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Chemical Changes at Different Stages of Seed Development in Vegetable Pigeonpeas (*Cajanus cajan*)*

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ABSTRACT

Developing green seeds of two vegetable pigeonpea (Cajanus cajan *L Millsp*) *cultivars that differ in their morphological characteristics were sampled at 24, 26, 28, 30 and 32 days after flowering (dates that are relevant to vegetable harvest) An increase in seed size was noticed between 24 and 26 days after flowering, although it continued up to 32 days after flowering The dry matter accumulation as the seed matured was greater in ICP 7035 than in T 15-15 Analysis of freeze-dried samples showed that soluble sugars, and proteins, decreased and starch content increased between 24 and 32 days after flowering Calcium and magnesium contents were considerably higher in T 15-15 than in ICP 7035, but there was little difference and copper contents ICP 7035 contained significantly higher amounts of soluble sugars than T 15-15 that it had sweet seeds, a requisite of vegetable pigeonpea cultivars*

Key words Vegetable pigeonpea, chemical changes, seed development

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INTRODUCTION

Pigeonpea (*Cajanus cajan* L Millsp) is an important pulse crop in India, and it is grown in tropical and subtropical regions of the world. The edible seeds of the leguminous plants are harvested, processed and consumed in many different ways. The developing pods of pigeonpea are harvested and shelled, and the green seeds are used as a vegetable in India and in some south-east Asian and African countries (Singh *et al* 1977; Faris *et al* 1987). Canned or frozen green pigeonpeas are used in Latin American and Caribbean countries and are also exported to North America and Europe (Mansfield 1981). Pigeonpea seeds are more nutritious when green than dry because they contain more protein, sugar and fat, but less flatulence-causing sugars and trypsin and amylase inhibitors before they are mature and dried (Singh *et al* 1984a).

To find out the right stage to harvest green pods, seeds are visually examined. Fully developed bright green seeds are preferred, but pods should be harvested just before they start losing their green colour (Faris *et al* 1987). It is also important to remember that the appearance of pods used as vegetables varies with each cultivar (Saxena *et al* 1983). Hand-picking or mechanical harvesting of green pods have become common practice for vegetable pigeonpea, and for large-scale processing for canning and freezing (Mansfield 1981). Because of the non-synchronised and continuous flowering behaviour of pigeonpea, it is difficult to pick developing pods at the same stage of physiological maturity. At ICRISAT Center, efforts have been made to identify and develop cultivars suitable for use as vegetables and to study their nutritional quality (Singh *et al* 1984a; Faris *et al* 1987). Pigeonpea pods sold as vegetables are generally picked 25–30 days after flowering (Singh *et al* 1984a). This study was planned to examine the changes in the levels of principal dietary constituents, and mineral and trace elements of pigeonpea at different stages of seed development in cultivars suitable for use as vegetables. One objective was to compare the two vegetable types (varieties) and to examine the changes with a view to suggesting a harvesting stage.

MATERIALS AND METHODS

Materials

Two genotypes (T 15-15 and ICP 7035) that differ in morphological and chemical characteristics were grown during the 1988 rainy season in deep vertisols at ICRISAT Center. For each cultivar a 100 m^2 plot was used. Two cultivars were allocated to the two plots randomly. Both plots had similar soil and field conditions and the cultivars were grown under normal cultural practices. Cultivar T 15-15 has green developing pods with medium sized seeds; it is widely grown in Gujarat State both as a vegetable and for its dry seeds. ICP 7035 has dark brown developing pods with large seeds that have a high soluble sugar content. Nearly 3000 flowers of each genotype were randomly chosen and tagged at the pollination stage on the same day. We could not undertake an experiment on bigger plots because of the high cost of operation and the non-availability of land. At the same time, since it is difficult to get about 3000 flowers on a single day in smaller plots, it was not feasible to work on more, but smaller, plots. About 20% of the tagged flowers set as pods. On each of 5 days (24, 26, 28, 30 and 32 days after tagging) the developing pods set by about 600 randomly assigned flowers were collected. Freshly harvested pods were shelled and the green seeds were separated. For each variety and on each day all seeds were collected into a single sample from which a 3-g and a *c* 40-g sample were taken. A 3-g green seed sample was used for moisture estimation, and the remaining sample (about 40 g) was freeze dried for chemical analysis. Moisture determinations were made by drying the samples in an oven at 55°C for 16 h. Prior to chemical analysis freeze dried samples (about 10 g) were finely ground in a Udy cyclone mill and passed through a 0·4-mm screen.

METHODS

Chemical constituents

The nitrogen content of the samples was determined using a Technicon auto analyser (Singh and Jambunathan 1981), and nitrogen values were converted to protein contents by multiplying by a factor of 6·25. Methods described previously were used to determine soluble sugars and starch (Singh *et al* 1980) and fibre contents (AOAC 1975).

Minerals and trace elements

A triacid mixture containing nitric, perchloric and sulphuric acids in the ratio of 20:4:1 was used for digestion. Freeze-dried defatted samples (0·5 g) were weighed and transferred to a block digester glass tube. After adding 6 ml of the triacid mixture, the sample was first digested at 70°C for 30 min, then at 180°C for 30 min, and finally at 220°C for 30 min. After digestion the mixture was cooled and dissolved in distilled water, and the volume was increased to 50 ml. The sample was then analysed for calcium, magnesium, zinc, iron and copper using an atomic absorption spectrophotometer (Varian Tectran Model 1200; Piper 1966).

Statistical analysis

For all chemical analyses, two replicates were used for the determination of each constituent. Standard errors (SE) were determined by one-way analysis of variance (Snedecor and Cochran 1967).

RESULTS AND DISCUSSION

Dry matter accumulation

In both genotypes, dry seed weight continued to increase until 32 days after flowering (Fig 1), but the increase was noticeably greater in ICP 7035 than in T 15-15 as the seeds matured. No noticeable differences in dry seed weight of these genotypes were observed at 24 and 26 days after flowering. The rate of dry matter accumulation appeared to be remarkably higher in ICP 7035 than in T 15-15

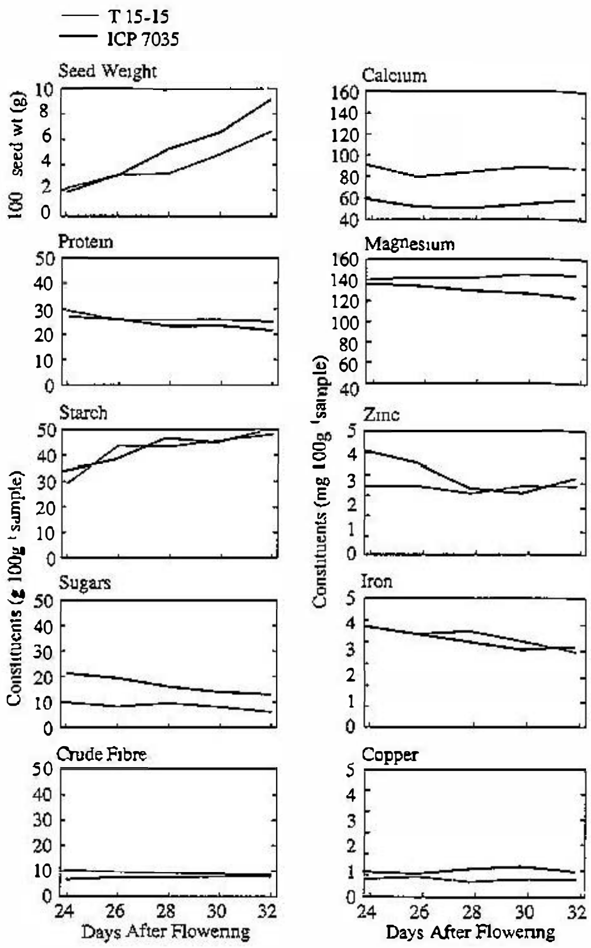

Fig 1. Levels of dry seed weight, protein, sugars, starch, crude fibre, calcium, magnesium, zinc, iron and copper at different stages of seed development in T 15-15 and ICP 7035.

between 26 and 28 days after flowering. This possibly happened because ICP 7035 has larger seeds than T 15-15. This is apparent from the differences in genotype dry seed weights at 24 and 32 days after flowering (Fig 1). As expected, seed moisture content decreased with maturation in both genotypes.

Singh *et al* (1980) reported that the weight of the developing seeds increased up to 28 days after flowering in ST-1 and HY 3C cultivars of pigeonpea. The results of this study indicate an increase in fresh weight up to 32 days, although the rate of increase was slightly slower at the later stages of development. However, it is to be expected that there will be differences between experiments carried out on different occasions in variable environmental conditions. Provided the seeds stay green, and with reference to these results on dry matter accumulation, developing seeds could be harvested at nearly 30 days after flowering and still be suitable for use as a vegetable.

Chemical changes

As shown in Fig 1, the percentage of soluble sugars and of protein decreased continuously in both genotypes. Starch content increased with maturation in ICP 7035 as well as in T 15-15 but the increase was more pronounced between 24 and 28 days after flowering in both genotypes. Protein content and soluble sugars showed a gradual decrease with maturation in both genotypes (Fig 1). However, when results were expressed as mg seed^{-1}, an increasing trend in the amounts of

soluble sugars, protein and starch was observed as the seeds increased in size and matured in both genotypes Crude fibre, expressed as a percentage of the sample weight, decreased continuously very slightly in T 15-15
slightly in ICP 7035 (Fig 1) as the seeds matured When the results were expressed as mg seed^{-1}, the amount of crude fibre increased with maturation in both cultivars but the increase was greater in ICP 7035 than in T 15-15

It has been reported that in pigeonpea seed rapid starch accumulation occurs during the period between 14 and 28 days after flowering, and is accompanied by reduction in the levels of soluble sugars during the same period (Singh *et al* 1980) Further, ICP 7035 has been reported as a cultivar that has a high seed soluble sugar content (Faris *et al* 1987) As shown in Fig 1, ICP 7035 contained remarkably higher amounts of soluble sugars than T 15-15 (Fig 1) at all stages of seed development studied These cultivars did not differ appreciably with respect to starch content during maturation This indicates that the developing green seeds of ICP 7035 are more biochemically active in accumulating soluble sugars Therefore this cultivar has sweet seeds that make it desirable as a vegetable

Mineral and trace elements

Mineral and trace elements, particularly calcium, iron and zinc, are important nutrients that are usually missing from the diets of low-income people in developing countries There were noticeable differences in the levels of calcium, magnesium, zinc, iron and copper in developing green seeds of T 15-15 and ICP 7035 (Fig 1) Calcium and magnesium were considerably higher in T 15-15 than in ICP 7035, but the reverse was true for copper at all stages of seed development The calcium content of T 15-15 was remarkably higher than ICP 7035 at all stages of seed development The iron contents were not appreciably different in these genotypes but decreased in both genotypes as the seeds matured However, zinc content of ICP 7035 was considerably higher than in T 15-15
flowering and showed no large difference during 28 to 32 days after flowering When consumed, developing green seeds are a richer source of iron, copper and zinc than mature seeds (Singh *et al* 1984b) The results of the present study show that green seeds of T 15-15 are a richer source of calcium and magnesium than ICP 7035 The results also suggest that, when picked between 26 and 32 days after flowering for use as a vegetable, the green seed of these genotypes does not show wide variation in its calcium, magnesium, zinc, iron or copper contents

CONCLUSIONS

Although it is not clear what quality factors are important in selecting genotypes for use as vegetables, breeders at ICRISAT started work some years ago on developing sweet large-seeded cultivars that also give stable production The results of this study indicate that, depending on the stage of harvesting, the levels of protein, sugars and starch vary but minerals and trace elements do not change appreciably in green pigeonpea seeds of these two genotypes used as vegetables There are also noticeable differences in these parameters among genotypes

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