate.

***Determination of functional properties*:** Functional properties of the six samples (A, B, C, D, E and F) were analyzed using Onwuka (2015). The properties determined include: bulk density, water absorption, swelling index, foaming, oil absorption, emulsion capacity, wettability, gelation time, andgelation temperature. Specific standard operations for each sample was carried out.

***Statistical analysis*:** The statistical package for social science SPSS version 23.0 was used. The data was subjected to analysis of variance (ANOVA) and treatment means were separated using Duncan's multiple range testing at a 95% confidence level (P<0.05)

Results

Table 1: Proximate Composition of Composite Flour Blends and Wheat Flour (%)

Samples	A	B	C	D	E	F
Moisture	9.13^{a} ± 0.31	9.10^{a} ± 0.17	7.77±0.35	8.27^{b}±0.31	6.93^{d} ± 0.31	7.13^{d}±0.11
Ash	1,02±0.02	3.29^{a} ± 0.03	1.35^{d} ± 0.02	2.62^{c}±0.03	2.49^{c} ± 0.17	3.02^{b}±0.06
Fat	1.87^{d}±0.06	2.81^{a} ± 0.03	2.16^{c} ± 0.04	2.75^{a}±0.04	1.84^{d} ± 0.05	2.66^{b}±0.04
Crude	11.34^{d}±0.04	23.49^{a}±0.10	10.66^{e}±0.04	21.67^{b}±0.08	9.52^{f} ± 0.07	18.71^{c}±0.10
Crude fiber	1.82^{e} ± 0.11	2.73^{a} ± 0.30	1.94^{d} ± 0.11	2.36^{b} ± 0.29	1.62^{f} ± 0.29	2.18^{c} ± 0.11
Carbohydrate	74.81^{c}±0.23	58.58^{f}±0.33	76.12^{b}±0.46	62.35^{e} ±0.26	77.59^{a} ±0.16	66.30^{d}±0.12

Values are means of data of duplicate determination. Values with the same superscript in the same column are not significantly different (P >0.05). Key: A = 100pecentWheat Flour, B = 100percentPigeon pea Flour, C = 100percentSorghum Flour, D; 80percentpigeon pea and 20percent sorghum flour,(D= 4:1), E: 50percent pigeon pea and 50percent sorghum flour, (E=1:1), F: 60percentPigeon pea and 40percent sorghum flour(F=3:2).

Table 1 shows the results of the proximate composition of sample A (100% WF), sample B (100%PPF), sample C (100% SF),Sample D (80%PPF: 20%SF), Sample E (50%PPF: 50%SF), and sample F (60%PPF: 40%SF). Values for moisture content ranged from 6.93% in sample E to 9.13 % in sample A. The ash content ranged from 1.02 % in sample A to 3.29 % in sample B, Value for fat ranged from 1.84 % in sample E to 2.81% in sample B. Crude protein ranged from 9.52 % in sample E to 23.49 % in sample B. Crude fiber ranged from 1.62 % in sample E to 2.73 % in sample B, Values for carbohydrate ranged from 58.58 % in sample B to 77.59 % in sample E.

Table 2: Functional Properties of the Composite Flour Blends

Sample	A	B	C	D	E	F
Bulk density	$0.78^{d} \pm 0.00$	$0.71^{e} \pm 0.00$	$0.85^{a} \pm 0.00$	$0.78^{d} \pm 0.00$	$0.81^{b} \pm 0.00$	$0.80^{c} \pm 0.00$
Water absorption capacity	$0.83^{b} \pm 0.06$	$1.27^{a} \pm 0.15$	$1.33^{a} \pm 0.06$	$1.37^{a} \pm 0.06$	$1.33^{a} \pm 0.12$	$1.33^{a} \pm 0.12$
Oil absorption capacity	$0.67^{c} \pm 0.05$	$0.94^{b} \pm 0.05$	$0.82^{b} \pm 0.10$	$1.13^{a} \pm 0.11$	$1.09^{a} \pm 0.05$	$0.67^{c} \pm 0.05$
Foam capacity	$19.50^{bc} \pm 1.09$	$21.94^{b} \pm 2.67$	$17.95^{c} \pm 1.09$	$20.12^{bc} \pm 1.09$	$18.24^{c} \pm 1.09$	$25.16^{a} \pm 1.09$
Emulsion capacity	$42.26^{b} \pm 1.03$	$40.46^{b} \pm 0.87$	$36.97^{c} \pm 1.05$	$33.95^{d} \pm 2.14$	$33.95^{d} \pm 2.14$	$42.77^{b} \pm .91$
Wetability	$71.00^{a} \pm 5.00$	$51.00^{b} \pm 3.61$	$35.67^{c} \pm 5.69$	$39.67^{c} \pm 3.51$	$49.67^{b} \pm 6.03$	$35.33^{c} \pm 4.04$
Swelling index	$1.81^{d} \pm 0.04$	$1.90^{c} \pm 0.04$	$2.15^{b} \pm 0.04$	$2.21^{ab} \pm 0.05$	$2.23^{a} \pm 0.08$	$1.76^{d} \pm 0.04$
Gelation time	$17.28^{d} \pm 0.13$	$12.91^{f} \pm 0.48$	$20.29^{b} \pm 0.23$	$14.68^{e} \pm 0.36$	$23.53^{a} \pm 0.55$	$18.77^{c} \pm 0.37$
Gelation temperature	$71.48^{c} \pm 0.08$	$66.00^{e} \pm 0.76$	$73.38^{b} \pm 0.17$	$69.90^{d} \pm 0.40$	$78.17^{a} \pm 0.26$	$73.14^{b} \pm 0.25$

Values are means of data of duplicate determination. Values with the same superscript in the same column are not significantly different (P > 0.05). Key:A = 100pecent Wheat Flour, B = 100percent Pigeon pea Flour, C = 100percent Sorghum Flour, D; 80percent pigeon pea and 20percent sorghum flour,(D= 4:1), E: 50percent pigeon pea and 50percent sorghum flour, (E=1:1), F: 60percent Pigeon pea and 40percent sorghum flour(F=3:2).

Table 2 shows the value for bulk density ranged from 0.71 g/ml in sample B to 0.85 g/ml in sample C. Water absorption capacity ranged from 0.83 g/ml in sample A to 1.37 g/ml in sample D. Values for oil absorption capacity ranged from 0.67 g/ml in sample A to 1.13 g/m in sample D. Foam capacity ranged from 17.95 % in sample C to 25.16 % in sample F, with values for emulsion capacity ranging from 33.95 % in sample D and E respectively to 42.77 % in sample F. Values for wettability ranged from 35.33 sec in sample F to 71.00 sec in sample A. The swelling index values obtained from this study ranged 1.76 ml in sample F to 2.23 ml in sample E. Gelation time ranged from 12.91 min in sample B to 23.53 min in sample E, Values for Gelation temperature ranged from 66.00 ^{o} c in sample B to 78.17 ^{o}C in sample E.

Discussion

The findings on proximate composition in table 1 shows that the moisture content ranged from 6.93% (50%PPF50%SF) to 9.13 %in the control (100% WF) Sample E(50%PPF50%SF) hadthe least moisture content 6.93 % as a result of decrease level of pigeon pea substitution. . The moisture content of all the samples were within the acceptable limit of not more than 10% for long term storage of flour (Awuchi, 2019). The ash content of the samples varied significantly. Sample B had higher ash content which implies the abundance of higher mineral contents in the sample. Ash content of the flour blends increased as the level of substitution with pigeon pea increased. The crude fiber content of sample B (100% PPF) had the highest value. Similar observation of increase in crude fiber content by constant increase in pigeon pea flour was reported by Adepeju, *et al* (2015) and Fasoyira, *et al*(2013). The protein contents of the flour samples ranged from 9.52 to 23.49. The protein contents were significantly different between the formulated flour blends and wheat flour. Sample B (100%)PPF had the highest protein (23.49%) and sample E (50%) PPF and (50%) SF had the lowest protein content (9.52%). The highest protein content observed in sample B for 100% PPF was similar to the value 22-73% reported by Olatunde, *et al*(2019) for cakes from pigeon pea, sweet potato and wheat flour. The fat content of the sample B (2.61%) and sample D (2.75%) were not significantly different (P<0.05). The fat value was highest in sample (100%)PPF which scored (2.81 %). The low fat content obtained in this study may indicate that flour blends will not undergo rapid oxidative rancidity during storage if suitably packaged (Adeola*et al* 2019). The carbohydrate content of the flour samples varied significantly (P<0.05) ranging from 58.58 % to 77.59 % with sample B(100%) PPF having the least value.

The functional properties of the flour blends showed that the bulk density of sample A (100%) wheat flour and sample D (80%) PPF flour and (20%) SF had the same value of 078.000. This could be as a result of higher addition of pigeon Pea flour to sorghum flour. The bulk density recordedwas higher than the one observed by (Arukwe, *et al* 2022). The blends low bulk densities suggests that the flour will need more packaging space since the smaller the mass, the bigger the space required. Water absorptioncapacity (WAC) of sample D (80%) PPF and (20%) SF had the highest value (1.37) while sample A (100%) WF had the least value of 0.83. The differences observed in the WAC of the flour samples showed that the flour has a variable degree of availability of water binding sites among the starches and also indicate different protein concentration and their degree of interaction with water (Aburime, *et al* 2020). The oil absorption capacity (OAC) of sample D (80%) PPF and (20%) SF had the highest OAC value of 1.13g/ml. Sample A (100%) WF and sample F (60%) PPF and (40%) SF had equal value and recorded the least. Oil absorption capacity is an important property in food product development because fat improves the flavor and mouth feel of foods. Protein ability to bind fat is shown by its oil absorption capacity (Arukwe, *et al* 2022). The foam capacity of sample F (60%) PPF and (40%) SF had the highest value of (25.16) while the least value was observed in sample C (100%) SF which had (17.95). There was variance in foam capacity. The emulsion capacity of sample D (80%) PPF and (20%) SF with sample E (50%) PPF and (50%) SF had the least value of 33.95. The highest value was recorded in sample F (60%) PPF and (40%) SF having value of (42.77). High emulsion capacity in flour blends showed that the flour samples are excellent emulsifier which may be due to high protein content (Iwe, *et al*, 2016) There was significant difference ($P<0.05$) in the wetability values of the samples. Sample F (60%) PPF and (40%) SF had the lowest value of (35.33) sec while sample A (100%) WF had the highest value of (71.00) sec. The swelling index of the flour sample varies. Sample F (60%) PPF and (40%) SF had the lowest swelling index of 1.76% while sample E (50%) PPF and (50%) SF had the highest swelling index value of 2.23%. The range obtained in this study was higher than the range of 1.21% to 1.4% reported by Bello, Udo&Mbak, (2017) for sprouted sorghum and defatted fluted pumpkin seeds flour blends.

The gelation time of sample B (100%) PPF recorded the least value while sample E (50%) PPF and (50%) SF had the highest value. The gelation temperature of sample E (50%) PPF and (50%) SF had the highest gelation temperature value while the least value was observed in sample B (100%) PPF which recorded 66.00. The observed values will enhance the texture and body of a food product (Peter Ikechukwu, 2020).

Conclusion

In this study, the proximate and functional properties of pigeon pea (*cajanuscajan*) and sorghum *(sorghum bicolor*) flour was extensively examined. The proximate composition of the flour samples of 100 percent (100%) pigeon pea and 100 percent (100%) sorghum flour and their composite flour blends were higher in protein, crude fiber, fat and ash content showing that they are valuable ingredients in food production particularly where protein energy malnutrition (PEM) is prevalent. The significant enhancement of protein content in the composite flour blends suggests a higher nutritional value making them a suitable alternative to wheat flour. The low moisture content observed in the composite flour samples indicates that the products will have a better shelf life and versatility in usage than wheat flour (control) making it a value addition to our indigenous food products. Higher ash content was recorded in 100 percent (100%) pigeon pea and its composite flour blends than 100 percent (100%) wheat flour. This showed that the composite flour blends will be rich in minerals. The favorable functional properties observed in the flour samples shows that the samples will be utilized in diverse house hold application/meals in Nigeria where they are cultivated. The use of pigeon pea and sorghum flour as functional ingredients in food production could potentially address hunger and house hold food insecurity there by contributing to the achievement of sustainable development goal 2 (zero hunger).

Recommendation

1. Awareness should be placed on the local uses of flour among household in Nigeria.
2. Homemakers should be enlightened on the importance of consuming these two indigenous cops. This could be achieved through formal and informal dissemination methods.
3. Use of products produced from pigeon pea and sorghum needs to be encouraged as an alternative to wheat flour, this will increase consumption in some areas where they are limited.

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