

Nutritional Quality of Vegetable Pigeonpeas [*Cajanus cajan* (L.) Millsp.]: Dry Matter Accumulation, Carbohydrates and Proteins

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—ABSTRACT—

Since average dry matter accumulation of green pigeonpea seeds intended for use as a vegetable was 65.6% of the total in matured seeds, green seeds were collected prior to physiological maturity. Green seed contained less starch and more dietary fiber than did mature seed. Flatulence causing oligosaccharides were present in a lower amount in green seed. Trypsin inhibitor activity (TIA) was more in mature seed whereas green and mature seed differed little in chymotrypsin inhibitor activity (CIA). The mean value for *in vitro* protein digestibility (IVPD) of green seed was more than that of mature seed. The green seed had a greater amount of tryptophan and threonine and the sulphur containing amino acids, methionine and cystine. It is concluded that the green seeds of pigeonpea genotypes are nutritionally better than their mature seeds.

INTRODUCTION

LEGUME SEEDS are important for supplying protein to diets in many parts of the world. Pigeonpea [*Cajanus cajan* (L.) Millsp.] is a nutritionally important grain legume of tropical and sub-tropical regions of the world. While pigeonpea is predominantly consumed in the form of cooked dhal (decorticated dry split seeds) along with cereals, it remains a common practice in several countries to consume the developing green seeds shelled out of fresh pods. In India, developing green pigeonpea seeds are used fresh as a vegetable in several states (Singh et al., 1977). The collection of pigeonpea pods is generally made 25–30 days after flowering. Large seeded varieties are preferred for this purpose. The green pigeonpeas, mostly processed by canning and freezing, are consumed in some Caribbean and Latin American countries (Mansfield, 1980). Although reports are available on the methods of processing green pigeonpea seeds (Sanchez et al., 1961), limited information is available on the nutritional quality of green seeds, particularly for those cultivars used as a vegetable in India.

In legumes, there are two main aspects of protein quality (Boulter et al., 1976). First, the amino acid composition relative to the F.A.O. reference pattern (FAO/WHO, 1973) and second, digestibility and the presence of antimetabolic proteins (Liener, 1969). A large variation in protease inhibitors and *in vitro* protein digestibility of pigeonpea and its wild relatives has been reported earlier (Singh and Jambunathan, 1981a). Improvement of the nutritional quality of pigeonpea is one of the objectives at ICRISAT (Jain et al., 1980). Besides breeding for improved grain type, the development of pigeonpea cultivars suitable for vegetable use has been emphasized recently in an International Pigeonpea Workshop held at ICRISAT (Jain et al., 1980). We have examined the nutritional composition of green seed of pigeonpea for use as a vegetable. This paper reports the dry matter and nutritional quality of carbohydrates and proteins in green seeds and compares the results with those of the mature seed.

MATERIALS & METHODS

Materials

Nine pigeonpea genotypes with a range of seed size (ICPL-102, ICPL-114, ICPL-119, ICPL-122, ICPL-128, ICPL-212, ICP-6997, ICP-7035 and cv. C-11) grown in unreplicated plots were used for this study. These were grown on black soil at ICRISAT Center, Patancheru, near Hyderabad during the 1980–81 rainy season. The crop was grown by using normal cultural practices. No irrigation or fertilizer was applied. The homogenous lots of pods containing green seeds were collected at the stage when pigeonpeas are generally harvested for use as a vegetable by growers. Green seeds were shelled out of these pods manually. Mature seed samples of these same genotypes were collected. The fresh weight of the green seeds was recorded. The material was freeze-dried and moisture content determined. Dried green and mature seed samples were ground in a Udy cyclone mill using a 0.4 mm screen. After defatting in a Soxhlet apparatus, using hexane, the material was used for chemical analyses.

Methods of analysis

Crude fiber was determined according to the method of AOAC (1975). The procedure described by Van Soest and Wine (1973) was followed for the estimation of neutral detergent fiber. The analysis of dietary fiber as an estimate of unavailable carbohydrates was carried out according to the method of Southgate et al. (1978).

Soluble sugars were extracted in a Soxhlet apparatus using 80% ethanol and estimated colorimetrically by the phenol-sulphuric acid method (Dubois et al., 1956). Thin-layer chromatography (TLC) was used to estimate glucose and fructose, sucrose, raffinose, stachyose and verbascose. TLC was carried out on a silica gel plate in the ascending fashion. The plates of 500 μ thickness were prepared using a slurry of silica gel-G in water and activated before use by heating it at 105°C for 35 min. The solvent used consisted of chloroform:acetic acid:water (6:7:1 v/v). After separation, sugar spots were detected on the TLC plates by spraying with aniline-diphenylamine reagents. The TLC plates were scanned in a densitometer and sugar concentrations were calculated in comparison with sugar standards which were run simultaneously under identical conditions. The following were the sources for the oligosaccharide standards: raffinose and stachyose (Sigma Chemical Co., USA) and verbascose (70% pure, a gift from Nestlé Products, Technical Assistance Co., Ltd., Switzerland) and other sugars of analar grade were used as standards.

Starch content in the dry residue, left after extraction of soluble sugar with 80% ethanol, was determined by enzymatic hydrolysis (Singh et al., 1980).

Amylase inhibitor activity. The inhibitor activity of pancreatic amylase (obtained from Sigma Chemical Co., USA) was carried out according to the method of Jaffe et al. (1973). Amylase inhibitor was extracted by shaking a defatted sample with 0.02M phosphate buffer pH 6.9 (1:10 w/v) for 2 hr at room temperature. The suspension was then centrifuged at 10,000 \times g for 15 min at room temperature. The supernatant was then heated for 10 min at 70°C, centrifuged again at 10,000 \times g for 15 min at room temperature, and the supernatant tested for amylase inhibitor activity.

Determination of *in vitro* digestibility of meal starch was determined using pancreatic amylase according to the procedure described by Singh et al. (1982). A suitable amount of defatted meal (50 mg) was dispersed in 1.0 ml of 0.2M phosphate buffer, pH 6.9. Pancreatic amylase (20 mg) was dissolved in 50 ml of the same buffer and 0.5 ml was added to a sample suspension. Maltose was used as the standard and the values were expressed as mg of maltose released per g of sample.

Amino acid analysis. A suitable quantity of sample (50 mg) was refluxed for 24 hr in 50 ml 6N HCl. After evaporating the HCl, the

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Table 1—Fresh and dry weight and moisture of green and mature seed of 9 pigeonpea cultivars

| Varieties | Pod color | Seed color (mature) | Green seed | | | Mature seed | | | Green seed as % of mature seed (dry wt basis) |
|-----------|--------------------|---------------------|--------------------|------------------|--------------|--------------------|------------------|--------------|---|
| | | | Fresh wt (mg/seed) | Dry wt (mg/seed) | Moisture (%) | Fresh wt (mg/seed) | Dry wt (mg/seed) | Moisture (%) | |
| ICPL-102 | Mixed ^a | Cream | 238.0 | 91.4 | 61.5 | 153.5 | 130.9 | 14.7 | 69.8 |
| ICPL-114 | Mixed | Cream | 198.4 | 75.3 | 62.0 | 130.8 | 117.0 | 10.5 | 64.3 |
| ICPL-119 | Mixed | Lt brown | 216.2 | 80.8 | 62.6 | 146.4 | 129.4 | 11.6 | 62.4 |
| ICPL-122 | Mixed | Lt brown | 200.6 | 82.1 | 59.1 | 143.4 | 129.0 | 10.0 | 63.4 |
| ICPL-128 | Green | Brown | 226.7 | 86.4 | 61.8 | 140.8 | 123.8 | 12.1 | 69.8 |
| ICPL-212 | Mixed | Cream | 206.9 | 90.4 | 56.4 | 144.6 | 126.0 | 12.2 | 71.7 |
| ICP-6997 | Green | Brown | 208.4 | 78.9 | 62.1 | 142.5 | 125.7 | 11.9 | 62.6 |
| ICP-7035 | Purple | Dk brown | 327.5 | 120.6 | 63.2 | 221.5 | 190.8 | 13.9 | 63.2 |
| cv. C-11 | Mixed | Brown | 154.8 | 66.4 | 57.1 | 118.7 | 103.8 | 12.6 | 64.0 |
| Mean | | | 198.6 | 85.8 | 60.7 | 149.1 | 130.7 | 12.2 | 65.6 |

Table 2—Mean and range values of seed coat, fibers, starch, amylase inhibitors and *in vitro* starch digestibility of green and mature seed of 9 pigeonpea cultivars

| Constituent | Maturity stage | Range | Mean | S.D |
|---|----------------|-------------|-------|------|
| | | | | |
| | Mature | 9.03-16.70 | 13.57 | |
| Crude fiber (%) | Green | 7.93- 8.67 | 8.19 | 0.13 |
| | Mature | 5.89- 7.02 | 6.57 | |
| Neutral-detergent fiber | Green | 18.18-23.40 | 20.67 | 0.74 |
| | Mature | 13.50-18.74 | 16.56 | |
| Dietary fiber (%) | Green | 22.08-24.76 | 23.08 | 0.60 |
| | Mature | 17.92-21.60 | 20.11 | |
| Starch (%) | Green | 46.60-50.99 | 48.39 | 0.78 |
| | Mature | 50.82-55.20 | 52.96 | |
| Amylase inhibitors ^a | Green | 15.89-19.26 | 17.28 | 1.25 |
| | Mature | 22.51-34.15 | 26.87 | |
| <i>In vitro</i> starch digestibility ^b | Green | 50.89-56.92 | 53.06 | 0.93 |
| | Mature | 32.43-40.10 | 36.22 | |

^a Units/g meal

^b Expressed as mg maltose released/g meal

^c Standard deviation of the difference

* Significant at 5% level

** Significant at 1% level

residue was dissolved in citrate buffer (pH 2.2). The amino acids were analyzed in a Beckman 120C amino acid analyzer. The mean coefficient of variability for the different amino acids ranged between 1.96 and 13.02% except for cystine where it was 22.12%.

Determination of tryptophan was carried out colorimetrically according to Spies and Chambers (1949) with minor modifications as follows: a suitable amount of sample (20–25 mg) was placed in a test tube which, after the addition of 10 ml of solution of dimethyl-aminobenzaldehyde (3 mg/ml of 19N H₂SO₄), was incubated in the dark at room temperature (25 ± 2°C) for 18 hr. After incubation, 0.1 ml of 0.45% solution of sodium nitrite was added and the tube allowed to stand at room temperature for 30 min before reading the density at 590 nm in Spectronic-21 spectrophotometer.

Trypsin inhibitor activity. The trypsin inhibitor activity (TIA) was assayed according to Kakade et al. (1969). Trypsin inhibitor was extracted by shaking 200 mg of defatted material with 10 ml of 0.1M phosphate buffer (pH 7.6) at room temperature for 1 hr. The extract was diluted fourfold. Aliquots containing 0.2, 0.4, 0.6 and 0.8 ml were assayed for trypsin inhibitor activity. Protein content of the extract was determined according to Lowry et al. (1951).

Chymotrypsin inhibitor activity. Chymotrypsin inhibitor activity (CIA) was assayed according to Kakade et al. (1970). Chymotrypsin inhibitor was extracted as described above for trypsin except that 0.1M borate buffer at pH 7.6 was used. Protein content of the extract was determined according to Lowry et al. (1951).

***In vitro* protein digestibility.** The determination of *in vitro* protein digestibility was carried out using pepsin and pancreatin enzymes (Sigma Chem. Co., USA) according to Singh and Jambunathan (1981b).

Polyphenolic compounds (polyphenols). Polyphenols were extracted from each defatted sample (500 mg) by refluxing with 50 ml of methanol containing 1% HCl for 4 hr. The extract was concentrated in a rotary flash evaporator and brought to 25 ml with methanol HCl. The amount of phenolic compounds were estimated as tannic acid equivalent according to the Folin-Denis procedure (Swain and Hillis, 1959).

RESULTS & DISCUSSION

Dry matter, fibers and starch contents

The moisture content of green seed ranged from 56.4–63.2% indicating a small variation between the average of the samples (Table 1). Dry matter content of green seed varied from 75.3–120.6 mg/seed and of the mature seed from 117.0–190.8 mg/seed for these genotypes. The dry weight of the green and mature seeds of cv C-11 was 66.4 and 103.8 mg/seed, respectively. The dry matter accumulation of the green seeds was about 65% of the dry matter contained by the fully mature seeds (Table 1). This shows that the seeds were collected considerably before physiological maturity, which is the stage for maximum dry matter accumulation during seed development. This lack of physiological maturity was also revealed by the lower levels of starch in the green seed compared to that in the mature seed (Table 2). In a previous study, percent starch in the dehulled pigeonpea seed was maximum in samples collected at 28 days after flowering (Singh et al., 1980).

A different trend between the green and mature seed indicated that the levels of crude-, neutral detergent-, and dietary-fiber in the developing seed were greater than in the mature seed. No clear differences between the large seeded pigeonpeas and the small-seeded one (C-11) were observed with respect to the levels of starch and various fibers (Table 2).

Amylase inhibitors and *in vitro* starch digestibility (IVSD)

Amylase inhibitors of green seeds were significantly lower than those of mature seeds (Table 2). Nutritionally, these inhibitors will be of little importance in countries where green seeds are consumed after cooking as amylase inhibitors become inactive when they are heated at 100°C (Hernandez and Jaffe, 1968). However, these inhibitors will be of considerable importance where fresh green seeds are consumed.

IVSD, expressed as mg maltose released/g meal, ranged between 50.89 and 56.92 with the mean being 53.06 for these genotypes (Table 2). Significantly lower values for IVSD were obtained in the mature seed samples. The lower IVSD values of mature pigeonpea seed could be due to two factors: higher levels of amylase inhibitors in mature seeds, and a more complex starch-protein matrix as a result of seed maturation. The maturity of the seed has been reported

