J Sci Food Agric 1991, **55**, 37–46

Cooking Quality and Nutritional Attributes of Some Newly Developed Cultivars of Chickpea (*Cicer arietinum*)

Umaid Singh, Nukala Subrahmanyam and Jagdish Kumar

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

(Received 4 September 1989; revised version received 19 July 1990; accepted 20 September 1990)

ABSTRACT

Eight newly developed and two commonly grown chickpea (Cicer arietinum *L) cultivars were evaluated for their cooking quality by measuring cooking time, water absorption and sensory properties. Nutritional aspects of cooked whole seed samples were measured chemically (including amino acids and minerals) and biologically in nitrogen-balance experiments with rats. Results indicated that kabuli (cream seed coat) may be generally preferred to desi (brown seed coat) cultivars in terms of cooking time and sensory properties. Calcium content was noticeably higher in desi than in kabuli cultivars, whereas magnesium, iron, copper and zinc showed no definite trend. Levels of lysine, threonine, methionine and cystine of these genotypes were within the range of FAO values. Desi and kabuli revealed no noticeable difference in protein and amino acids. However, biological value was considerably higher for kabuli than for desi. Consequently, kabuli contained more utilisable protein and may be nutritionally better than desi. In general, cooking quality and nutritional aspects of both newly developed and control cultivars were similar.*

Key words: Cooking quality, nutritional aspects, desi, kabuli cultivars, chickpea.

INTRODUCTION

Chickpea (*Cicer arietinum* L) is an important source of protein in several developing countries. Among the world's grain legumes, chickpea (Bengal gram or garbanzo bean) is second to dry beans (*Phaseolus vulgaris*) in cultivated area and third in

*Submitted as JA No. 950 by ICRISAT.

J Sci Food Agric 0022-5142/91/$03.50

production to dry beans and dry peas (*Pisum sativum*). In India, it is the most important pulse crop. Chickpeas can be classified into two basic types, desi and kabuli. Desi seeds, generally yellow to black in colour, are smaller and have a rougher surface. Kabuli seeds are usually large and light coloured. Desi chickpeas constitute about 85% of the total production, and the kabuli types constitute the remaining 15% (ICRISAT 1987). The kabuli types are grown mainly in Mediterranean countries whereas the desi types predominate in the Indian subcontinent.

The available literature on the nutritional composition and grain quality of chickpea has been summarised in recent reviews (Singh 1985; Williams and Singh 1987). ICRISAT, which has a global mandate to improve chickpea, has attempted to improve its yield and grain quality and has developed new genotypes (Kumar *et al* 1985; Singh *et al* 1986). These genotypes (ICCV 1, ICCV2, ICCV 3, ICCV 4 and ICCV 5) have been released or are under test for cultivation. Other lines, such as ICCC 37 and ICCC 42, which have reached the advance stage of breeding, will soon be released. The objective of this paper is to report and discuss the results of tests of cooking quality, chemical composition (including amino acids, minerals and trace elements) and biological evaluation of these newly developed genotypes.

MATERIALS AND METHODS

Materials

Experimental seed material consisted of five desi (ICCV 1 [ICCC 4], ICCC 37, ICCC 42, K 850 and Annigeri) and five kabuli (ICCV 2 [ICCL 82001], ICCV 3 [ICCL 83006], ICCV 4 [ICCL 83004], ICCV 5 [ICCL 83009] and ICCV 6 [ICCC 32]) genotypes. K 850 and Annigeri are commonly grown in central and peninsular India. The others are newly developed cultivars for these areas. The genotypes were grown at the ICRISAT Center during the post-rainy season 1987/88 in deep black vertisols without irrigation or fertiliser. After harvest, seed samples of these genotypes were stored in plastic bags in a cold room at 5 C until used for analysis in the present study. All samples were stored under similar conditions to eliminate differences due to storage conditions.

Methods

Determination of cooking time

For determination of the cooking time a block digester (Model 20 DB, Tecator, Höganäs, Sweden) was used. This apparatus insured a uniform and constant temperature during boiling. About 100 ml distilled water in a 250-ml digestion tube was brought to boiling point and then a 20-g seed sample was added. Boiling was continued, and boiled samples at intervals of 1 min were drawn and tested for their softness by pressing them between fingers and thumb. The time taken to achieve the desirable consistency was recorded as the cooking time of the sample.

Water absorption

Whole-seed samples (about 10 g) were heated in distilled water (50 ml) at 80 C for 1 h using the block digester. Excess water was discarded and traces of water were

removed with filter paper. An increase in weight of the seed sample after this treatment was expressed as g g^{-1} sample.

Sensory analysis
Such sensory properties as colour, texture, flavour, taste and general acceptability were evaluated by 10 panel members. Seed samples were boiled for 70 min, and freshly boiled samples were served for sensory evaluation. The following rating scale was used: 1 = poor, 2 = fair, 3 = good and 4 = excellent.

Cooking of whole seed
About 1 kg whole-seed samples of each genotype were cooked for 15 min at 1·05 kg cm^{-2} in a pressure cooker. After cooking, the whole content including the broth was dried in an oven at 50 C. Cooked and dried samples were ground in a Udy cyclone mill and passed through a 0·4-mm screen.

Chemical analysis
Nitrogen content in the samples was determined using the Technicon Autoanalyzer (Singh and Jambunathan 1980), and nitrogen values were converted into protein by multiplying by a factor of 6·25. For amino acid analysis, freshly ground samples were defatted in a Soxhlet apparatus using *n*-hexane. Previously published methods were used for the determination of ash, fat and crude fibre (AOAC 1975), and soluble sugar and starch (Singh *et al* 1981). Moisture content was determined by drying the samples overnight in the oven at 110 C. All these constituents were analysed in duplicate. All results were expressed on moisture-free basis.

Minerals and trace elements
For digestion we used a triacid mixture containing nitric acid, perchloric acid and sulphuric acid in the ratio of 20:4:1 (v/v). Defatted samples (0·5 g) were weighed and transferred to a block digester glass tube. After adding 6 ml of triacid mixture, the content was digested first 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. Suitable aliquots were analysed for calcium, magnesium, zinc, copper, iron and manganese with an atomic absorption spectrophotometer (Varian Tectron Model 1200) (Piper, 1966).

Amino acid analysis
Defatted samples (50 mg) were refluxed in 50 ml of 6M HCl for 24 h. After refluxing, the acid was removed by a rotary flash evaporator, and the residue was washed with water to remove HCl and taken in a known volume of citrate buffer (pH 2·2). An aliquot of each sample was used for analysis in a Beckman 119-CL amino acid analyser.

Biological evaluation of protein quality
We determined true digestibility (TD), biological value (BV), net protein utilisation (NPU) and utilisable protein (UP) by using groups of five Wistar-strain male rats weighing about 70 g. Each rat was fed a daily diet of 10 g (dry weight basis)

containing 150 mg nitrogen. At the end of 5 days, unconsumed diet weight was recorded and total nitrogen intake was calculated. The calculation of TD, BV, NPU and UP values was conducted according to Eggum (1973).

RESULTS AND DISCUSSION

The results on seed size, seed coat content, cooking time, water absorption and sensory properties of these cultivars are presented in Table 1. One-hundred-seed weight of desi cultivars varied from 14·2 to 29·7 g, and of kabuli from 18·5 to 32·2 g. Kabuli cultivars are often described as having larger seeds than desi cultivars. However, there was considerable overlap in the cultivars studied. The seed coat content of desi types was about two-and-a-half times heavier than that of the kabuli types. This variance supports the results of the earlier study (Jambunathan and Singh 1979). We noticed large differences in the cooking time of these genotypes, but not for water absorption. Desi genotypes required considerably more time, although ICCV 1 and ICCC 37 cooked as fast as kabulis, possibly because of their smaller seed size. The newly developed cultivars required less cooking time than the control K 850 or Annigeri (Table 1). K 850 required the longest cooking time due to its larger seed size. Williams *et al* (1983) reported a positive and significant correlation between seed size and cooking time for chickpeas. However, ICCC 42, which has about the same seed size as K 850, took less time to cook.

Of the various sensory properties, colour evaluation scores were considerably higher in kabuli cultivars than in desi types. Properties such as texture, flavour and taste, on the other hand, revealed few differences. A considerable amount of chickpea produced in the world is consumed in the form of whole seed (Williams and Singh 1987). Based on these results it appears that kabuli types are preferred in terms of cooking time and general acceptability (Table 1).

The levels of various chemical constituents were comparable between newly developed and control cultivars, as shown in Table 2. Crude fibre content revealed significant differences between desi and kabuli types due to the higher seed coat content of desi genotypes (Table 2). Crude fibre, acid detergent fibre and neutral detergent fibre have shown large differences between desi and kabuli groups attributable to seed coat content (Singh 1984). Protein and starch, the principal constituents of chickpea, did not reveal large differences.

Minerals and trace elements are important dietary nutrients. Calcium and iron are usually deficient in the diets of low-income people, particularly infants, preschool children, and pregnant and lactating women. Calcium content ranged between 110·0 and 197·1 mg per 100g sample, a significant variation. Similar variations in iron content were observed. ICCV 1 contained the highest amount of calcium and iron based on the results of non-replicated trials. The results suggest the possibility of identifying genotypes with higher calcium and iron contents which are nutritionally important. However, the effects of differences in growing conditions would have to be eliminated before genotypes with higher mineral contents could be identified. No large differences in the magnesium, zinc and copper contents of these cultivars were observed.

TABLE 1
Cooking quality and sensory properties of whole seed of newly developed chickpea cultivars, ICRISAT, 1987 88

Genotype	*100-seed mass*[a] (*g*)	*Seed coat*[a] (%)	*Cooking time*[a] (*min*)	*Water absorption*[a] *g per 100 g*	*Colour*[b]	*Texture*[b]	*Favour*[b]	*Taste*[b]	*General*[b] *acceptability*
Desi									
ICCV 1	14·2	14·5	76	0·9	2·6	2·9	2·7	2·5	2·7
ICCC 37	16·1	12·2	72	1·0	2·5	2·9	2·9	2·8	2·8
ICCC 42	29·7	11·5	81	0·9	2·7	2·0	2·8	2·8	2·5
K 850	28·8	10·2	96	0·9	2·7	2·0	2·6	2·9	2·8
Annigeri	20·0	13·6	82	1·0	2·5	2·5	2·6	2·6	2·6
Kabuli									
ICCV 2	25·8	6·5	75	1·0	3·4	2·5	2·8	2·8	2·9
ICCV 3	32·3	5·9	73	0·9	3·5	2·6	2·9	2·9	3·1
ICCV 4	25·0	5·4	72	1·0	3·6	3·0	3·0	3·1	3·2
ICCV 5	26·3	4·8	72	0·9	3·6	3·1	3·1	3·3	3·4
ICCV 6	18·5	5·9	76	1·0	3·6	2·5	2·7	2·8	2·9
SE ±	0·58	0·32	1·4	0·01	0·05	0·13	0·09	0·13	0·14

[a]Based on two determinations for each genotype.
[b]Average of ten panel members; rating score: 1 = poor, 2 = fair, 3 = good, and 4 = excellent.

Table 2

Chemical composition (g per 100 g sample) of the newly developed chickpea cultivars, ICRISAT, 1987–88[a]

Cultivar	Protein	Sugars	Starch	Ash	Fat	Crude fiber	Ca	Mg	Fe	Zn	Cu
	(%)						mg per 100 g sample				
Desi											
ICCV 1	21·0	4·5	49·9	3·2	5·5	9·7	197·1	148·1	9·3	5·2	1·1
ICCC 37	20·6	6·0	55·4	3·1	6·1	8·1	176·4	167·3	9·6	3·2	0·9
ICCC 42	19·2	5·9	58·2	3·4	6·4	7·5	160·9	167·6	6·7	4·6	1·1
K 850	20·4	5·9	57·8	3·5	6·0	7·7	138·6	181·2	6·3	4·9	1·1
Annigeri	19·4	4·9	54·9	3·0	6·0	9·4	182·4	136·5	5·6	3·7	1·0
Kabuli											
ICCV 2	23·4	6·2	51·1	3·4	5·8	4·2	149·2	161·8	8·8	3·8	1·0
ICCV 3	18·3	6·9	59·2	3·2	6·8	3·6	129·0	123·7	7·9	3·9	1·0
ICCV 4	21·2	7·0	57·4	3·9	6·6	3·8	110·0	145·1	6·4	5·4	0·9
ICCV 5	19·5	6·8	59·1	3·5	6·7	3·7	113·4	168·4	5·9	4·4	1·1
ICCV 6	19·6	6·9	60·1	3·6	5·1	3·0	118·0	141·6	8·9	5·3	1·1
SE ±	0·12	0·08	0·25	0·03	0·14	0·14	3·59	7·71	0·24	0·16	0·02

[a]Based on two determinations for each genotype and results expressed on moisture-free basis

TABLE 3
Amino acid composition (g per 100 g protein) of newly developed chickpea cultivars (whole seed cooked)

Amino acid	*Desi*					*Kabuli*				
	ICCV 1	*ICCV 37*	*ICCC 42*	*K 850*	*Annigeri*	*ICCV 2*	*ICCV 3*	*ICCV 4*	*ICCV 5*	*ICCV 6*
Lysine	6·3	6·8	6·9	6·6	7·0	6·1	7·2	6·5	6·9	7·1
Histidine	2·4	2·3	2·4	2·5	2·5	2·6	2·1	2·4	2·3	2·2
Arginine	9·7	9·7	9·4	9·2	9·0	9·6	9·7	9·8	9·7	9·8
Aspartic acid	11·4	11·3	11·4	11·2	11·6	11·3	11·7	11·5	11·6	11·4
Threonine	3·7	3·8	3·6	3·5	3·7	3·5	3·9	3·8	3·7	3·7
Serine	4·7	5·0	5·0	4·9	4·9	4·6	5·0	5·0	5·0	5·0
Glutamic acid	16·4	16·3	16·2	16·1	16·0	16·1	16·6	16·4	16·2	16·2
Proline	4·0	4·0	3·8	3·8	4·2	4·0	4·1	4·2	4·2	4·2
Glycine	3·9	3·9	3·9	4·0	3·9	3·9	4·0	4·0	4·1	4·2
Alanine	4·5	4·2	4·1	4·1	4·4	4·3	4·4	4·3	4·1	4·2
Cystine	1·3	1·3	1·3	1·3	1·3	1·4	1·5	1·4	1·3	1·4
Valine	4·4	4·3	4·3	4·4	4·5	4·4	4·5	4·4	4·2	4·2
Methionine	1·4	1·5	1·4	1·4	1·4	1·5	1·4	1·5	1·3	1·5
Isoleucine	4·5	4·4	4·1	4·1	4·3	4·3	4·4	4·3	4·3	4·1
Leucine	7·1	7·3	7·2	7·0	7·4	7·2	7·2	7·1	7·1	7·2
Tyrosine	3·4	3·3	3·4	3·3	3·1	3·4	3·2	3·4	3·3	3·3
Phenylalanine	5·4	5·3	5·1	5·0	5·3	5·4	5·4	5·4	5·2	5·2

TABLE 4

Biological value (BV), true digestibility (TD), net protein utilisation (NPU), and utilisable protein (UP) of cooked whole seed of newly developed chickpea genotypes, ICRISAT 1987 88[a]

Genotype	*Protein* %	*BV* %	*TD* %	*NPU* %	*UP* %
Desi					
ICCV 1	21·0	77·7	80·4	62·4	12·2
ICCC 37	20·6	76·2	85·1	64·7	12·6
ICCC 42	19·2	74·7	80·0	59·7	10·6
K 850	20·4	78·6	84·3	66·3	12·6
Annigeri	19·4	72·7	80·1	58·3	10·5
Kabuli					
ICCV 2	23·4	79·0	83·8	66·2	14·3
ICCV 3	18·3	89·6	82·9	74·3	12·7
ICCV 4	21·2	83·8	82·1	68·8	13·4
ICCV 5	19·5	83·7	85·9	72·0	13·1
ICCV 6	19·6	86·6	86·0	74·4	13·5
SE ±	0·12	2·10	1·19	2·00	0·38

[a]Based on five determinations for each treatment on moisture-free basis.

The amino acid compositions of the newly developed and control cultivars ar given in Table 3. The levels of various essential and non-essential amino acids di not show great variation. Like other legumes, chickpea is a rich source of lysin which varied from 6·1 to 7·1 g per 100 g sample for these genotypes, indicatin little variation. The sulphur-containing amino acids methionine and cystine (a well as threonine) are essential limiting amino acids for these genotypes. Thi finding was also observed in several chickpea cultivars by Boulter *et al* (1977 According to Khan *et al* (1979), however, threonine was the first limiting amin acid in chickpea, followed by the sulphur-containing amino acids methionine an cystine. When considered together, methionine and cystine contents of th genotypes varied from 2·6 to 2·9 g per 100 g protein. The lower values for thes amino acids obtained in the present study may have been due to heat treatmen as the analysis is based on cooked samples. Geervani and Theophilus (198(reported that sulphur amino acids were considerably reduced after pressure cookin of pulses. Lysine, threonine and sulphur amino acid contents of these genotype are within the range of FAO values (FAO 1970) and even higher for some cultivars

The BV of kabuli types, which were high in utilisable protein, was noticeabl higher than that of desi types (Table 4). Protein digestibility of these genotype ranged between 80 and 86% with a mean of 83·1%. These values for protei digestibility are slightly lower than those reported for chickpea genotypes by Kha *et al* (1979) and Eggum and Beames (1983). We noticed no large differences in th protein digestibility and net protein utilisation of desi and kabuli types (Table 4 However, according to Singh and Jambunathan (1981), the in-vitro protei digestibility of whole seed of desi types was noticeably lower than that of th

kabuli types. This they attributed to the differences in polyphenolic compounds. Even though these desi and kabuli genotypes revealed no noticeable difference in protein content, kabulis appear nutritionally superior to desis. The higher biological value of the proteins of the kabuli types may be due to the higher bioavailability of the sulphur amino acids methionine and cystine, which play important roles in determining the nutritive value of legume proteins (Eggum and Beames 1983).

ACKNOWLEDGEMENTS

The authors thank R Jambunathan and H A van Rheenen for their interest in this study. We also thank Seetha Kannan for amino acid analyses and G Venkateswarlu for assistance in rat feeding trials.

REFERENCES

AOAC 1975 *Official Methods of Analysis* (12th edn). Association of Official Analytical Chemists, Washington DC.

Boulter D, Evans I M, Aukland A K 1977 The amino acid composition of seed meals of a range of *Cicer arietinum* (chickpea) types. *Bull Fac Sci Riyad Univ* **8** 1–6.

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, Beames R M 1983 The nutritive value of seed protein. In: *Seed Proteins Biochemistry, Genetics and Nutritive Value*, eds Gootschalk W & Muller H P. Dr W Junk, The Hague, pp 499–531.

FAO 1970 Amino acid content of food and biological data of proteins. *FAO Tech Rep Ser No* 24. Food and Agricultural Organization, Rome.

Geervani P, Theophilus F 1980 Effect of home processing on the nutrient composition of certain high yielding legume varieties. *Ind J Nutr Dietet* **17** 443–446.

ICRISAT 1987 *Annual Report 1986*. International Crops Research Institute for the Semi-Arid Tropics, Patancheru, AP.

Jambunathan R, Singh U 1979 Studies on desi and kabuli chickpea (*Cicer arietinum*) cultivars. 1. Chemical composition. In: *Proc Int Workshop on Chickpea Improvement*. ICRISAT, Patancheru, AP.

Khan M A, Jacobsen I, Eggum B O 1979 Nutritive value of some improved varieties of legumes. *J Sci Food Agric* **30** 395–400.

Kumar J, Haware M P, Smithson J B 1981 Registration of four short duration *Fusarium* wilt-resistance kabuli (garbanzo) chickpea germplasms. *Crop Sci* **25** 576–577.

Piper C S 1966 *Soil and Plant Analysis*, Hans Publisher, Bombay, p 272–274.

Singh O, Singh K B, Sethi S C, Jain K C, Gowda C L L, Kumar J, Smithson J B 1986. Registration of ICCV 1 chickpea. *Crop Sci* **25** 576–577.

Singh U 1984 Dietary fiber and its constituents in desi and kabuli chickpea (*Cicer arietinum* L) cultivars. *Nutr Rep Int* **29** 419–426.

Singh U 1985 Nutritional quality of chickpea (*Cer arietinum* L): current status and future research needs. *Plant Foods Hum Nutr* **35** 339–351.

Singh U, Jambunathan R 1980 Evaluation of rapid methods for the estimation of protein in chickpea (*Cicer arietinum*). *J Sci Food Agric* **31** 247–254.

Singh U, Jambunathan R 1981 Studies on desi and kabuli chickpea (*Cicer arietinum*) cultivars: levels of protease inhibitors, levels of polyphenolic compounds and in vitro protein digestibility. *J Food Sci* **46** 1364–1367.

Singh U, Jambunathan R, Saxena N P 1981 Changes in carbohydrates, amino acids and

proteins in developing seed of chickpea. *Photochemistry* **20** 373–378.
Williams P C, Singh U 1987 The chickpea – nutritional quality and the evaluation of quality in breeding programmes. In: *The Chickpea*, eds Saxena M C & Singh K B. CAB International, Slough.
Williams P C, Singh K B, Nakkoul H 1983 Relation of some physical aspects of kabuli type chickpeas to cooking time. *J Sci Food Agric* **34** 492–496.