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Full Length Research paper

Functional and Organoleptic Properties of Pigeon Pea (*Cajanus cajan*) Flours: A Comparative Analysis

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Three varieties of pigeon pea were processed using three processing methods: soaking, blanching and roasting at different temperatures and time periods and the dehulling efficiency of methods were assessed. The pigeon pea seeds were processed into flours using the appropriate methods that enhance dehulling efficiency. The chemical and functional properties of the flour samples were determined. The different flours were processed into traditional foods: bean cake (akara) and pudding (*moinmoin*). Sensory analyses of the products were determined. Higher protein and ash contents were recorded in the blanched and roasted samples than in the soaked samples. Phytate content of soaked samples were significantly reduced in comparison with the blanched and roasted seeds. The bulk density, water absorption capacity and oil absorption capacity of the flours were in the range 50.12 - 62.30 g/ml, 110 - 155 g/100 g, 9 5 - 132g/100 g, respectively. Highest bulk density and water absorption capacity were recorded in flour sample from roasted pigeon pea seed of variety 5C. In comparison of the sensory qualities of the pigeon pea flours with cowpea as either *akara* or moinmoin, products of roasted seed flour were least accepted among the samples.

Key words: Pigeon pea, processing methods, functional properties, traditional foods, sensory qualities.

INTRODUCTION

Pigeon pea (*Cajanus cajan*) is a locally available, affordable and under-utilized grain legume of the tropics and sub-tropics. Pigeon pea varieties has protein content in the range of 23 - 26% (Oshodi et al.,1985).The protein content is comparable with those in other legumes like cowpea and groundnut which have been used in complementing maize. It is rich in mineral quality and fibre content. Pigeon pea grows well in Nigeria but the hard-to-cook phenomenon and the presence of anti-ntutrients have limited its utilisation (Nene et al.,1990; El-Tabey, 1992).

It is usually eaten in cooked form like cooked beans in Nigeria but it consumes a lot of fuel, mostly cooked with firewood (a scarce and dwindling resource). Many rural low income families prefer pigeon pea to cooked cowpea because it is cheaper in cost, more filling in the stomach and has a more acceptable taste. Women cook it using firewood overnight for about 8 - 12 h. This consequently leads to high loss of nutrients. For the urban low income families, the bean is desirous for its taste but they cannot afford the required time nor fuel required in its cooking. Since pigeon pea are well adapted to tropical regimes and insufficient protein of good quality is a limiting factor in developing countries with ever increasing population, appropriate processing to improve the utilization of this legume is of high importance. Attempts have been made to improve its utilisation in human diet due to increasing need for cheaper and available plant proteins to meet the increasing demand of the Nigerian populace. Reduce cooking time and acceptibility have been achieved for pigeon pea through dehulling process (Fasoyiro et al., 2006). Fermentation process had also been utilized to

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increase the protein and textural qualities of the seeds (Fasoyiro et al., 2009). Pigeon pea seeds apart from being hard to cook, they are hard to dehull thus the drudgery process of dehulling the seed is also limiting the utilization of pigeon pea into other form of products apart from cooking the seeds (Fasoyiro et al., 2005). Developing the pigeon pea seeds into flours using appropriate processing technology that will improve the dehulling process will improve the utilization of the seeds.

Hence, this study attempts to improve the dehulling process of pigeon pea. The objectives of this study are to assess the effect of different processing methods on ease of dehulling of the seeds from different varieties of pigeon pea, to assess the chemical and functional properties of flours and to determine the sensory qualities of their products.

MATERIALS AND METHODS

Three varieties of pigeon pea seeds: 5C (light brown seed colour), 17C (red-brown seed colour) and 32C (dark brown seed colour) and Ife-brown cowpea seeds were obtained from the Institute of Agricultural Research and Training, Ibadan, Nigeria.

Determination of dehulling efficiency of seeds

The varieties of pigeon pea were processed using three methods. The first method involves soaking in hot water at four different temperatures 40, 50, 60 and 70°C for different time intervals ranging from 10 to 30 min. The second method involves blanching the seeds at 100°C for different time intervals ranging from 10 to 30 min and the third method involves roasting of the seeds for 5 to 15 min. Twenty seeds were then counted from each lot and dehulled using mortar and pestle. The dehulling efficiency of the seed was determined as the percentage of seeds dehulled in 2 min using a stop watch (IAR&T Annual Report, 2009). The hydration capacity of the soaked seeds was determined as the percentage difference in soaked seed and its initial weight before soaking.

Processing of pigeon pea into flour

One kilogram of each variety of pigeon pea were sorted to remove dirts.

Soaking method

Three hundred grams of each variety was soaked in hot water (initial temperature 60°C) for 30 min. The seeds were dehulled by rubbing between the palms, drained and oven-dried at 50°C for 8 h. The dried seeds were milled using hammer mill and the flour was sieved with 1mm sieve size. The flour was packed inside a polyethylene bag.

Blanching method

Three hundred grams of each of the variety was added to boiling water and boiled for 20 min. The seeds were drained and oven-dried at 50°C for 8 h. The dried seeds were milled using hammer mill and the flour was sieved with 1mm sieve size. The flour was packed inside a polyethylene bag.

Roasting method

Three hundred grams of the seeds was moistened with 50 ml of water. The moistened seed was left to equilibrate for 15 min. The seeds were then roasted on electric fryer for 10 min at 150°C while the seeds were being continuously turned. The roasted seeds were dehulled using mortar and pestle, and the seed coat was winnowed from the seeds. The roasted seeds were milled using hammer mill and the flour was sieved with 1 mm sieve size. The flour was packed inside a polyethylene bag.

Chemical properties of flours

Chemical composition: protein, fat, crude fibre and ash contents of flours were determined. Protein content was determined using Kjeldahl method and nitrogen content of the samples was multiplied by a factor 6.25. Ether extract was by Soxhlet extraction. All the analyses were done in triplicate using AOAC method (1984). Phytate content was determined using the method of Davies and Reid (1979). Trypsin inhibitor content of the flours was determined using the method of Kakade et al. (1969).

Functional properties of flours

Bulk density was determined using the gravimetric method as described by Okaka and Potter (1976). The sample (10 g) was weighed into a 25 ml graduated cylinder. The cylinder was gently tapped ten times against the palm of the hand. The bulk density was expressed as the sample per volume occupied by the sample. Water absorption capacity of the flours was determined as described by Sosulski et al. (1976). The sample (1 g) was added to 20 ml distilled water in weighed 25 ml centrifuge tube. The suspension was stirred occasionally with a glass rod for 30 min at 25°C. The supernatant was decanted and discarded and the tube and content was reweighed. Oil absorption capacity was also determined according to the method of Sosulski et al. (1976).

Sensory evaluation of products from pigeon pea flours

The flours were processed into *Akara* and *Moinmoin* as shown in Figure 1. These were compared with *akara* and *moinmoin* from fresh paste cowpea processed using the traditional method of soaking, dehulling and milling into paste. Samples were coded and presented as random numbers to twenty panel of judges to test for the following attributes: appearance, colour, flavour, taste and overall acceptability.

The panelists were provided with a mouth rinse in between each tasting. The attributes were scored using a nine- point hedonics scale where nine equals like extremely and one equals dislike extremely.

Statistical analyses

The data from the chemical analyses and sensory testing were subjected to analysis of variance (ANOVA) and means were separated by Duncan multiple range test (SAS, 1995).

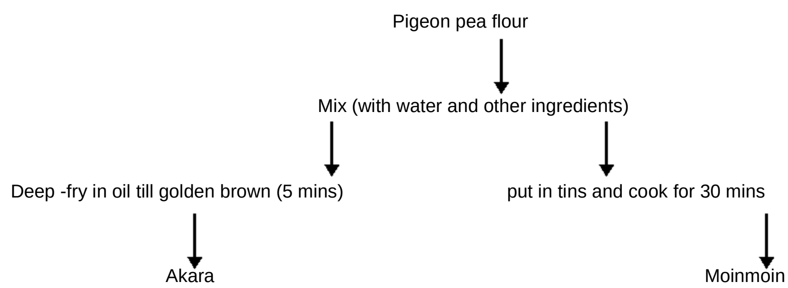

Figure 1. Flow chart showing "*akara* and moinmoin" preparation.

Table 1. Effect of soaking temperature-time on hydration and dehulling efficiency of pigeon pea seeds.

Soaking medium (°C; min)	Pigeon pea varieties	Hydration capacity (%)	Dehulling efficiency (%)
40; 20	5C	25.2	44.3
	17C	34.3	46.2
	32C	22.1	44.7
40; 30	5C	34.6	41.1
	17C	20.3	43.7
	32C	22.9	44.3
50; 20	5C	45.6	48.4
	17C	49.3	47.3
	32C	44.7	41.1
50; 30	5C	33.3	40.3
	17C	44.2	54.2
	32C	45.7	54.6
60; 20	5C	54.2	64.5
	17C	53.2	73.3
	32C	50.1	68.4
60; 30	5C	55.3	70.3
	17C	58.4	78.1
	32C	52.3	85.3
70; 20	5C	50.4	55.3
	17C	56.3	57.3
	32C	64.3	59.1
70; 30	5C	52.4	52.3
	17C	53.8	56.2
	32C	54.5	55.6

Results show means of three replicates.

RESULTS AND DISCUSSION

The effect of soaking temperature and time on hydration and dehulling efficiency of pigeon pea seeds is shown in Table 1. Seeds soaked in the hot water at 40°C have hydration capacity in the range of 20.3 - 34.3% and dehulling efficiency of 44.1 - 46.2%. Highest hydration capacity of the seeds was recorded when soaked in hot water at 60 and 70°C for 20 - 30 min. The dehulling efficiency at this temperature and time was in the range

Table 2. Effect of blanching temperature-time on hydration and dehulling efficiency of pigeon pea seeds.

Blanching (°C; min)	Pigeon pea varieties	Dehulling efficiency (%)
	5C	45.3
100; 10	17C	46.2
	32C	33.1
	5C	67.2
100; 20	17C	76.4
	32C	77.3
	5C	61.2
100; 30	17C	65.3
	32C	60.1

Result shows means of three replicates.

Table 3. Effect of roasting temperature-time on hydration and dehulling efficiency of pigeon pea seeds.

Roasting (°C; min)	Pigeon pea varieties	Dehulling efficiency (%)
	5C	46.7
150; 5	17C	40.4
	32C	30.5
	5C	55.2
150; 10	17C	44.8
	32C	49.3
	5C	31.5
150; 15	17C	35.7
	32C	20.2

Result shows means of three replicates.

of 70.3 - 85.3% for the different variety of seeds tested. The increased hydration capacity of the seeds with increase in temperature could be attributed to the increase in rate of absorption of water by the seed coats at higher temperatures thus hastening rate of swelling of the cotyledons. It was also observed that optimum water absorption by the seeds was at 60°C, while dehulling efficiency decreased at 70°C. In Table 2, the effect of temperature and time of blanching on dehulling efficiency of different variety of pigeon pea seeds were recorded. The dehulling efficiency of the blanched seeds increased when boiled for 20 min while beyond this value, a slight decrease was recorded at 30 min of blanching

In Table 3, the effect of roasting temperature and time on dehulling efficiency was recorded. Similar observation with blanched seeds was noted with increase in roasting time. Dehulling efficiency increased from roasting time at 150°C on an electric fryer of 5 to 10 min and reduced when increased further to 15 min. This shows that optimum roasting time is 10 min, anything beyond this will lead to sticking of the seed coat to the cotyledon thus increasing the drudgery process.

The chemical composition of the flours from soaked, blanched and roasted seeds of pigeon pea is presented in Table 4. Protein content of the soaked seeds ranged from 18.34 - 20.13%, for blanched seeds 20.12 - 22.19% and for the roasted seeds within 23.01 - 24.05%. Ether extract from the flour ranged from 1.04 - 2.345, crude fibre 1.64 - 4.02% and ash content 1.02 - 4.01%. The soaked seeds had the lowest ash content in the range of 1.02 - 1.49%. Ash content is an indication of total mineral quality. Lowest ash content of the flour from the soaked seeds shows that leaching of minerals into the soak water leads to the loss of minerals in the flours. Lower phytate content of 1.23 - 1.67 Tiu/mg was obtained in the flours from the soaked pigeon pea seeds in comparison with higher values recorded from the flours of the blanched and roasted seeds. Trypsin inhibitor of all the flours was significantly reduced especially by the blanching and roasting methods.

Table 4. Comparison of chemical composition of flours from three pigeon pea varieties with the seeds (dry matter basis).

Samples	Protein (%)	Fat (%)	Ether extract (%)	Ash (%)	Phytate g/100g	Trypsin inhibitor (Tiu/mg)
PP1S	19.02^{c}	2.11^{b}	3.62^{b}	1.02^{e}	1.23^{e}	4.11^{d}
PP2S	18.34^{c}	3.04^{a}	2.45^{b}	1.53^{e}	1.45^{e}	5.12^{c}
PP3S	20.13^{b}	1.77^{c}	1.75^{c}	1.49^{e}	1.67^{e}	4.41^{d}
PP1B	22.17^{b}	3.23^{a}	2.95^{b}	3.44^{c}	3.32^{c}	2.11^{e}
PP2B	22.05^{b}	1.06^{c}	1.04^{c}	3.56^{c}	3.56^{bc}	1.85^{e}
PP3B	20.12^{b}	1.14^{c}	2.22^{b}	3.65^{c}	2.12^{d}	2.33^{e}
PP1R	24.01^{a}	2.45^{b}	3.12^{a}	4.01^{a}	3.65^{bc}	2.23^{e}
PP2R	23.01^{ab}	2.21^{b}	2.89^{ab}	3.23^{c}	3.88^{b}	2.22^{e}
PP3R	23.01^{a}	1.86^{c}	3.01^{a}	2.22^{d}	3.45^{bc}	2.14^{e}
PP1	24.90^{a}	2.34^{b}	3.89^{a}	4.74^{b}	5.65^{a}	8.55^{b}
PP2	25.21^{a}	2.21^{b}	4.02^{a}	5.10^{a}	4.33^{b}	9.23^{a}
PP3	23.33^{ab}	2.01^{b}	3.99^{a}	3.90^{c}	3.78^{bc}	8.13^{b}

Means in the same column not followed by the same letter are significantly different at 5% level of significance. PP1S- pigeon pea variety 5C soaked; PP2S-pigeon pea variety 17C soaked; PP3S-pigeon pea variety 32C soaked; PP1B-pigeon pea variety 5C blanched; PP2B-pigeon pea variety 17C blanched; PP3B-pigeon pea variety 32C blanched; PP1R-pigeon pea variety 5C roasted; PP2R-pigeon pea variety 17C roasted; PP3R-pigeon pea variety 32C roasted.

Table 5. Functional properties of flours from the pigeon pea varieties

Samples	Bulk density (g/ml)	Water absorption capacity (g/100g)	Oil absorption capacity (g/100g)
PP1S	50.33^{c}	123^{d}	99^{e}
PP2S	52.00^{c}	110^{e}	95^{ef}
PP3S	50.12^{c}	132^{c}	111^{d}
PP1B	59.22^{a}	145^{b}	104^{e}
PP2B	50.14^{c}	125^{d}	111^{d}
PP3B	53.12^{b}	134^{c}	120^{c}
PP1R	62.30^{a}	155^{a}	122^{c}
PP2R	55.01b	132^{c}	132^{a}
PP3R	56.34^{b}	145^{b}	127^{b}

Values in the same column not followed by the same letter are significantly different at 5% level of significance. PP1S- pigeon pea variety 5C soaked; PP2S-pigeon pea variety 17C soaked; PP3S-pigeon pea variety 32C soaked; PP1B-pigeon pea variety 5C blanched; PP2B-pigeon pea variety 17C blanched; PP3B-pigeon pea variety 32C blanched; PP1R-pigeon pea variety 5C roasted; PP2R-pigeon pea variety 17C roasted; PP3R-pigeon pea variety 32C roasted.

The functional properties of the different flour are presented in Table 5. Bulk density of flours from soaked seeds ranged between 50.12-50.33 g/100g while those of flours from the blanched seeds 50.14 - 59.22g/100g and roasted seeds 55.01 - 62.30g/100g. Water absorption capacity of the flour from the soaked seeds was in the range of 110 - 132g/100g, blanched 134 - 145g/100g and roasted 132 - 155g/100g. The flours from the roasted seeds generally had the highest water absorption capacity followed by flours form the blanched seeds while flours from the soaked seeds had the lowest values. Abbey and Ibeh (1988) observed also that heat-treated flours tend to absorb more water due to gelatinization of carbohydrates and heat dissociation of proteins. Oil absorption capacity of flours from the soaked seeds ranged between 95 - 111 g/100 g, blanched seeds 104 - 111 g/100 g and roasted seeds 120 - 132 g/100 g. Flours from roasted seeds also had highest oil absorption capacity followed by the flours from the blanched seeds. Fat absorption property of flours is known to be of importance to food formulation and sensory characteristics such as mouth-feel and flavour. In food formulation where high oil absorption capacity is required, flours from roasted pigeon pea should be put into consideration as alternative to it is the flour from the blanched seeds.

Table 6 shows the recipe for traditional foods made from pigeon pea flours, while Figure 1 shows the flow diagram for preparing the products. The sensory properties of the *akara* and *moinmoin* from the processed flours is shown in Tables 7 and 8.

Table 6. Recipes for *akara* and *moinmoin*.

Ingredients	Akara	Moinmoin
Pigeon pea flour (g)	100	100
Water (ml)	30	50
Dry pepper (g)	5	5
Onion (g)	10	10
Maggi (cube)	1	1
Oil (ml)	100	10
Salt (g)	0.5	0.5

Table 7. Sensory analysis of *akara* from the flour of the varieties of pigeon pea.

Akara	Appearance	Colour	Flavour	Taste	Overall acceptability
PP1S	5.8^{c}	6.3^{b}	6.1^{b}	6.2^{ab}	5.6^{c}
PP2S	5.1^{c}	6.4^{b}	6.5^{b}	6.8^{a}	5.7^{c}
PP3S	5.4^{c}	6.3^{b}	7.5^{a}	6.5^{ab}	5.8^{bc}
PP1B	6.5^{b}	6.5^{b}	7.4^{a}	6.2^{ab}	6.4^{b}
PP2B	6.3^{b}	6.1^{b}	6.4^{b}	6.5^{ab}	6.6^{b}
PP3B	6.1^{b}	6.8^{a}	6.8^{ab}	6.2^{ab}	6.8^{a}
PP1R	3.3^{d}	3.1^{d}	3.3^{d}	2.1^{e}	3.2^{d}
PP2R	3.1^{d}	2.9^{d}	2.0^{e}	2.9^{d}	2.7^{de}
PP3R	2.1^{e}	3.0^{d}	2.2^{e}	3.1^{d}	2.4^{d}
Cowpea	7.3^{a}	7.2^{a}	6.8^{ab}	6.7^{a}	7.3^{a}

Values in the same column not followed by the same letter are significantly different at 5% level of significance. PP1S-pigeon pea variety 5C soaked; PP2S-pigeon pea variety 17C soaked; PP3S-pigeon pea variety 32C soaked; PP1B-pigeon pea variety 5C blanched; PP2B-pigeon pea variety 17C blanched; PP3B-pigeon pea variety 32C blanched; PP1R-pigeon pea variety 5C roasted, PP2R-pigeon pea variety 17C roasted; PP3R-pigeon pea variety 32C roasted.

Table 8. Sensory analysis of *moinmoin* from the flour of the varieties of pigeon pea.

Moinmoin	Appearance	colour	flavour	Mouth feel	Overall acceptability
PP1S	6.9^{a}	6.8^{ab}	7.0^{a}	6.7^{b}	7.3^{a}
PP2S	6.7^{ab}	6.7^{ab}	6.8^{a}	7.2^{b}	7.7^{a}
PP3S	7.4^{a}	6.5^{b}	7.2^{a}	6.5^{b}	6.8^{a}
PP1B	6.7^{ab}	6.5^{b}	7.1^{a}	6.5^{b}	7.1^{a}
PP2B	6.9^{ab}	6.6^{ab}	6.4^{b}	6.8^{b}	7.0^{a}
PP3B	7.0^{a}	6.8^{a}	6.8^{ab}	7.7^{a}	7.2^{a}
PP1R	3.8^{d}	2.2^{d}	6.8^{ab}	7.8^{a}	5.1^{d}
PP2R	4.4^{d}	2.8^{d}	5.3^{d}	7.4^{a}	5.4^{d}
PP3R	3.7^{d}	2.0^{d}	6.1^{b}	7.5^{a}	5.4^{d}
Cowpea	7.5^{a}	7.4^{a}	7.8^{a}	7.4^{a}	7.5^{a}

Values in the same column not followed by the same letter are significantly different at 5% level of significance. PP1S- pigeon pea variety 5C soaked, PP2S-pigeon pea variety 17C soaked, PP3S-pigeon pea variety 32C soaked, PP1B-pigeon pea variety 5C blanched, PP2B-pigeon pea variety 17C blanched, PP3B-pigeon pea variety 32C blanched, PP1R-pigeon pea variety 5C roasted, PP2R-pigeon pea variety 17C roasted, PP3R-pigeon pea variety 32C roasted.

Moinmoin and *akara* are traditional food products in Nigeria usually prepared from fresh cowpea paste. Higher scores for appearance and colour of *akara* from flours of soaked and blanched seeds were recorded indicating higher preference for these against the *akara* from the flour of the roasted seeds. Flours from blanched pigeon pea varieties were the most acceptable in terms of the qualities assessed. Flours from the roasted pigeon pea varieties were the least accepted in terms of the qualities assessed. One key attribute desired for *moinmoin* is good mouth-feel. For moinmoin, flours from the roasted pigeon pea varieties were not acceptable in appearance and colour but acceptable in flavor, mouth-feel and overall acceptability. The samples from cowpea had highest scores for *moinmoin* compared to akara.

Conclusion

Pigeon peas seeds can be easily dehulled when soaked at 20 - 30 min or when blanched at 100°C for 20 min. Functional property of the flours depends on the processing method used. Variety of seed does not have significant effect on functional property of the flour. Pigeon pea flour from soaked or blanched seeds are better utilized for *moinmoin* and *akara* processing than the roasted seeds. Developed time-saving cooking technologies for pigeon pea will reduce nutrient losses and fuel consumption and provide product diversification. This will increase the well-being of the rural women especially in saving cooking time and having better nutrition for their household especially their children. These traditional foods from pigeon pea are expected to serve as income generating sources for the women in boosting their family sustainability hence, reducing poverty especially among the low income families in Nigeria.

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