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Studies on the intrinsic physico-chemical properties of pigeon pea (*Cajanus cajan* L.) seed flour

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ABSTRACT

Intrinsic physico-chemical properties of pigeon pea (*Cajanus cajan* L cv. IITA 8860) seed flour were investigated. The results indicated that although pigeon pea seed weight, volume and density were in the range reported for some commonly consumed seed legumes, the seed exhibited lower hydration and swelling coefficients. The seed flour was a good gel-forming agent; more hydrophobic but less lipophilic in nature; and it had poor foaming qualities and poor emulsion stability. Furthermore, its protein showed least solubility at pH 4.0.

Keywords: Pigeon pea, physico-chemical properties, flour.

INTRODUCTION

In recent times, nutrition research has focused attention on bridging the gap between the population growth and protein supply in Nigeria. Research efforts have been on the introduction of cheaper and affordable vegetable protein sources in the diets of the less privileged and low-income group. In this regard, nutritional quality potential of the under-exploited seeds of *Cajanus cajan* L. has been reported (Oloyo, 2002; 2004). This therefore, adds to the list of food legumes such as *Vigna unguiculata* and *Glycine max* that have been earlier targeted in the campaign for increased consumption to prevent incidence of protein malnutrition among the populace. However, acceptability of *Cajanus cajan* seeds as ingredients in prepared foods requires a knowledge of its physical and functional properties. The present study reports on the intrinsic physico-chemical properties of *Cajanus cajan* seeds. The information will assist in predicting useful applications of the seed flour in prepared foods.

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MATERIALS AND METHODS

Clean and healthy seeds of pigeon pea, *Cajanus cajan* L. cv. IITA 8860 were collected from the International Institute of Tropical Agriculture, Ibadan, Nigeria.

Determination of physical properties

Physical properties of seeds were studied in accordance with the procedures of Attia *et al.*, (1994). Weight of randomly sampled 100 seeds was taken, and the volume was measured by absolute displacement using distilled water. Apparent density of the seeds was calculated by dividing weight of seeds by their volume. Percentage seed coat was calculated by manually decorticating 100 seeds. Hydration coefficient and swelling coefficient were determined by soaking 50 g of seeds in 150 ml

distilled water for 16 h, while noting the weight and the volume of soaked seeds at intervals of 4 h. Hydration coefficient was calculated as the percentage increase in weight of seeds, while swelling coefficient was calculated as the percentage increase in volume of seeds.

Determination of functional properties

A bulk of the seeds were oven-dried at 60°C for 24 h, milled in a Wiley mill to pass through a 40 mm mesh sieve, and then stored in air-tight container for subsequent chemical analyses.

a. Least gelation concentration

Least gelation concentration was determined following the procedure of Coffman and Garcia (1977). Suspensions of the milled seed samples, i.e., 2, 4, 6, 8, 10, 12, 14 and 16% (w/v) were prepared in 10 ml distilled water in test tubes. The test tubes containing these suspensions were heated in a boiling water bath for 60 min. after which they were rapidly cooled to 4oC under running cold tap water. Cooling at this temperature continued for another 2 h. The minimum concentration of the sample which did not drip or slip from inverted tubes determined the least gelation concentration.

b. Water and oil absorption properties

Water and oil absorption capacities were determined by the method of Sathe *et al.*,(1982). A 0.5 g milled seed sample was added to each of 5 ml distilled water and 5 ml oil (AVOP vegetable oil) in separate 10 ml graduated centrifuge tubes. The mixtures were stirred with glass rods to disperse the samples in both solvents. After standing for 30 min at room temperature (29-30°C), the mixtures were centrifuged (5000 x g, 30 min). Volumes of both supernatants were noted, and then excess water or oil absorbed was expressed as the percentage water or oil bound by 100 g sample. Densities of water and oil used were 1 g/ml and 0.88 g/ml, respectively.

c.Emulsion properties

Emulsions were prepared according to the method of Sathe and Salunkhe (1981). Milled seed sample (1 g) was blended in a KENWOOD blender with 50 ml distilled water for 30 s at high speed. Vegetable oil (AVOP) was added continuously from a burette at the rate of 5 ml/min while blending continued. Oil addition was stopped when the nature of emulsion changed, as marked by decreased homogeneity. The emulsion so prepared was then used to study emulsion capacity and stability. A portion of the emulsion was centrifuged (35000 x g) until the volume of oil separated from the emulsion was constant in order to determine emulsion capacity. Another portion of the emulsion was allowed to stand in a graduated cylinder for 0, 0.5, 1, 2, 3, 4, 5, 6 and 24 h at room temperature while noting the volume of water separated. Emulsion capacity and stability were calculated using the following equations.

$$\text{Emulsion capacity (\%)} = \frac{\text{Height of emulsified layer}}{\text{Height of whole layer}} \times 100$$

$$\text{Emulsion stability (\%)} = \frac{\text{Height of the remaining emulsified layer}}{\text{Height of whole emulsified layer}} \times 100$$

d.Foaming properties

Foaming capacity and stability were determined according to the method reported by Coffman and Garcia (1977). A sample of 2.0 g seed flour was whipped with 100 ml distilled water for 5 min in a KENWOOD Blender at speed setting "Max" and then

poured into a 250 ml graduated measuring cylinder. The total volume at time intervals of 0.0, 0.25, 0.5, 1.0, 1.5, 2.0, 3.0 and 4 h was noted. Percent volume increase was calculated according to the following equation.

$$\text{Volume increase (\%)} = \frac{\text{Volume after whipping (ml) x Volume before whipping (ml)}}{\text{Volume before whipping (ml)}} \times 100$$

e.Protein solubility

Protein solubility profile was determined in the pH 2 to 12 for the sample at room temperature (29-30°C) by the method of Narayana and Narasinga Rao (1982). A 0.2 g of milled sample and 20 ml distilled water were shaken for 2 h at room temperature. The pH of resultant slurries was adjusted to values ranging from 2 to 12 using either 0.1 M HCl or 0.1 M NaOH. Insoluble materials were removed by centrifugation (3500 x g, 30 min) and the supernatant was digested for subsequent total nitrogen determination by the micro Kjeldahl procedure. Percentage nitrogen was converted to crude protein by multiplying %N by 6.25.All determinations were done in three replications, and all data obtained in the study were subjected to statistical analysis using the Statistical Package for Social Sciences (SPSS Inc. 1998) on a COMPAQ personal computer.

RESULTS AND DISCUSSION

The physical properties shown in Table 1 indicated that seed weight and volume of *Cajanus cajan* were similar to those reported for *Glycine max* and *Vigna unguiculata* (Kay, 1979), but less than those of *Cicer arietinum* and *Phaseolus lunatus* (Kay, 1979; Attia *et al.*, 1994) and higher than those of lentil (Kay, 1979). The seed coat (as percent of the whole seed) of *Cajanus cajan* was similar to that of *Phaseolus lunatus*, but lower than that of *Vigna unguiculata*, and was about twice that of *Cicer aeritinum* (Kay, 1979; Attia *et al.*,1994). The seeds of *Cajanus cajan* and *Cicer arietinum* had similar apparent densities. *Cicer arietinum* seeds had higher hydration and swelling coefficients than those of *Cajanus cajan* (Attia *et al.*,1994). Compared to *Cicer aeritinum*, lower values of hydration and swelling coefficients observed in *Cajanus cajan* might be due to its higher percent seed coat more so that seed coat acts as a barrier for water migration into seeds (Rolston, 1978). Results in Table 1 showed that rates of hydration and swelling of *Cajanus cajan* seeds were rapid within 8 h of soaking and approached zero after 12 h.

Table 1. Physical properties of pigeon pea seeds

Parameter	Mean	±SD
100 seed weight (g)	10.57	1.029
100 seed volume (cm^3)	9.01	1.006
Apparent seed density (g/cm^3)	1.17	0.003
Seed coat (%)	8.88	1.376
Hydration coefficient (%) at:		
4 h	39.83c*	2.289
8 h	70.83b	3.289
12 h	91.00a	4.068
16 h	91.00a	5.300
Swelling coefficient (%) at:		
4 h	68.74t*	3.215
8 h	81.27s	4.646
12 h	112.50r	6.872
16 h	112.50r	5.139

*Mean values denoted by different subscripts, r-t within the column for a parameter differ significantly at P(0.05).

* Mean values denoted by different subscripts, a-c within the column for a parameter differ significantly at P(0.05).

Table 2 shows the functional properties of *Cajanus cajan* seed flour. The least gelation concentration exhibited by *Cajanus cajan* seed flour was less than that shown by *Lupinus*

mutabilis seed and *Phaseolus vulgaris* seed flour (Sathe *et al.*, 1982). The result thus tended to suggest that *Cajanus cajan* seed flour is a better gel-forming agent and the gel produced from the flour is relatively firmer. Differences in the gelling properties of legume flour have been ascribed to the relative ratios of different constituents (i.e. proteins, carbohydrates and lipids) and that interactions between such components have a significant role in the functional properties (Sathe *et al.*, 1982). Indeed, *Cajanus cajan*, *Lupinus mutabilis* and *Phaseolus vulgaris* seed flour differ in their chemical composition (Kay, 1979; Sathe and Salunkhe, 1981; Sathe *et al.*, 1982; Oloyo, 2002) and this might have accounted for the differences in the least gelation concentrations.

Water absorption by the *Cajanus cajan* seed flour was higher than those reported for sunflower seed, *Glycine max*, *Lupinus mutabilis* seed and *Phaseolus vulgaris* seed flour (Sathe *et al.*, 1982), an indication that the *Cajanus cajan* seed flour is more hydrophobic in nature (Lin *et al.*, 1974). The higher water absorption for the *Cajanus cajan* seed flour might be due to its low fat content and the predominance of polar amino acids in its protein structure (Kay, 1979). While polar amino acids have shown to be the primary sites for water absorption, fat creates lipophilic environment that blocks the water binding sites on the proteins (Kuntz, 1971; Chou and Morr, 1979).

Table 2. Functional properties of pigeon pea seed flour

Parameter	Mean	±SD
Least gelation concentration (%)	8.00	0.592
Water absorption capacity (%)	409.00	12.098
Oil absorption capacity (%)	251.00	9.162
Foaming capacity (%)	9.81	1.827
Emulsion capacity (%)	20.93	1.021
Emulsion stability (%)	42.50	2.010

Data on oil absorption of *Cajanus cajan* seed flour (Table 2) showed that it absorbed less oil than water, thus suggesting the seed's protein is less lipophilic. While it absorbed more oil than soybean flour, sunflower seed flour, lupin seed flour, wheat flour and full-fat fluted pumpkin, it absorbed less than isolated protein concentrates from soybean, lupin seed, great northern seed, sunflower seeds (Lin *et al.*, 1974; Sathe *et al.*, 1982, Giami and Bekebain, 1992).

Emulsion capacity of *Cajanus cajan* seed flour shown in Table 2 was in the range reported for full-fat fluted pumpkin seed flour, wheat flour, soybean seed flour, and protein concentrates and isolates from soybean and sunflower seeds. On the other hand, the emulsion capacity for the pigeon pea flour was less than those of lupin seed flour and sunflower seed (Lin *et al.*, 1974; Sathe *et al.*, 1982; Fagbemi and Oshodi, 1991). Figure 1 depicts the emulsion stability of the pigeon pea flour. It revealed that the emulsion stabilized for only 2 h after which water separation began. The emulsion broke down rapidly within 6 to 24 h on standing at 29°C, and it was considered poor. However, the medium emulsion capacity of the pigeon pea flour may be useful for food applications especially serving as a replacement

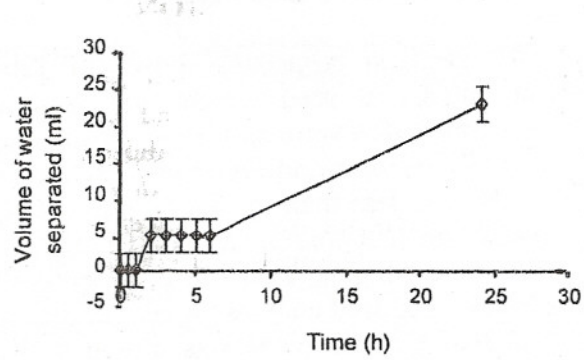

Figure 1. Effect of keeping time on emulsion stability of pigeon pea seed flour

for wheat and soybean flour as meat additive, meat extender, binder formulation and in stabilizing colloidal food system (Fagbemi and Oshodi, 1991).

Foaming capacity of pigeon pea seed flour (Table 2) compared with that reported for full-fat fluted pumpkin seed flour (Fagbemi and Oshodi, 1991) but it was lower than those of soybean seed flour, sunflower seed flour (Lin *et al.*, 1974) and lupin seed flour (Sathe *et al.*, 1982). The foaming stability of pigeon pea seed flour depicted in Figure 2 indicated that it was poor as it collapsed within 1 h of standing at 29°C. Foaming characteristics of flour and protein isolates or concentrates had been associated with the concentration of protein, fat and carbohydrate in the substrates. While protein causes an increase in foaming capacity and stability, the reverse was true for fat and carbohydrates (Richert, 1979; Sathe and Salunkhe, 1981; Sathe *et al.*, 1982). The poor foaming capacity and stability of the pigeon pea flour, therefore, may be attributed to the lower protein and higher carbohydrate contents of the seed flour, compared to those of soybean, sunflower and lupin seeds flour (Lin *et al.*, 1974; Kay, 1979; Sathe *et al.*, 1982; Oloyo, 2002).

Profile shown in Figure 3 indicated that solubility of the pigeon pea seed flour protein

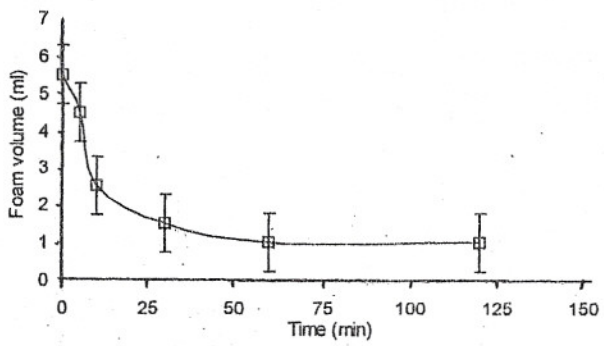

Figure 2. Foaming stability of pigeon pea seed flour

was pH dependent. Least solubility was at pH 4.0 and it increased with the increase of pH. The result is suggestive that the isoelectric pH of pigeon pea seed flour protein is about pH 4. The trend in protein solubility observed in the present study agreed with the solubility profiles

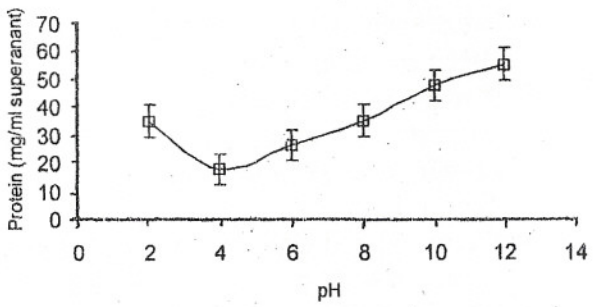

Figure 3. Effect of pH on pigeon pea seed protein solubility

of lupin seed flour (Sathe *et al.*, 1982), and full-fat fluted pumpkin seed flour (Fagbemi and Oshodi, 1991; Giami and Bekebain, 1992) where minimum solubility was recorded at pH 4.0. Also, Ruiz and Hove (1976) and Narayana and Narasinga Rao (1982) observed isoelectric pH of 4.5 for dehulled lupin seed proteins and winged bean flour, respectively.

CONCLUSION

From the foregoing, it may be concluded that although *Cajanus cajan* L cv. IITA 8860 seed weight, volume and density were within the range reported for some commonly consumed seed legumes, the seeds exhibited lower hydration and swelling coefficients. The seed flour was a good gel-forming agent; more hydrophobic but less lipophilic in nature and it had poor foaming qualities and poor emulsion stability. Furthermore, its protein showed least solubility at pH 4.0.

REFERENCES

Attia RS, El-Tabey Shehata AM, Aman ME and Hamza MA 1994. Effect of cooking and decortication on the physical properties, the chemical composition and the nutritive value of chick pea (*Cicer arietinum* L.). Food Chem. 50: 125-131.

Chou DH and Morr CV 1979. Protein-water interactions and functional properties.J.Amer. Oil Chem. Soc. 56: 53A.

Coffman CW and Garcia VV 1977. Functional properties and amino acid contents of a protein isolate from bean flour. J. Food Tech. (UK) 12: 473

Fagbemi TN and Oshodi AA 1991. Chemical composition and functional properties of full-fat fluted pumpkin seed flour (*Telafaria occidentalis*). Nig. Food J. 9: 26-32.

Giami SY and Bekebain DA 1992. Proximate composition and functional properties of raw and processed full-fat fluted pumpkin (*Telfaria occidentalis*) seed flour. J. Sci. Food Agric. 59: 321-325.

Kay DE 1979. Food Legumes. Tropical Product Institute, London.

Kuntz ID 1971. Hydration of macromolecules. 3. Hydration of polypeptides. J. Chem. Soc. 93: 514.

Lin MJY, Humbert ES and Sosulski, FW 1974. Certain functional properties of sunflower meal products. J. Food Sci. 39: 368-370.

Narayana K and Narasinga Rao MS 1982. Functional properties of raw and processed winged bean (*Psophocarpus tetragonolobus*) flour.J. Food Sci. 47:1534-1538.

Oloyo RA 2002. Processing effects on the chemical composition and nutritional potential of pigeon pea, *Cajanus cajan* L. La Rivista Italiana Delle Sostanze Grasse 78: 273-276.

Oloyo RA 2004. Effects of germination on the nutritional quality of pigeon pea (*Cajanus cajan* L.) Food Chem. 85: 479-502.

Richert SH 1979. Physical-chemical properties of whey protein foams. J. Agric. Food Chem. 27: 665.

Rolston MP 1978. Water impermeable seed dormancy. The Bot. Rev., 44: 365-396.

Ruiz LP Jr. and Hove EL 1976. Conditions affecting production of a protein isolate from lupin seed kernels. J. Sci. Food Agric. 27: 667.

Sathe SK and Salunkhe DK 1981. Functional properties of great northern bean (*Phaseolus vulgaris*)proteins emulsion, foaming, viscosity and ge lation properties.J.Food Sci. 46: 751-756.

Sathe SK Deshpande SS and Salunkhe DK 1982. Functional properties of lupin seed (*Lupinus mutabilis*)proteins and protein concentrates. J. Food Sci. 47: 491-498.

SPSS Inc. 1998. SPSS 9.0 for Windows. Standard Version.

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