Physical Properties, Chemical Composition And Nutritional Quality Of Two Cultivars Of Pigeon Pea (*Cajanus Cajan L.)*

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Abstract

Physical properties, chemical composition and nutritional quality potentials of the seeds of two cultivars of Cajanus cajan were studied. Differences between the two cultivars were less pronounced except in their contents of calcium, phosphorus, phytic acid, trypsin inhibitory activity and glutelins. In addition, both cultivars contained valuable nutrients and food energy comparable to those of the commonly consumed seed legumes. Presence of tannins, phytic acid, oxalate, phenolics and trypsin inhibitors in the seeds may not constitute any problem in the utilization of the nutrients once the seeds are subjected to processing involving either heat treatment, soaking, dehulling and germination or their combination before consumption.

Résumé

Comme étude sur la physique biens, chimique composition et alimenta qualite potentialité de 2 cultivars de Cajanus cajan était amena. Aucun insigne différence exista entre la cultivars excepté aux leur contenu de calcium, phosphorus, phytic acide, trypsin engorge activité et glutelins. Et, de cultivars contenant utile nutrients et aliment énergie pareil pour ceux de la commun consomma pépin legumes. Présence de tannins, phytic acide, oxalate, phenolics et trypsin engorge aux la pépin mai non constitua quelconque problème aux la Utilité de la nutrients si la pépin étaient traita par chauffage, garda aux eau, arracha la pépin manteau et germination ou leur combinaison avant consommation.

Introduction

In Nigeria, dietary proteins from animal sources are expensive and are in short supply. The problem is further aggravated by the rapid population growth of the country, which makes it difficult for food protein production to keep pace with demand (UNFAO, 1996). In recent times, focus of nutrition research in Nigeria has been on the search for food legumes that constitute cheaper alternative sources of protein and calories. The present study reports that physical properties, chemical composition and nutritional quality of two cultivars of pigeon pea. Cultivation of the legume is well supported by the climatic and soil conditions of the western region of Nigeria (Kay, 1979). Its seeds are boiled and eaten by natives (Oyenuga, 1968).

Materials and Methods

Sample Collection and Physical Properties.

Samples of clean, healthy and dry seeds of two cultivars of pigeon pea, *Cajanus cajan L.*, namely CITA-2 and CITA-3, used in this study were collected from International Institute of Tropical Agriculture, Ibadan, Nigeria. 100 seed weight and volume, apparent density, percent seed coat, hydration coefficient and swelling coefficient were determined as described elsewhere (Attia et al., 1994). Samples of the seeds were freeze-dried, ground to pass through a 40 mm mesh sieve in preparation for subsequent chemical analysis.

Chemical Analysis

Samples were removed from the milled seed samples for the determination of total nitrogen, ether extract, crude fibre and ash (AOAC, 1980). Crude protein was calculated by multiplying kjeldahl nitrogen by the factor 6.25. Nitrogen free extractives (NFE) was estimated by difference. Total ash was fractionated into soluble and acid insoluble ash using the method of Egan *et al,* (1981). The food energy content was estimated by multiplying the percentages of crude protein, ether extract and nitrogen free extractives (total crude carbohydrates) by the factors of 4, 9 and 4 respectively (Osborne and Voogt, 1978).

Total sugar content was determined by the phenol-sulphuric acid method of Dubois et al (1956). Starch content was determined by the direct acid hydrolysis method followed by glucose determination by the Lane and Eynon method (AOAC, 1980) using 0.9 as a conversion factor. Neutral detergent fibre (NDF), acid detergent fibre (ADF), cellulose and lignin were determined as described by Baker (1977). Insoluble hemicellulose was calculated by difference. Non-nutritive matter (NNM) was estimated as the addition of acid-insoluble ash and lignin (Fonnesbeck, 1976). Digestible energy values of samples for different laboratory animals were estimated by fitting data from chemical analyses into the prediction equations described by Fonnesbeck (1976).

Calcium, copper, iron, magnesium, manganese, sodium, potassium and zinc were determined with an atomic absorption spectrophotometer (Perkin Elmer 2380, Perkin Elmer Ltd., USA). Total phosphorus was determined colorimetrically using phosphovanadomolybdate method of AOAC, (1980). The antinutritional factors such as phytic acid (Wheeler and Ferrel, 1971), total oxalate (Krishna and Ranjhan, 1980), tannins (Burns, 1971), total phenolics (Swain and Hills, 1959) and trypsin inhibitory activity (Kakade *et al,* 1969) were determined in all samples.

The total (true) proteins in the samples were extracted by the methods of Basha *et al.* (1976) as modified by Mohan and Janardhanan (1993). The extracted proteins were purified by precipitation with cold 20% trichloroacetic acid. The seed protein fractions (i.e. albumins, globulins, prolamins and glutelins) were successively extracted and quantified as described by Gheyasuddin *et al.* (1970).

Statistical Analysis

All chemical analysis and estimations of the physical properties were done in three replicates. Data obtained in this study were analysed using Statistical Package for Social Sciences (SPSS Inc. 1988) on a COMPAQ personal computer.

Results and Discussion

The physical properties of the *Cajanus cajan* seeds indicated that differences between the cultivars were not remarkable (table 1). Ranges of seed weight and volume of *Cajanus cajan* cultivars in this study 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). While the seeds of *Cajanus cajan* and *Cicer arietinum* had similar apparent density, the latter had higher hydration and swelling coefficients (Attia *et al,* 1994). 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).

Table 2 shows the proximate and mineral composition of the seeds of *Cajanus cajan.* There was no significant difference in the nutrient composition of both cultivars except in their potassium and phosphorus contents where CITA-2 was superior. Compared with the seeds of *Vigna unguiculata,* the results revealed that the seeds of *Cajanus cajan* contained lower total crude carbohydrates (NFE) and higher crude fibre contents. However, seeds of both legumes were similar in crude protein, fat and ash contents (Oyenuga, 1968). With the exception of their higher crude fibre content, the seeds of *Cajanus cajan* was closer to the seeds of *Phaseolus lunatus* in proximate composition (Ologhobo and Fetuga, 1986). Compared with the seeds of *Vigna capensis* and *Vigna sinensis,* seeds of *Cajanus cajan* contained lower food nutrients excepting NFE (Mohan and Janardhanan, 1993). The caloric values of the two cultivars of *Cajanus cajan* were lower than those of *Vigna capensis* and *Vigna sinensis*, but were about the same with the food energy values of *Vigna unguiculata, Phaseolus lunatus, Phaseolus limensis, Pisum sativum* and *Lens culimaris* (Mieners *et al*, 1976).

With the exception of calcium, the seeds of both cultivars of *Cajanus cajan* were superior to those of *Abrus precatorius* (Rajaram and Janardhanan, 1992) in their contents of the mineral elements determined in this study. Furthermore, *Cajanus cajan* seeds were richer in their mineral composition than the seeds of *Vigna unguiculata, Phaseolus vulgaris, Lens culineris* and *Pisum sativum* (Kay, 1979). Compared with *Cicer arietinum,* while *Cajanus cajan* seeds were inferior in their contents of sodium, potassium, calcium and magnesium, both legumes contained similar contents of manganese, copper, iron and zinc. *Cajanus cajan* was superior in the phosphorus contents (Attia *et al.* 1994). While *Cajanus cajan* is superior to *Vigna capensis* and *Vigna sinensis,* in the contents of sodium, manganese, zinc and phosphorus, the reverse is the case in the contents of potassium, calcium, magnesium, iron and copper (Mohan and Janardhanan, 1993).

Protein fractions of the seeds of both cultivars of *Cajanus cajan* were not significantly different except in the glutelins contents where CITA-2 contained significantly higher amount (Table 3). The proteins are similar to those of *Vigna unguiculata, Lens culinaris, pisum sativum, Phaseolus lunatus, Cicer arietinum, Vigna capensis* and *Vigna sinensis* in that they contain more globulins plus a small quantity of albumins (Kay, 1979; Mohan and Janardhanan, 1993). Indeed, the composition of the proteins of the seeds of *Cajanus cajan* cultivars investigated in the present study compared with those of *Vigna capensis* and *Vigna sinensis* (Mohan and Janardhanan, 1993).

Estimation of the total caloric value of foods by the method of Osborne and Voogt (1978) was based on energy contributed by protein, fat and carbohydrates. Crude fibre (or cell wall carbohydrates or neutral detergent fibre, NDF) was not considered on the assumption that it was indigestible by human digestive enzymes (Southgate, 1969). On the contrary, Fonnesbeck (1976) confirmed partial utilization of cell wall carbohydrates and declared lignin as the indigestible component of the cell wall carbohydrates. Together with acid-insoluble ash, lignin constituted the non-nutritive matter of the food. In addition, Fonnesbeck (1976) established regression equations describing the relationship between nutritive and non-nutritive components of foods and digestible energy (DE) values of such foods for different species of animals. Consequently, soluble carbohydrates, fibre and non-nutritive fractions of the seeds of *Cajanus cajan* were determined and the digestible energy values estimated. Results presented in Tables 4 and 5 showed that with the exception of total sugar, CITA-2 cultivar contained non-significantly higher contents of the carbohydrate fractions and estimated digestible energy values.

Like the seeds of other leguminous plants, the seeds of both *Cajanus cajan* cultivars evaluated contain tannin, phytic acid, oxalate, pheonolics and trypsin inhibitor (Table 6) all of which have been reported to limit utilization of the legumes by interfering with the digestion, absorption and metabolism of the valuable nutrients they contain (Liener, 1980; Nowacki, 1980). Both cultivars differ remarkably in their contents of phytic acid, phenolics and trypsin inhibitory activities where CITA-2 contained significantly higher concentrations of the antinutritional factors. However, remarkable success has been recorded in improvement of nutrient availability of legume seeds by soaking, dehulling, germination and heat treatment (Haider, 1981; Ologhobo and Fetuga, 1986; Batra *et al.*, 1986; Manan, *et al.* 1987; Bansal *et al.* 1988; Shastry and John, 1991; Elemo *et al.*, 1998).

Conclusion

From the foregoing, it may be concluded that both cultivars of *Cajanus cajan* contained valuable nutrients and food energy comparable to those of the commonly consumed seed legumes. Presence of tannins, phytic acid, oxalate, phenolics and trypsin inhibitors in the seeds may not constitute problem in the utilization of the nutrients once the seeds are subjected to processing involving either or combination of heat treatment, soaking, dehulling and germination before they are consumed.

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Table 1: Physical properties of the pigeon pea cultivars

Parameter	Pigeon pea cultivars		
	CITA-2	CITA-3	± SEM*
100 Seed weight (g)	10.60	10.65	0.025
100 Seed volume (cm^3)	9.00	9.03	0.015
Apparent density (g/cm^3)	1.18	1.18	0.000
Seed coat (%)	7.95	8.12	0.085
Hydration coefficient	178.00	181.00	1.500
Swelling coefficient	206.00	211.00	2.500

*SEM, standard error of the mean.

Table 2: Proximate and mineral composition of the pigeon pea cultivars

Constituent	Pigeon pea cultivars		
	CITA-2	CITA-3	± SEM*
Proximate composition (g/100g DM)			
Crude Protein	20.16	21.19	0.290
Fat	1.47	1.57	0.050
Nitrogen free extractives	67.47	66.22	0.625
Crude fibre	6.46	6.89	0.215
Ash	3.99	4.13	0.070
Soluble ash	3.85	3.98	0.065
Acid insoluble ash	0.14	0.15	0.005
Energy (Kcal/100g DM)	365.55	363.77	0.890
Mineral composition (mg/100g DM)			
Sodium	42.90	41.56	0.670
Potassium	85.49	87.03	0.770
Calcium	134.15a+	125.52b	4.650
Magnesium	80.86	82.59	0.865
Manganese	3.10	2.91	0.095
Iron	6.03	6.25	0.110
Copper	1.22	1.19	0.015
Zinc	4.21	4.35	0.070
Phosphorus	313.8a	289.2b	7.300

*SEM, standard error of the mean.
+Mean values denoted by different subscripts differ significantly at P (0.05).

Table 3: True protein and protein fractions of the pigeon pea cultivars.

Component (g/100g DM)	Pigeon pea cultivars		
	CITA-2	CITA-3	± SEM*
Total (true) protein	17.99	18.52	0.265
Albumins	3.48	3.58	0.050
Globulins	12.19	13.14	0.475
Prolamins	1.16	1.19	0.015
Glutelins	1.16a+	0.59b	0.285

*SEM, standard error of the mean.
+Mean values denoted by different subscripts differ significantly at P (0.05)

Table 4: Total sugar, starch and dietary fibre components of the pigeon pea cultivars

Constituent (g/100g DM)	Pigeon pea cultivars		
	CITA-2	CITA-3	± SEM*
Total sugar	3.42	3.68	0.130
Starch	37.58	35.25	1.165
NDF	7.3	7.1	0.100
ADF	1.51	1.48	0.015
Hemicellulose	5.79	5.62	0.085
Lignin	0.08	0.06	0.010
Cellulose	1.43	1.42	0.005
Non-nutritive matter	0.22	0.21	0.005

*SEM, standard error of the treatment means.

Table 5: Anti-nutritional factors in the pigeon pea cultivars

Constituent	Pigeon pea cultivars		
	CITA-2	CITA-3	± SEM*
Tannins (mg/100g)	2.25	2.16	0.045
Phytic acid (mg/100g)	506.6	476.1	15.25
Total oxalate (g/100g)	14.93	16.41	0.740
Total phenolics (μg/100g)	24.1	21.5	1.300
Trypsin inhibitory activity+	15.04	18.27	1.615

*SEM, standard error of the mean.
+Express as units of enzyme activity inhibited per mg protein.

Table 6: Estimated digestible energy, DE (Kcal/100g DM) values of the seeds of pigeon pea cultivars for different laboratory animals+

Laboratory animals	Pigeon pea cultivars		
	CITA-2	CITA-3	± SEM*
Rabbit	367.94	365.52	
Rat	399.03	394.85	
Swine	417.98	414.59	
Mean	394.98	391.65	1.665

+Prediction equations of Fonnesbeck (1976) used for DE estimation are:

Rabbit: DE = 4.67 – 0.231NNM (%) – 0.0456 CP (%)
R^2, 0.971; $S_{y,x}$, 0.101

Rat: DE = 2.54 – 0.0272 CF (%) + 0.0241 SC (%)
R^2, 0.973; $S_{y,x}$, 0.094

Swine: DE = 2.22 + 0.0292 SC (%) – 0.129 Lignin (%)
R^2, 0.983; $S_{y,x}$, 0.073.

*SEM, standard error of the mean.