J Sci Food Agric 1993, **61**, 395–400

Cooking Characteristics, Chemical Composition and Protein Quality of Newly Developed Genotypes of Pigeonpea (*Cajanus cajan* L)*

Umaid Singh,‡ Paleti Venkateswara Rao, Nukala Subrahmanyam and Kulbhushan Saxena

International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru PO, Andhra Pradesh 502 324, India

(Received 8 July 1992; revised version received 14 December 1992; accepted 7 February 1993)

Abstract: Eight newly developed pigeonpea genotypes (ICPL 87, ICPL 151, ICPL 270, ICPL 366, ICPL 87051, ICPL 87063, ICPL 87067, and ICPV 1), and the two controls (BDN 2 and C 11) were analysed for cooking quality parameters and chemical composition, including amino acids and minerals. Protein quality was evaluated by determining the true protein digestibility, biological value, net protein utilisation (NPU), and utilisable protein. These genotypes differed significantly ($P < 0.01$) in the dhal cooking time. Sensory properties of dhal of these genotypes were found to be within the acceptable range, even though there were considerable differences among genotypes. Dhal protein, calcium, magnesium, zinc, and iron contents of these genotypes showed noticeable differences. Calcium content of ICPL 87067 was the highest (85·6 mg per 100 g) and of ICPL 87 the lowest (54·4 mg per 100 g) indicating large differences among the newly developed genotypes. No noticeable differences in sulphur-containing amino acids of these genotypes were observed. NPU was the highest (65·4%) for ICPL 366 and the lowest (56·6%) for ICPL 270 and ICPL 87067 indicating significant ($P < 0.01$) differences among genotypes studied.

Key words: cooking characteristics, chemical composition, dhal, protein quality, pigeonpea.

INTRODUCTION

Grain legumes are important sources of proteins, minerals, and vitamins for millions of people in the world, particularly in the developing countries (Singh and Singh 1992). Besides the improvement of productivity, adaptability, and yield stability in grain legumes, worldwide attention is needed to improve the nutritional quality of grain legumes by breeding techniques or developing suitable processing methods. In this context, the monitoring of newly developed genotypes of grain legumes for cooking quality and various nutritional attributes has been emphasised (Singh *et al* 1991).

Pigeonpea, also called red gram, is among the important grain legumes, grown and consumed in the tropics and the semi-arid tropics. Pigeonpea occupies an important place in human nutrition as a source of dietary proteins, carbohydrates, and minerals in several countries (Singh and Eggum 1984; Singh 1989). Chemical composition, protein content, amino acid composition, and digestibility are important nutritional attributes of pigeonpea for consumers. The cooking quality of pigeonpea is primarily assessed by its cooking time. Organoleptic properties such as taste, colour, flavour, and texture of the cooked product, collectively referred to as consumer preferences, are also important aspects of cooking quality. In India, pigeonpea is mostly consumed after dehusking in the form of dhal (decorticated dry split cotyledons) and cooking in water to a desirable softness; whereas in some African countries whole seeds of

* Submitted as JA No. 1336 by International Crops Research Institute for the Semi-Arid Tropics, Pantancheru PO, Andhra Pradesh 502 324, India.

‡ To whom correspondence should be addressed.

J Sci Food Agric 0022-5142/93/$06.00

pigeonpea are consumed after boiling. The developing seeds shelled out of harvested green pods are also used as a vegetable in some parts of India, and some African, Latin American, and Caribbean countries.

At the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) improving the nutritional quality of pigeonpea by breeding is emphasised. High-protein genotypes with acceptable seed size (about 10–12 g per 100 seeds) have been developed and detailed studies have confirmed that high-protein genotypes of pigeonpea contain more utilisable proteins and are nutritionally superior to normal protein genotypes (Singh *et al* 1990). The research into pigeonpea at ICRISAT aims at developing new genotypes with improved yields and stability across environments, and in recent years several such genotypes have been developed (ICRISAT 1990). The present study evaluates the cooking quality and nutritional attributes of newly developed genotypes of pigeonpea to better utilise these for food purposes.

MATERIALS AND METHODS

Materials

The seed material for the present study consisted of eight newly developed genotypes (ICPL 87, ICPL 151, ICPL 270, ICPL 366, ICPL 87051, ICPL 87063, ICPL 87067 and ICPV 1 (ICP 8863)) and two commonly grown genotypes (C 11 and BDN 2) as controls. ICPL 87 and ICPL 151 were early-maturing genotypes requiring 90–130 days to mature and ICPL 366 was a late-maturing one that requires 180–200 days for maturity. Other genotypes belonged to medium-maturity groups that require 130–180 days for maturity. Genotypes were grown in plot sizes of four rows, 4 m long, spaced at 60 cm with three replications. Bulk samples were used for analysis. Seed samples were provided by the Pigeonpea Breeding Unit at ICRISAT. These genotypes were grown at ICRISAT Centre, Patancheru, India, during the 1988 rainy season under similar field conditions. After harvest, the grain samples were cleaned, sun-dried and stored in a cold room at 5 °C until analysed.

The decortication of whole-seed samples to prepare dhal was done using a tangential abrasive dehulling device (Ehiwe and Reichert 1987). For chemical analysis and rat-feeding trials, dhal samples were ground in a Udy cyclone mill using a 0·4 mm screen.

Methods

Seed colour and 100-seed mass

The seed colour was estimated by visual evaluation. For determination of seed mass, 100-seeds were counted manually and weighed. Averages of five replicates of each genotype were recorded.

Cooking characteristics and sensory evaluation

Cooking time was determined by boiling the dhal in distilled water in a BD–20 heating block digestor (Tecator, Sweden). The dhal sample (10·0 ± 0·5 g) was boiled in 50 ml distilled water; during boiling samples were removed at 1 min intervals and examined for their softness by pressing them between the forefinger and the thumb to determine the cooking time. For water absorption, dhal samples (5·0 g ± 0·5 g) were boiled for 20 min in excess distilled water (35 ml) in the BD-20 block digester. The excess water after boiling was decanted and the dhal weighed. The amount of water taken up by the dhal was calculated and the results were expressed as an increase in dhal weight per gram of sample. The percentage of solids dispersed into the cooking water was determined by boiling the dhal sample (5·0 ± 0·5 g) for 20 min. The boiled material was passed through a 20 mesh sieve and the residue thoroughly washed with distilled water. After washing, residue was dried at 110 °C for 3 h. The loss in weight of dhal after boiling was calculated and expressed as percentage of solids dispersed into cooking water.

Sensory analysis was conducted by a panel of 10 trained panel members familiar with the product. Dhal samples were boiled in sufficient distilled water for 20 min. Excess water was discarded and freshly prepared samples were given to panel members for evaluation of colour, taste, texture, flavour and general acceptability. Samples were evaluated under normal light at room temperature (25 ± 1 °C) using individual booths. The panellists cleansed their palates between samples by using drinking water. A rating scale of 4—excellent, 3—good, 2—fair, and 1—poor was used.

Chemical analysis

Standard AOAC (1980) procedures were used to determine ash (AOAC 7·004) and fat (AOAC 7·056) content. Nitrogen content was estimated using the Technicon auto analyser procedure (Singh and Jambunathan 1981), and nitrogen values were converted into protein values by multiplying them by 6·25. Soluble sugars were extracted from the defatted sample using 80 % ethanol in a Soxhlet apparatus. Aliquots were used to estimate soluble sugars by the phenol–sulphuric acid method (Dubois *et al.* 1956). Starch content was determined according to Singh *et al* (1980). Amino acid analysis was carried out by refluxing the finely ground defatted samples in 6 M HCl for 24 h. After refluxing acid was removed in a rotary flash evaporator and the aliquots were analysed in a Beckman 119-CL amino acid analyzer. For mineral and trace element analyses, samples were digested using a triacid mixture and aliquots were analysed for calcium, magnesium, zinc, iron, and manganese in an atomic absorption spectrophotometer (Varian Tectron Model-1 200) (Piper 1966). All results on chemical analyses are expressed on a dry weight basis.

TABLE 1
Cooking quality and sensory evaluation of cooked dhal of different pigeonpea genotypes

Genotype	*Maturity group*	*Seed colour*	*100 seed mass*[a] (g)	*Cooking time* (min)[b]	*Water absorption*[b] (gg^{-1})	*Solids dispersed*[b] (%)	*Sensory evaluation*[c]				
							Colour	*Texture*	*Flavour*	*Taste*	*General acceptability*
ICPL 87	Early	Brown	10·9	19	2·1	29·0	2·6	3·5	2·5	2·5	2·5
ICPL 151	Early	Cream	9·3	24	1·9	23·5	3·7	3·2	3·0	3·0	3·1
ICPL 270	Medium	Brown	12·4	18	2·3	28·6	2·6	3·5	2·6	2·5	2·6
ICPL 366	Late	Brown	10·4	20	1·9	28·2	3·5	3·2	3·1	2·6	2·8
ICPL 87051	Medium	Cream	14·6	24	1·4	22·5	3·0	2·2	3·2	3·1	3·1
ICPL 87063	Medium	Cream	13·5	26	1·7	22·5	3·0	2·2	3·2	3·1	3·1
ICPL 87067	Medium	Cream	15·1	27	1·7	21·1	2·8	1·9	3·0	2·7	2·7
ICPV 1 (ICP 8863)	Medium	Brown	10·4	21	1·9	29·4	3·5	3·3	3·2	3·4	3·3
C11	Medium	Brown	11·2	22	1·7	28·9	3·5	2·5	3·2	3·2	3·3
BDN 2	Medium	Cream	7·9	23	1·8	26·9	3·1	2·9	3·1	3·2	3·1
SE				±0·6	±0·05	±1·25	±0·12	±0·08	±0·11	±0·07	±0·09

[a] Based on five determinations.
[b] Based on two determinations.
[c] Based on the judgment of 10 panel members.

Biological evaluation of protein quality

Dhal samples were cooked at 15 lb pressure (~ 103·5 kPa) for 15 min in a pressure cooker; and after cooking whole broth was freeze-dried and ground to a fine powder in a Udy cyclone mill using a 0·4 mm screen. The cooked dhal samples were evaluated for true protein digestibility, biological value, net protein utilization, and utilisable protein by conducting rat-feeding experiments according to Eggum (1973).

RESULTS AND DISCUSSION

Dhal cooking time of these genotypes varied from 18 min for ICPL 270 to 27 min for ICPL 87067. Similar variations were observed for water absorption and solids dispersion of these genotypes (Table 1). Sharma *et al* (1977) identified some pigeonpea varieties requiring less time (20·0–21·5 min) for cooking. In the present study, the cooking time of ICPL 87, ICPL 270, ICPL 366, and ICPV 1 ranged between 18 and 21 min, i.e. requiring less time for cooking. Several factors affect the cooking time of pigeonpea genotypes (Singh *et al* 1984) and some possible effect of environmental factors on the cooking time of present genotypes could not be ruled out. Although more genotypes belonged to the medium-maturity group, no trend was observed in cooking time of genotypes belonging to different maturity groups (Table 1). However, it was reported that cooking quality of early-maturing cultivars was better than that of the medium- and late-maturing genotypes (Singh *et al* 1984). There was a positive correlation ($r = 0·41$) between cooking time and seed size, and a negative correlation ($r = -0·53$) between 100-seed weight and solids dispersed, although the magnitudes of correlations were low and non-significant. This observation generally tends to agree with the findings of positive and significant correlations between seed size and cooking time in chickpea (Williams *et al* 1983) and in lentils (Erskine *et al* 1985). Similarly, the correlation between protein content, and respectively, calcium and magnesium contents were 0·87 and 0·85, both positive and significant ($P < 0·01$). Additional studies using more genotypes are needed to confirm these correlations in pigeonpea. Such organoleptic properties as colour, texture, flavour, taste and general acceptability showed noticeable differences among the genotypes (Table 1). Score on general acceptability was the highest (3·3) for ICPV 1 and C 11 followed by ICPL 151, ICPL 87051, and ICPL 87063. Although all the genotypes studied were within an acceptable range, the score on general acceptability ranged between 2·5 and 2·7 for ICPL 87, ICPL 270, and ICPL 87067 indicating low values for these genotypes. Based on the sensory evaluation, no genotype had a poor rating, ie unacceptable. General scoring pattern was between fair and good on the rating scale. This indicated that all newly developed genotypes would be acceptable to the consumer.

Dhal protein content of newly developed genotypes ranged between 20·5 and 23·9 g per 100 g whereas the protein content of control genotype C 11 was 23·4 g per 100 g and BDN 2 22·8 g per 100 g (Table 2). Protein content of these genotypes was within the range reported for 43 commercial genotypes of pigeonpea (Singh and Jambunathan 1981). No significant differences were observed in starch, soluble sugars, fat and ash contents of these genotypes (Table 2). Starch content of these genotypes ranged between 56·3 and 60·0 g per 100 g

TABLE 2
Chemical constituents of dhal of different pigeonpea genotypes[a]

Genotype	Protein (g per 100 g)	Starch (g per 100 g)	Soluble sugars (g per 100 g)	Fat (g per 100 g)	Ash (g per 100 g)	Calcium (mg per 100 g)	Magnesium (mg per 100 g)	Zinc (mg per 100 g)	Iron (mg per 100 g)
ICPL 87	20·5	56·3	6·8	2·0	3·7	54·4	106·9	3·3	4·0
ICPL 151	20·5	60·0	6·6	2·0	3·5	60·0	83·3	2·8	4·8
ICPL 270	21·5	56·8	6·9	2·0	4·0	61·3	113·2	2·8	3·7
ICPL 366	22·7	60·0	6·3	2·3	3·7	71·3	142·5	3·2	4·4
ICPL 87051	23·1	56·8	6·5	2·0	3·8	73·8	151·9	2·7	3·7
ICPL 87063	22·7	56·8	7·0	1·9	3·5	67·6	146·3	2·7	3·7
ICPL 87067	23·9	58·2	6·9	2·0	3·9	85·6	148·8	2·6	3·6
ICPV 1 (ICP 8863)	21·8	58·4	6·9	1·9	3·4	66·9	117·6	2·6	4·0
C 11	23·4	58·7	7·0	2·3	3·5	67·5	120·0	2·7	4·2
BDN 2	22·8	58·4	7·1	2·0	3·6	67·5	135·7	2·6	4·2
SE	±0·23	±0·42	±0·05	±0·06	±0·05	±4·59	±4·98	±0·05	±0·17

[a] Based on two determinations for each constituent. All results are expressed on a dry weight basis.

TABLE 3
Amino acid composition (g per 100 g protein) of some newly developed genotypes, ICRISAT centre, rainy season 1988[a]

Amino acid	ICPL 87	ICPL 151	ICPL 270	ICPL 366	ICPL 87051	ICPL 87063	ICPL 87067	ICPV 1	BDN 2	C11
Aspartic acid	9·4	9·1	9·5	9·5	9·4	9·3	9·5	9·5	9·5	9·6
Threonine	3·0	3·2	3·3	3·2	3·2	3·1	3·1	3·1	3·2	3·1
Serine	4·5	4·3	4·6	4·6	4·6	4·7	4·5	4·7	4·5	4·2
Glutamic acid	22·0	21·3	21·4	21·6	21·5	21·4	21·4	21·4	21·5	21·5
Proline	5·5	5·5	5·5	5·7	5·7	5·7	5·7	5·4	5·5	5·6
Glycine	3·3	3·5	3·5	3·3	3·6	3·2	3·1	3·3	3·4	3·3
Alanine	4·4	4·4	4·4	4·4	4·3	4·6	4·4	4·5	4·3	4·4
Cystine	1·2	1·2	1·2	1·2	1·2	1·2	1·2	1·2	1·2	1·2
Valine	4·7	4·4	4·7	4·5	4·3	4·4	4·4	4·5	4·5	4·7
Methionine	1·3	1·4	1·3	1·3	1·3	1·2	1·2	1·4	1·3	1·3
Isoleucine	3·6	3·5	3·4	3·5	3·6	3·3	3·3	3·7	3·2	3·5
Leucine	6·5	6·9	7·0	6·7	6·7	6·8	6·9	6·9	6·9	6·8
Tyrosine	3·6	3·5	3·5	3·5	3·4	3·4	3·5	3·6	3·4	3·5
Phenylalanine	8·6	8·5	8·7	8·6	8·4	8·3	8·5	8·5	8·4	8·7
Histidine	3·7	4·0	3·7	3·7	3·5	3·7	3·6	3·7	3·6	3·6
Lysine	6·9	6·7	6·7	6·8	6·6	6·9	6·5	6·8	6·7	6·9
Arginine	6·3	6·7	6·5	6·6	6·5	6·7	6·5	6·5	6·6	6·6

[a] Based on analysis of cooked dhal samples.

being considerably higher than those ranging between 39·0 and 56·0 g per 100 g reported for several cultivars of pigeonpea by Sharma *et al* (1977). Calcium content was the highest (85·6 mg per 100 g) for ICPL 87067 and the lowest (54·4 mg per 100 g) for ICPL 87 indicating a large variation among genotypes. Similar variations among genotypes were noticed for magnesium content (Table 2). Zinc and iron contents of these genotypes did not reveal significant differences. Whole grain of pigeonpea is a good source of calcium as the husk provides about 70% of the total grain calcium (Sankar Rao and Deosthale 1981; Singh *et al* 1984). Since most of the pigeonpea produced in India is consumed in the form of dhal, the mineral content, particularly the calcium content, of dhal needs more attention. Among the various dietary nutrients, calcium is deficient in the diets of people living in certain villages in India (Ryan *et al* 1984). The calcium content of dhal samples of some genotypes in the present study is considerably lower than that reported by Singh *et al* (1984).

Amino acid composition of newly developed and control genotypes is presented in Table 3. Generally, grain legumes are regarded as good sources of lysine. The lysine content of newly developed genotypes ranged between 6·5 and 6·9 g per 100 g protein and that of C 11 was 6·9 g per 100 g protein. When considered together, methionine and cystine contents of these genotypes ranged between 2·4 and 2·6 g per 100 g protein indicating little variation among the genotypes studied. It was reported that the sulphur-containing amino acids and

TABLE 4
Biological evaluation of cooked dhal of newly developed and control pigeonpea genotypes[a]

Genotype	*Protein* (%)	*True protein digestibility* (%)	*Biological value* (%)	*Net protein utilisation*[b] (%)	*Utilisable protein*[c] (%)
ICPL 87	20·5	89·1	66·0	58·9	13·8
ICPL 151	20·5	88·3	68·2	60·2	12·3
ICPL 270	21·5	87·6	64·7	56·6	12·1
ICPL 366	22·7	92·4	70·6	65·4	14·8
ICPL 87051	23·1	90·6	66·7	60·5	14·0
ICPL 87063	22·7	87·9	65·3	57·4	13·0
ICPL 87067	23·9	92·8	61·0	56·6	13·5
ICPV 1 (ICP 8863)	21·8	87·6	67·9	59·5	13·0
BDN 2	22·8	89·6	64·8	58·0	13·2
C 11	23·4	88·8	69·7	61·9	12·7
SE	±0·23	±1·42	±2·35	±2·30	±0·52

[a] Based on five determinations for each treatment.
[b] Net protein utilisation = (true protein digestibility × biological value)/100.
[c] Utilisable protein = (protein × net protein utilisation)/100.

tryptophan are the most limiting amino acids of legumes and the lowest values for sulphur-containing amino acids were for pigeonpea (Eggum and Beame 1983). Present results also indicate low values for sulphur-containing amino acids in pigeonpea. Amino acid composition of newly developed genotypes is comparable to that of the commonly grown genotypes (C 11 and BDN 2).

In addition to chemical analysis, biological evaluation of protein provides useful information with regard to its overall quality. Methods of cooking influence the protein quality parameters. However, there were no significant differences in protein digestibility and net protein utilisation of boiled and pressure-cooked dhal samples of pigeonpea (Geervani and Theophilus 1980). True protein digestibility of pressure-cooked dhal samples of newly developed genotypes varied from 87·6 to 92·8% indicating that some genotypes have better protein digestibility as compared to the control (C 11) which showed a true protein digestibility value of 88·8% (Table 4). The biological value of C 11 was higher (69·7%) than those of the several newly developed genotypes (Table 4). However, the biological value of ICPL 366 was the highest (70·6%) and the lowest (61·0%) being for ICPL 87067. This indicated significant ($P < 0·01$) differences in biological values among the genotypes. True protein digestibility and biological value of cooked dhal samples of these genotypes were slightly higher than those of the cooked dhal samples of high-protein lines of pigeonpea reported by Singh *et al* (1990). It is emphasised that true protein digestibility and biological value of ICPL 366 were the highest among the genotypes studied (Table 4). These produced highest values for net protein utilisation and utilisable protein for ICPL 366 suggesting its nutritional superiority.

CONCLUSIONS

Considerable genetic variability occurred in protein, calcium, magnesium, iron, and zinc contents of newly developed pigeonpea genotypes. Although amino acid composition including methionine and cystine did not reveal noticeable differences, net protein utilisation of newly developed genotypes ranged between 56·6 and 65·4% indicating significant differences in the nutritive value of protein of these genotypes. Considering increasing energy costs for cooking, the development of fast-cooking genotypes would be desirable. Some newly developed genotypes required longer cooking time than the control genotypes though all the genotypes studied were acceptable from a sensory standpoint. Monitoring of quality attributes of newly developed genotypes is important to both food scientist and breeders to ensure the acceptability of such genotypes as human food.

ACKNOWLEDGEMENTS

The authors thank G. Venkateswarlu and BH Rao for their technical assistance in the present study.

REFERENCES

AOAC 1980 *Official Methods of Analysis* (13th edn). Association of Official Analytical Chemists, Washington DC, U.S.A.

Dubois M, Gilles K A, Hamilton J K, Rebers P A, Smith F 1956 Colorimetric methods for determination of sugars and related substances. *Anal Chem* **28** 350–356.

Eggum B O 1973 *A Study of Certain Factors Influencing Protein*

Utilization in Rats and Pigs. Report 406, National Institute of Animal Science, Copenhagen, Denmark.

Eggum B O, Beame R M 1983 The nutritive value of seed proteins. In: *Seed Proteins—Biochemistry, Genetics and Nutritive Value*, ed Gottschalk W & Muller H P. Dr W Junk, The Hague, The Netherlands, pp 499–531.

Ehiwe, A O F, Reichert R D 1987 Variability in dehulling quality of cowpea, pigeonpea, and mung bean cultivars determined with the tangential abrasive dehulling device. *Cereal Chem* **64** 86–90.

Erskine W, Williams P C, Nakkoul H 1985 Genetic and environmental variation in the seed size, protein, yield, and cooking quality of lentils. *Field Crops Res* **12** 153–161.

Geervani P, Theophilus F 1980 Effect of home processing on the protein quality of selected legumes. *J Food Sci* **45** 707–710.

ICRISAT 1990 *Annual Report 1989*. International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh, India.

Piper C S 1966 Mineral analyses by wet digestion with sulphuric acid, nitric acid, and perchloric acid. In: *Soil and Plant Analysis*. Hans Publisher, Bombay, India, pp 272–274.

Ryan J G, Bidinger P D, Rao N P, Pushpamma P 1984 *The Determinants of Individual Diets and Nutritional Status in Six Villages of Southern India*. Research Bulletin No. 7, International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh, India.

Sankar Rao D S, Deosthale Y G 1981 Mineral composition of four Indian food legumes. *J Food Sci* **46** 1962–1963.

Sharma Y K, Tiwari A S, Rao K C, Misra A 1977 Studies on chemical constituents and their influence on cookability in pigeonpea. *J Food Sci Technol* **14** 38–40.

Singh U 1989 Role of pigeonpea in human nutrition. In: *Uses of Tropical Grain Legumes*. ICRISAT, Patancheru, India, pp 129–135.

Singh U, Eggum B O 1984 Factors affecting the protein quality of pigeonpea (*Cajanus cajan* L.). *Plant Foods Hum Nutr* **34** 273–283.

Singh U, Jambunathan R 1981 Methods for the estimation of protein in pigeonpea (*Cajanus cajan* L.) and the relationship between whole grain and dhal protein contents. *J Sci Food Agric* **32** 705–710.

Singh U, Singh B 1992 Tropical grain legumes as important human foods. *Econ Bot* **46** 310–321.

Singh U, Jambunathan R, Narayanan A 1980 Biochemical changes in developing seeds of pigeonpea (*Cajanus cajan*). *Phytochemistry* **19** 1291–1295.

Singh U, Kherdekar M S, Sharma D, Saxena K B 1984 Cooking quality and chemical composition of some early, medium and late maturing cultivars of pigeonpea (*Cajanus cajan* L.). *J Food Sci Technol* **21** 367–372.

Singh U, Jambunathan R, Saxena K B, Subrahmanyam N 1990 Nutritional quality evaluation of newly developed high-protein genotypes of pigeonpea (*Cajanus cajan* L.) *J Sci Food Agric* **50** 201–209.

Singh U, Subrahmanyam N, Kumar J 1991 Cooking quality and nutritional attributes of some newly developed cultivars of chickpea (*Cicer arietinum* L.). *J Sci Food Agric* **55** 37–46.

Williams P C, Nakoul H, Singh K B 1983 Relationship between cooking time and some physical characteristics in chickpea (*Cicer arietinum* L.). *J Sci Food Agric* **34** 492–496.