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FUNCTIONAL PROPERTIES AND PASTING CHARACTERISTICS OF FLOUR FROM FIVE VARIETIES OF NIGERIAN PIGEON PEA *(CAJANUS CAJAN)*

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ABSTRACT
The functional and pasting characteristics of flour produced from five selected varieties of Nigerian Pigeon pea, namely, NSWCC-46, NSWCC-35, NSWCC-18, NSWCC-28, and NSWCC-32 were evaluated. The functional properties include: loosed bulk density (0.4g/cm^3); packed bulk density (0.6 to 0.7g/cm^3); water absorption capacity (119.0 to 125.0%); oil absorption (123.5 to 133.3%); foaming capacity (16.3 to 29.2%); foaming stability (13.6 to 34.3%); emulsifying property (0.2 to 0.4%); solubility (0.9 to 12.1%) and least gelation capacity (6.0 to 8.0%). The pasting characteristics were: peak (3.53 to 61.83 RVU); trough (1.67 to 56.1 RVU); breakdown values (1.83 to 6.53 RVU), final viscosities (11.43 to 92.08 RVU); set back values (6.67 to7.03 RVU); peak time (9.75 to 23.83mins); and pasting temperature (94.13 to 95.45 °C). The overall results of this study have shown that the measured quality indices should provide base line data for value addition in the use of pigeon peas in food systems and enhance the production and utilization potentials of the crop, including food security for the country.

Keywords: Pigeon pea, Varieties, Nigerian, Functional Properties, Pasting Characteristics.

INTRODUCTION
Pigeon pea *(Cajanus cajan)* is one of the oldest food crops known to mankind and ranks fifth in importance among edible legumes of the world (Morton, 1976; Salunkhe *et al,* 1986). The plant is remarkably resistant to both low temperatures (as low as 5 to 10 °C) and high temperature (up to 40°C) and thus; it is an ideal crop that fits into cropping systems in many parts of the world (Sinhg, 1977). Pigeon pea is used for food, feed and fuel. It is a rich source of proteins, carbohydrates, dietary minerals and soluble vitamins (Sinhg *et al,* 1990). Wild species of pigeon peas have been found to be a promising source of high protein. Pigeon peas are similar nutritionally to cowpea and can be used in

much the same way (Henshaw *et al,* 1990). The antinutritional factors in pigeon pea are less than they are in soybeans, peas and common beans (Karmath and Belavady, 1980). But even upon the potentials, pigeon pea appears to be an underutilized legume in West Africa sub-region and especially in Nigeria; at present the cultivation is gradually being left in extinction, which may be due to the fact that it has tough and firm seed coat and therefore, takes longer time to hydrate or cook than other legumes. Henshaw *et al,* (1999) reported that slight reduction in cooking time was only possible after the seed must have been pre-soaked for at least 16hours, while the addition of trona only without pre-soaking of seeds was affirmed to be less effective in reducing cooking time of pigeon pea. However, the processing of pigeon pea into flour (ready-to-use) could possibly increase the utilization of the crop. Pigeon pea flour stands to be a convenient food ingredient with the potentials of promoting its individual utilization. Nevertheless, a novel food such as pigeon pea flour samples must be functionally and aesthetically reliable, if they are to be accepted. . One important factor in determining the potential uses of pigeon pea flour is the identification of the functional properties.

According to Mc Watters (1986), the successful performance of legume flours as food ingredients depends on the functional characteristics and sensory quality which they impart on end products. Novel foods and food ingredients from pigeon pea flour samples must be functionally reliable if they are to be accepted for use. Pasting properties are functional properties relating to the ability of an item to act in paste -like manner. Pasting characteristics have been associated with cooking and textural quality of various food products (Otegbayo *et al.,* 2006).

The objective of this work is to evaluate the functional properties and pasting characteristics of flours produced from different pigeon pea varieties that are commonly grown in Nigeria.

MATERIALS AND METHODS

Pigeon pea varieties used for the analysis were procured from Institute of Agricultural Research and Training (IAR & T) in Ibadan, Nigeria.

Preparation of Pigeon Pea Flour

The pigeon peas were processed according to the method of Nnanna and Philips (1990). The pigeon pea grains were soaked in water at 30 ± 1 ^0C for 10 mins after cleaning. The soaked grains were then dehulled and dried at a low temperature of 5^0C in an air oven for 12hrs, milled and passed through sieve to obtain pigeon pea flour samples that were then packaged in moisture-proof polyethylene bags and stored under refrigeration (4 ^0C) for further analysis.

Functional Properties

Water absorption and oil absorption capacities were determined according to the method described by Hayta *et al,* (2002). Loose and bulk densities were determined following the method of Akapanunan and Markaty (1981). Oil emulsion and stability determination were by method described by Beuchat (1977). Foaming capacity and stability were determined by method of Coffman and Garcia (1977) while least gelation capacity and solubility were determined by Abulude (2001) and Leach *et al* (1959) respectively.

Pasting Properties

Pasting properties were determined using Rapid Visco Analyzer model (RVA 3D=, Network Scientific, Australia).

Statistical Analysis

All data obtained (in triplicate) were subjected to Analysis of variance (ANOVA) using SPSS, statistical package (Version 10.0, 2000 Edition). Means were separated with Duncan Multiple Ranged Test (DMRT) (Steel and Torrie, 1981).

RESULTS AND DISCUSSION

Functional properties determine the application and use of food materials for various food products. The values of bulk density (loose and packed) obtained (0.4 to 0.7 g/cm^3 as shown in Table 1) are slightly higher than the value of 0.29 g/cm^3 observed by Gianni *et al.* (1992) for full fat winged bean flour and 0.48 g/cm^3 reported by Bello and Okezie (1982) for winged bean protein isolate, but similar to the values of 0.7 g/cm^3 reported for various cowpea flours by Henshaw and Sobowale (1996). Adeboye (2008) had also reported values of 0.05 to 0.7 g/cm^3 and 0.5 to 0.6 g/cm^3 for instant yam breadfruit flour, and bambara flour respectively.

However, the figures obtained for the flours as seen in Table 1; were found to be lower than 0.96 to 0.97 g/cm^3 recorded for red and white sweet potato flours (Onuh *et al.,* 2009) would enhance the formulation of weaning foods (Eneche and Owhero, 2005). The values of water absorption of the flour samples (Table 1) compared favourably with the value reported for soybean flour (130 %) according to Lin *et al.* (1974), and the flour of the African yam bean colour varieties (118 to 179 %) as reported by Oshodi *et al.* (1997) and various lima bean flours; 130 to 140 % (Oshodi and Adelodun, 1993). Oil seed flour had 70 to 120 % (Olaofe *et al.,* 1994) and Akintayo (1997) who recorded a value of 90.2% for *Telfairia occidentals*. The water absorptivity reported in the present study suggested that the examined flours may be used in the formulation of some foods such as sausage, dough, processed cheese, soups, comminuted meat, baked products and doughnut, where handling characteristics, mouth feel and textural quality of food are affected by water incorporation (Olaofe *et al.,* 1998; Oshodi and Ekperigin, 1989). Oil absorption capacity has been attributed to the physical entrapment of oil. This is important since oil acts as flavour retainer and increases the mouth feel of foods (Eke and Akobundun, 1993). The values of oil absorption obtained (Table 1) were in close agreement with that of bambara groundnut (130.0%) reported by Adebowale and Lawal (2004), and for varieties of African yam bean flour (93.3 to 145%) as reported by Oshodi *et al.* (1997), *Bilphia sapida* pulp flours (125.0 to 131.6%) by Akintayo *et al.* (2002), melon seed (122%) by Olaofe *et al.* (1994), *P. angularis* (91.4%) and *P. calcaratus* (128.7%) as reported by Chaus and Cheung (1998). The values obtained for the flours in the present study (Table 1) make the flours potentially useful in structural interaction in foods especially in flavour retention, improvement of palatability and extension of shelf life, particularly in bakery or meat products, where fat absorption may be desirable.

The values of foaming capacity reported were comparatively higher than the value obtained for benni seed (18.0 %), pearl millet (11.3 %) and guinea (9.0 %) as reported by Oshodi et al. (1999) and seed flour (8.2 %) as reported by Akintayo et al. (2002) and fluted pumpkin seed flour (10.8%) as reported by Fagbemi and Oshodi; (1991). Nevertheless, the value were lower than that of soy flour (970%) and sunflower (230 %) as reported by Lin et al. (1974), Great Northern bean flour (320%) according to Sathe and Salunkhe (1981), and varieties of African yam bean (54.0%) as reported by Adeyeye *et al.* (1994) the foaming stabilities in 30mins ranged from 13.6 to 19.3 % as shown in Table 1 this suggest that the flours studied in this work may be attractive for products like cakes or whipping topping, where foaming characteristics are important (Kinsella, 1976). However, Grahams and Phillips (1976) linked good foamability with flexible protein molecules that can reduce surface tension while highly ordered globular protein, which is relatively difficult to surface denature give low foamability. One may therefore suggest that flours may contain high concentration of flexible protein. The values of Emulsion capacities obtained (Table 1) were higher than the values reported for soybean flour (18.0%) and wheat flour (11.0%) by Lin *et al.* (1974). According to Achi (1999), the higher the concentration of protein in the food flour, the higher the emulsion capacity and stability. This has shown that the flours studied in this work were high protein. The Emulsifying properties of the flours make them to be useful as an additive for stabilization of fat emulsions in the production of sausages, soups and cakes (Altschul, 1974). The higher the least gelation concentration, the higher the amount of flour needed to form a gel (Adebowale *et al.,* 2005). The values of least gelation concentration obtained varied from 6.0 to 8.0 % (Table 1). The values were however lower than the least gelation concentration of most food legumes (Sathe *et al.,* 1982; Olaofe *et al.,* 1994; Oshodi, 1992).

It could therefore be seen from this study that the pigeon pea flours required a lower concentration for gel formation. The ability of protein to form gels and provide a structural matrix for holding water, flavours, sugar and food ingredients is useful in food applications in the development of new products, thereby, providing an added dimension to protein functionality (Oshodi *et al.,* 1997; Sathe *et al.,* 1982). Such low gelation concentrations observed (Table 1) should be an advantage in the use of these flours for formulation of curd or as an additive to other gel-forming materials in food products. The higher the solubility, the better the flour reconstitutes in water (Kulkarni *et al.,* 1991).

The results obtained in Table 1 have shown that the flours studied in this work had values ranging from 10.9 to 12.1 % for protein solubility; when starch-based foods are heated in an aqueous environment they undergo series of changes known as gelatinization and pasting. These are two of the most important properties that influence quality and aesthetic considerations for food systems, since they affect texture and digestibility as well as the end use of starchy foods (Adebowale *et al.,* 2005). Pasting characteristics have been associated with cooking and textural quality of various food products.

The values of peak viscosity of the flour samples from this study varied between 3 and 61 RVU (Table 2). These values were comparably lower than those obtained for yam flour (230 RVU), bread fruit flour (340 RVU) according to (Adebowale *et al.,* 2008), cowpea flour (340 RVU) according to Olopade *et al.* (2005) and various varieties of cowpea starches (890 to 127 RVU) as reported by Henshaw and Adebowale (2004). High peak viscosity is an indication of high starch content (Osungbaro, 1990) and it is also related to the water binding capacity of starch (Adebowale *et al.,* 2005). The relatively low peak viscosity exhibited in the flour samples could be indicative that the flour may not be suitable for products requiring high gel strength and elasticity, while being suitable in the preparation of complementary foods (Onimawo and Egbekun, 1998). The values of trough recorded (Table 2) were also lower than that of yam flour and bread fruit flour (214 and 257 RVU, respectively) as reported by Adebowale *et al.* (2008). The breakdown viscosity value is an index of the stability of starch (Fernandez and Berry, 1989). The values (1.83 to 6.53 RVU) obtained for the breakdown viscosity of the flour samples were also found to be considerably low as shown in Table 2. The values of the final viscosity of the analyzed flour samples (Table 2) were also comparably lower than that of yam flour (300 RVU) and bread fruit flour (300 RVU) Adebowale *et al.* (2008) and cowpea flour (500 RVU) according to Olapade *et al.* (2005). Setback values of the flour samples as presented in Table 1 (9.75 – 35.9 RVU) were found to be low when compared with the values for other legumes, such as cowpea and this indicate that the flours were not susceptible to retrogradation (aggregation of part of starch to form microcrystals which could precipitate).

Moreso, pastes may be produced from the flours and stored with minimum retrogadation (Oti and Akobundun, 2007). Peak time is defined as a measure of the cooking time (Adebowale *et al.,* 2008). The peak time values shown in Table 2 were found to be in the same trend with that of yam flour and breadfruit flour as reported by Adebowale *et al.* (2008). The results of the pasting temperature (Table 2) have shown that all the flours had high pasting temperatures which ranged between 94 – 96 ^{0}C. These pasting temperatures were higher than those reported by previous investigators. Adebowale *et al.* (2008) reported 83 to 84 ^{0}C for yam flour and bread fruit flour, respectively and Henshaw and Adebowale (2004) reported a range of 68 – 75 ^{0}C for some cowpea flour variety samples. Olapade *et al.* (2005) reported 72 ^{0}C for cowpea flour, Tolmasquim *et al.* (1971) reported a range of 69 – 78 ^{0}C for fine varieties of cowpea starch, Tialijadi and Breene (1984) reported a range of 64 – 68 ^{0}C and Elofaki *et al,* (1983) reported values of 65 – 73 ^{0}C.

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Table1: Functional Properties of Flour Samples from Selected Nigerian Pigeon pea Varieties

Varieties	Bulk Density		Water Absorptivity (%)	Oil Absorption Capacity (%)	Foaming Capacity (%)	Foaming Stability 30mins (%)	Emulsion Capacity (%)	Emulsion Stability (%)	Protein Solubility (%)	Least Gelation Conc. (%)
	Packed (g/cm^3)	Loose (g/cm^3)								
NSWCC – 46	0.4 ± 0.0^{b}	0.7 ± 0.0^{b}	119.0 ± 0.0^{e}	123.5 ± 0.0^{d}	25.0 ± 0.0^{b}	14.9 ± 0.5^{d}	0.2 ± 0.2^{b}	0.4 ± 0.0^{e}	11.8 ± 0.2^{b}	8.0 ± 0.0^{d}
NSWCC – 35	0.4 ± 0.0^{c}	0.6 ± 0.0^{e}	120.5 ± 0.0^{e}	125.0 ± 0.0^{c}	29.2 ± 0.0^{a}	13.6 ± 0.4^{e}	0.4 ± 0.0^{a}	0.4 ± 0.0^{e}	10.9 ± 0.2^{c}	8.0 ± 0.0^{c}
NSWCC – 18	0.4 ± 0.0^{a}	0.6 ± 0.0^{d}	125 ± 0.0^{b}	131.6 ± 0.0^{b}	18.2 ± 0.0^{d}	25.3 ± 1.1^{d}	0.4 ± 0.0^{a}	0.4 ± 0.0^{d}	$12.1 \pm 0.2^{a.b}$	8.0 ± 0.0^{b}
NSWCC – 28	0.4 ± 0.0^{a}	0.7 ± 0.0^{b}	119.0 ± 0.0^{d}	122.0 ± 0.0^{e}	21.7 ± 0.0^{e}	19.3 ± 0.0^{ec}	$0.0.0^{av}$	0.4 ± 0.0^{av}	11.7 ± 0.2^{a}	8.0 ± 0.0^{a}
NSWCC – 32	$0.4+0.0^{b}$	$0.6+0.0^{c}$	$125.0+0.0^{a}$	$133.3+0.0^{a}$	$16.3+0.0^{e}$	$34.3+0.2^{a}$	$0.4+0.0^{a}$	$0.4+0.0^{a}$	$11.8+0.^{b}$	$6.0+0.0^{e}$

$\pm$ Standard deviation of three replicates
Mean values followed by different superscript within column are significantly different ($P < 0.05$)

Table 2: Pasting Characteristics of Flour Samples from Selected Nigerian Pigeon pea Varieties

Varieties	Peak 1 (RVU)	Through (RVU)	Breakdown (RVU)	Final Viscosity (RVU)	Setback Value (RVU)	Peak Time (Min)	Pasting Temperature ($0^{0}C$)
NSWCC – 46	42.17 ± 0.1^{a}	38.67 ± 0.1^{a}	3.51 ± 0.0^{e}	62.53 ± 0.1^{c}	$23.83+0.1^{c}$	7.03 ± 0.1^{d}	95.45 ± 0.0^{b}
NSWCC – 35	38.17 ± 0.1^{a}	31.67 ± 0.1^{a}	6.53 ± 0.1^{e}	56.92 ± 0.1^{d}	$22.25+0.1^{c}$	7.03 ± 0.1^{d}	94.35 ± 0.0^{b}
NSWCC – 18	3.53 ± 0.1^{c}	1.67 ± 0.1^{e}	1.83 ± 0.0^{d}	11.43 ± 0.1^{e}	$9.75+0.1^{a}$	6.93 ± 0.0^{b}	95.23 ± 0.1^{a}
NSWCC – 26	61.83 ± 0.1^{a}	56.17 ± 0.0^{b}	5.67 ± 0.0^{e}	92.08 ± 0.1^{a}	35.9 ± 0.0^{c}	7.03 ± 0.1^{d}	94.56 ± 0.0^{b}
NSWCC – 32	$56.83+0.0^{a}$	$53.8+0.0^{a}$	$3.0+0.1^{e}$	$76.42+0.1^{b}$	$22.6+0.1^{c}$	$6.67+0.0^{d}$	$94.13+0.1^{b}$

$\pm$ Standard deviation of three replicates
Mean values followed by different superscript within column are significantly different ($P < 0.05$)

CONCLUSION

In conclusion, the flours have comparable levels of cooking time with other legumes. Also the results have shown that the flour samples may store well with long shelf life. The flour pastes had very low retrogradation characteristics and of higher gelatinization properties. The flours could find various and useful applications in foods systems. An increase in the use of the flours will enhance crop production and prevent the extinction of *Cajanus cajan.* Infact, the availability of the crop will contribute positively to food security in the country.

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