Grain Quality and Biochemistry
Progress Report 12/89

Chickpea and Pigeonpea

Report of Work

January - December 1989

ICRISAT

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

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Chickpea

Foreword

This report on the work done during January - December 1989 has been prepared to share the information with scientists who have an interest in grain quality and biochemistry aspects of chickpea and pigeonpea.

This is not an official publication of ICRISAT and should not be cited.

Umaid Singh and
R. Jambunathan

Chickpea Progress Report 1989

Project No. : **BN-103 (87) IC**

Title : **Study of grain and food quality of chickpea**

Ob ectives and Scope

a. Monitor the grain quality and cooking quality of advanced breeding lines

b. Investigate the role of physicochemical properties in determining the cooking time of whole seed and dhal

c. Standardize the laboratory procedure to prepare food products - pakoda, phutana, kadi, chapati, and dhokla and study their consumer acceptance and nutritional quality

d. Study the physicochemical and storage quality of chickpea dhal flour (besan) in relation to such products.

e. Study the cebulling quality and associated nutrient losses in chickpea.

Key words : Grain quality, food quality, pakoda, phutana, kadi, chapati, dhokla, physicochemical properties storage quality

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Contents

1. Particle size index of desi and kabuli cultivars

Physicochemical characteristics of desi and kabuli types continued to receive our increasing attention. The particle size index (PSI) which is related to grain hardness was determined in four desi and five kabuli genotypes. Whole seed and dhal samples of these genotypes were dried in the oven at 55°C for 2 h and ground uniformly in Buhler and Udy mills. Uniformly ground sample (10 g) were sieved through meshes of 250 and 150 micrometer (um) openings and the unsieved sample was calculated as percentage of the sample and expressed as PSI. As shown in Table 1, the PSI values were considerably higher in whole seed than in dhal samples and this might have been due to seed coat contents. It also appeared that Udy mill produced finer flours as compared to Buhler mill. Although there were no clear differences in PSI values of desi and kabuli groups, the differences between genotypes were significant ($P \leq 0.01$). We plan to determine grain hardness of these genotypes using Kiya hardness and Instron food testers to study the relationship between grain hardness and particle size index of these cultivars. Also, these results will be related to cooking quality characteristics of these cultivars.

2. Determination of seed floatation values

It has often been emphasized that grain hardness, particularly in cereals, could be determined by floatation tests. Grain samples are graded on the basis of their density in an organic solvent. But sodium nitrate, has been suggested for grading cereals. We initiated studies to determine the floatation values of desi and kabuli cultivars of chickpea. Different concentration of sodium nitrate solutions were studied (Table 2). A large

variation in seed floatation values were observed, even though there were no large differences in desi and kabuli groups. ICCV 6 showed the highest floatation value and the lowest value was obtained for ICCC 37. These are the results of preliminary investigations. Moreover, the method of determining floatation values needs further standardization. Further, work will be continued in this direction using more number of cultivars.

3. Cooking quality and chemical composition of Australian chickpeas

We determined the cooking time, water absorption, seed coat, protein, and fat contents of three cultivars, Dooen, Amethyst, and Tyson received from Warwick, Queensland, Australia. Cooking time of whole seed of these samples ranged between 86 and 94 min and of dhal samples between 37 and 45 min (Table 3). Protein content of dhal samples of these cultivars varied from 23.7 to 24.7% showing a small variation. In addition, we also analyzed 16 breeding lines from the same place for cooking time and protein content (Table 4). Whole seed cooking time varied from 75 to 99 min and protein content from 19.4 to 22.4% being comparable with the results of genotypes from ICRISAT Center.

4. Nutritive value of chickpea leaf

Chickpea green leaf when harvested at about 35-40 days after planting is used as a vegetable. Keeping in mind the nutritive value, freeze-dried leaf samples (collected at 37 days after planting) of ICC 506 and Annigeri grown in irrigated and unirrigated fields from an experiment conducted in collaboration with chickpea entomology unit were analyzed for protein, sugars, fiber contents, moisture, and soluble nitrogen. Soluble sugars and reducing sugars were were considerably higher in chickpea leaf samples of irrigated than in the unirrigated in ICC 506. But no noticeable changes in sugars content of Annigeri were observed due to irrigation (Table 5).

Proline has a tendency to accumulate in drought condition. It was significantly higher in leaf samples of both Annigeri and ICC 506 from unirrigated than those from irrigated field. Starch content of these leaf samples ranged between 15.9 and 19.7% and crude fiber content varied from 9.2 to 12.0% showing no significant ($P<0.01$) differences between the two treatments.

5. Chemical constituents of chickpea leaf at different stages of plant growth

In collaboration with pulses entomology unit, we studied the chemical constituents of chickpea leaf samples collected at different stages of plant growth. Two cultivars, one susceptible to pod borer (Annigeri) and another resistant to pod borer were selected for this purpose in order to examine the role of chemical constituents of leaf in influencing the pod borer attack in chickpea. Effect of irrigation was also studied on these constituents. Leaf samples at 37, 44, 51, 58, 65, 72, 79 and 86 days after planting were collected. Leaf samples were freeze-dried and analysed for moisture, protein, soluble nitrogen, proline, soluble sugars and nonreducing sugars. The results of these experiments are summarised in Tables 6-11. Moisture content of leaf decreased as the plants matured and this was observed in both irrigated and unirrigated fields (Table 6). Variable results were recorded for total nitrogen content of leaf samples (Table 7). Also, total nitrogen levels showed no definite trend when the results of irrigated and unirrigated fields were compared (Table 7). In general, it was observed that nitrogen content of leaf samples of Annigeri was higher than those of the ICC 506. Soluble nitrogen content of the leaf might have been influenced by irrigation. But the results of present study reflected no changes in the nitrogen content of the leaf samples of

irrigated and unirrigated fields (Table 8). Interestingly, the soluble nitrogen content of the leaf did not show large variation at different stages of plant growth and also the differences between genotypes were not large. This indicated that nitrogen metabolism in chickpea may not be influenced by irrigation and genotype.

Proline has a tendency to accumulate in drought condition. This was also observed in our study as the proline content of leaf samples from the unirrigated field was significantly ($P<0.01$) higher than those of the irrigated field (Table 9).

Accumulation of photosynthates at different stage of chickpea plant growth is an important biochemical activity of the plant. In this context, soluble sugars play an important role. Soluble sugars and reducing sugars of chickpea leaf were studied at different stages (Tables 10-11). Soluble sugar content of the leaf increased up to 58 days after planting except in irrigated samples of ICC 506 and then decreased upto 72 days after planting in both the genotypes irrespective of irrigation treatment (Table 10). No large differences in soluble sugar contents of Annigeri and ICC 506 were observed. Also, irrigation did not remarkably change the levels of soluble sugars of chickpea leaf. Reducing sugars which constituted about 15-20% of the total soluble sugars in the leaf, revealed some noticeable change due to irrigation in the later stages of growth for both genotypes (Table 11).

These above mentioned constituents have been studied keeping in mind the insects behavior at different stages of growth. Entomologists have collected data on this aspect from these fields and would like to interpret these results accordingly.

Table 1. Particle size index (PSI) of newly developed and control chickpeas, ICRISAT Center, Postrainy season 1987/88[1]

Genotype	Whole seed[2]				Dhal[2]			
	Particle size (> um, %)				Particle size (> um, %)			
	Buhler		Udy		Buhler		Udy	
	250	150	250	150	251	150	250	150
Desi								
ICCV1 (ICCC 4)	13.6	30.3	12.4	16.0	0.9	18.2	1.5	4.6
ICCC 37	7.4	22.5	18.5	14.4	2.0	12.7	1.4	4.3
ICCC 42	6.2	20.1	16.3	14.6	1.3	11.0	1.5	3.8
Control								
Annigeri	13.4	27.1	16.6	14.6	1.1	12.5	0.8	2.9
Kabuli								
ICCV 2 (ICCL 82001)	8.9	29.4	8.8	14.7	1.0	20.4	1.3	3.3
ICCV 3 (ICCL 83006)	20.0	35.5	9.4	14.9	0.7	14.5	1.8	4.8
ICCV 4 (ICCL 83004)	4.3	16.9	6.6	12.8	1.0	18.9	1.1	3.9
ICCV 5 (ICCL 83009)	3.8	15.9	6.3	11.4	0.5	13.9	1.7	4.2
ICCV 6 (ICCC 32)	5.5	21.8	8.1	15.5	1.1	17.5	1.7	5.4
SE	±0.79	±1.07	±0.20	±0.46	±0.24	±0.79	±0.13	±0.29

1. Based on two determinations of each genotype.
2. Samples were ground in Buhler and Udy mills after drying in then oven at 55°C for 2h for similar moisture levels.

Table 2. Effect of sodium nitrate concentration on seed floatation values of chickpea cultivars[1]

Cultivar	Sodium nitrate solution (%)		
	70	72	74
	Floatation value (%)		
Desi			
ICCV 1	20.0	20.0	16.6
ICCC 37	10.0	13.3	10.0
ICCC 42	23.3	26.7	23.3
Annigeri	26.7	20.0	30.0
K 850	40.0	40.0	33.0
Kabuli			
ICCV 2	20.0	16.7	16.7
ICCV 3	26.7	23.3	26.7
ICCV 4	16.6	20.0	16.6
ICCV 5	13.3	13.3	14.0
ICCV 6	63.0	60.0	60.0

1. Based on single analysis.

Table 3. Analysis of chickpea genotypes[1]

Cultivar		100 seed mass (g)	Seed coat (%)	Cooking time (min)	Water absorption (g/g)	Protein (%)	Fat (%)
DOOEN	a	20.2	13.7	94.0	1.18	20.2	6.7
	a	-	-	37.0	1.40	23.7	6.8
AMETHYST	a	15.5	15.9	86.0	1.32	20.0	5.9
	b	-	-	45.0	1.37	24.0	7.0
TYSON	a	13.6	16.9	89.0	1.22	20.8	6.0
	b	-	-	43.0	1.41	24.7	6.8
SE±		0.13	0.13	1.63	0.017	0.33	0.13

1. Received from Dr. R. Brinsmead, Warwick, Australia

a. Whole seed

b. Dhal (decorticated dry split cotyledons)

Results are averages of duplicate determinations

Table 4. Analysis of chickpea genotypes[1]

Genotype identity number	100 seed mass (g)	Seed coat (%)	Whole seed		Dhal	
			Protein (%)	Cooking time (min)	Protein (%)	Cooking time (min)
232-4	24.7	14.1	22.4	75.0	25.8	35.0
488-1	15.6	15.5	20.4	78.0	24.6	37.0
243-7	18.7	13.5	21.7	82.0	24.0	32.0
449-2	15.3	13.7	22.2	86.0	24.6	38.0
225-7	17.8	14.2	20.7	85.0	25.0	40.0
244-1	21.4	14.5	21.3	79.0	24.4	35.0
232-5	20.7	13.8	20.2	87.0	23.2	36.0
365-5	19.2	14.3	20.2	90.0	23.8	38.0
247-7	24.8	13.2	21.7	93.0	24.7	39.0
859-2	13.8	16.0	20.7	92.0	24.6	39.0
585-6	15.3	13.5	19.4	95.0	23.7	44.0
462-4	16.1	13.7	21.1	97.0	24.7	49.0
462-1	15.5	13.7	21.0	91.0	24.1	46.0
449-8	16.1	13.5	21.5	99.0	23.7	44.0
571-5	15.9	14.8	20.4	89.0	24.1	47.0
462-5	14.5	13.8	20.7	92.0	24.6	47.0

1. Received from Dr R. Brinsmead, Warwick, Australia

Results are averages of duplicate determinations

Table 5. Chemical constituents of leaf samples of Annigeri and ICC 506 cultivars collected at 37 days after planting, ICRISAT Center, postrainy season, 1988/89[1]

Constituent	Annigeri		ICC 506		SE
	Irrigated	Unirrigated	Irrigated	Unirrigated	
Moisture (%)	80.9	79.0	80.2	78.1	±1.64
Protein (%)	26.8	27.5	25.0	24.7	±0.88
Proline [mg(100 g)$^{-1}$]	47.6	69.0	59.0	79.5	±1.35
Soluble nitrogen (%)	0.4	0.4	0.3	0.4	±0.14
Soluble sugars (%)	6.8	6.5	6.9	5.8	±0.28
Reducing sugars (%)	1.6	1.5	1.6	1.0	±0.06
Nonreducing sugars (%)	5.3	4.9	5.3	4.7	±0.18
Starch (%)	13.1	18.9	19.7	15.9	±0.32
Crude fiber (%)	10.0	9.2	12.0	11.2	±0.40

1 Based on analysis of freeze-dried samples in duplicate.

Table 6. Moisture content of leaf samples collected at different stages of Annigeri and ICC 506 cultivars, ICRISAT Center, postrainy season 1988/89[1]

Cultivar	Days after planting							
	37	44	51	58	65	72	79	86
Annigeri								
Irrigated	80.9	80.5	81.3	77.8	77.2	77.0	75.8	75.2
Unirrigated	79.0	79.6	78.1	73.4	72.2	73.3	70.5	65.5
ICC 506								
Irrigated	80.2	79.6	80.4	77.1	75.9	76.0	74.1	72.9
Unirrigated	78.1	78.4	76.6	71.2	70.2	71.1	68.7	68.8
SE	±1.23	±0.86	±1.04	±0.79	±0.64	±1.12	±0.56	±0.72

1. Based on analysis of five replications

Table 7. Nitrogen content of leaf samples collected at different stages of Annigeri and ICC 506 cultivars, ICRISAT Center, postrainy season 1988/89[1]

Cultivar	Days after planting							
	37	44	51	58	65	72	79	86
	Nitrogen [g(100 g)$^{-1}$ dry weight]							
Annigeri								
Irrigated	4.2	3.5	3.6	3.9	4.2	4.7	3.6	2.9
Unirrigated	4.4	4.1	4.0	4.4	4.0	4.2	2.9	1.5
ICC 506								
Irrigated	4.0	3.8	3.9	4.3	4.3	4.4	3.3	2.8
Unirrigated	3.9	4.0	3.8	3.9	3.7	3.7	3.3	1.5
SE	±0.23	±0.18	±0.20	±0.11	±0.34	±0.23	±0.09	±0.06

1 Based on analysis of five replications

Table 8. Soluble nitrogen content of leaf samples collected at different stages of Annigeri and ICC 506 cultivars, ICRISAT Center, postrainy season 1988/89[1].

Cultivar	Days after planting							
	37	44	51	58	65	72	79	86
	Soluble nitrogen [g(100 g)$^{-1}$ dry weight]							
Annigeri								
Irrigated	0.4	0.3	0.4	0.3	0.3	0.5	0.4	0.3
Unirrigated	0.4	0.4	0.5	0.4	0.4	0.5	0.4	0.3
ICC 506								
Irrigated	0.3	0.3	0.4	0.4	0.3	0.5	0.3	0.3
Unirrigated	0.4	0.4	0.4	0.3	0.3	0.5	0.4	0.2
SE	±0.03	±0.02	±0.01	±0.01	±0.02	±0.01	±0.02	±0.01

1. Based on analysis of five replications

Table 9. Proline content of leaf samples collected at different stages of Annigeri and ICC 506 cultivars, ICRISAT Center, postrainy season 1988/89[1].

Cultivar	Days after planting							
	37	44	51	58	65	72	79	86
	[mg(100 g)$^{-1}$ dry weight]							
Annigeri								
Irrigated	47.6	27.7	39.1	31.7	55.5	45.3	30.8	15.5
Unirrigated	69.0	41.2	60.8	90.0	119.3	82.0	86.3	48.3
ICC 506								
Irrigated	59.0	32.5	28.7	25.3	46.9	47.4	32.5	17.5
Unirrigated	79.5	42.1	51.5	89.5	108.5	76.7	74.9	26.1
SE	±2.34	±1.78	±3.02	±2.79	±3.27	±1.89	±2.04	±1.16

1. Based on analysis of five replications

Table 10. Soluble sugar contents of leaf samples collected at different stages of Annigeri and ICC 506 cultivars, ICRISAT Center, postrainy season, 1988/89[1].

Cultivar	Days after planting							
	37	44	51	58	65	72	79	86
	Soluble sugars [g(100 g)$^{-1}$]							
Annigeri								
Irrigated	6.8	10.5	14.4	15.3	8.5	6.5	7.1	8.4
Unirrigated	6.5	9.1	14.0	15.4	10.4	6.8	7.6	7.4
ICC 506								
Irrigated	6.9	11.6	14.2	13.9	7.1	6.0	7.7	8.3
Unirrigated	5.8	10.6	14.4	14.6	9.2	7.1	7.7	7.2
SE	±0.24	±0.36	±0.27	±0.24	±0.19	±0.21	±0.06	±0.07

1. Based on analysis of five replications

Table 11. Reducing sugar content of leaf samples collected at different stages of Annigri and ICC 506 cultivars, ICRISAT Center, postrainy season, 1988/89[1]

Cultivar	Days after planting							
	37	44	51	58	65	72	79	86
	Reducing sugars [g(100 g)$^{-1}$]							
Annigeri								
Irrigated	1.5	1.4	2.3	1.5	1.0	1.6	1.9	1.5
Unirrigated	1.6	1.3	2.0	1.6	2.0	1.8	3.2	2.5
ICC 506								
Irrigated	1.0	0.9	1.7	1.6	0.6	1.9	2.1	2.5
Unirrigated	1.1	1.4	3.1	1.7	1.1	3.3	3.6	3.0
SE	±0.01	±0.02	±0.02	±0.01	±0.01	±0.03	±0.02	±0.03

1. Based on analysis of five replications

Pigeonpea

Project No. : BN-102 (87) IC

Project Title : **Study of grain and food quality parameters of pigeonpea**

Objectives and Scope

a. Monitor grain quality and cooking quality of advanced breeding lines.

b. Investigate the role of physicochemical properties involved in determining the cooking time of whole seed and dhal.

c. Evaluate the protein quality by rat feeding trials and study the factors that affect protein digestibility.

d. Explore the possibility of preparing some new food products of pigeonpea and study their consumer acceptance and nutritional quality.

f. Develop a suitable procedure for dehulling quality and study the relationship between grain characteristics and dehulling quality of different genotypes.

Key words : Grain quality, cooking quality, physicochemical properties, consumer acceptance, chemical composition, nutritional quality.

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Contents

1. New food uses

To enhance utilization of pigeonpea in East Africa and Southeast Asia, we continued to explore the feasibility of using pigeonpea for various food items of these regions.

1.1 African foods

With the help of a trainee from Kenya, three important Kenyan food products namely, Isyo, Mukimwa, and Muthokoyi were prepared. Isyo was prepared by using separately boiled maize and pigeonpea dhal in the ratio of 4:5, whereas Mukimwa was prepared by mixing boiled maize and whole seed pigeonpea with boiled and peeled potatoes. In case of Muthokoyi, boiled dehulled maize and pigeonpea whole seeds are mixed with vegetables eg., carrot peas, cabbage and then fried. Organoleptic properties of these food products were evaluated and found acceptable by the panel members. Further, these products will be evaluated using more number of cultivars and also will be studied for their chemical constituents.

1.2 Southeast Asian foods

1.2.1 Tempeh quality of whole seed and dhal

We continued to study pigeonpea tempeh quality. In Indonesia, whole seeds of pigeonpea and soybean are the raw material used to prepare tempeh. Whole seeds are used for this purpose because of lack of proper dehulling facilities. We compared the tempeh quality of the product prepared by using whole seed and dhal as raw material. Seven genotypes (C 11, ICPL 87, HPL 40, T 7, NP (WR) 15, LRG 30 and BDN 2) were used for this study, the results of which are summarised in Table 1. The organoleptic properties such as color, taste, texture, and flavor did not show differences between whole seed and dhal samples (Table 1). Also, the differences among cultivars were not significant with respect to the organoleptic properties

of tempeh.

1.2.2 Effect of fermentation on chemical constituents

It is known that fermentation is an important process in the preparation of tempeh. We examined the effect of fermentation on chemical constituents of pigeonpea dhal. For tempeh preparation, soaked and boiled dhal samples of C 11 and Nylon were fermented using Rhizopus oligosporus obtained from Indonesia. As a control, soaked and boiled dhal samples was used. Fermented and fried, and control samples were freeze-dried and defatted. These samples were analysed for protein, soluble nitrogen, starch and soluble sugars. Protein content increased and starch content decreased due to fermentation (Table 2). We observed a remarkable increase in both soluble sugars and soluble nitrogen as a result of fermentation. An increase in soluble sugars after fermentation might have been due to the enzymatic degradation of starch.

Further, fermented samples were analysed for amino acid composition as shown in Table 3. No large differences in the levels of essential and nonessential amino acids were observed. However, lysine content slightly decreased in the fermented sample, nylon (Table 3).

1.2.3 Noodle quality - starch extraction

For efficient utilization of grain legumes for the preparation of starch noodles, two important characteristics are : 1) improved rate of starch extraction i.e. more starch yield and 2) good clarity and appearance of extracted starch. We examined these two starch properties using dhal samples of ten pigeonpea cultivars (ICPL 151, ICPL 87, C 11, ICPL 270, ICP 8863, ICPL 366, ICPL 87051, ICPL 87063, ICPL 87067, and BDN 2). Starch yield of these cultivars varied from 64.3 and 82.0 % as shown in Table 4.

This indicated that there are genotypic differences in starch yield of cultivars, even though it is difficult to rule out the possible effect of environment and agronomic practices on starch yield of pigeonpea cultivars. Additional studies in this direction will be useful.

1.3 Quick-cooking dhal

Preliminary efforts were made to examine the possibility of developing fast-cooking pigeonpea dhal. Chemical coating of dhal sample of cultivar C 11 was done by soaking the sample in 1% (w/v) solution of either sodium carbonate or sodium bicarbonate solutions for 4 hr, followed by washing with water, steaming in a pressure cooker, and drying in an oven at 50°C overnight. This chemical coating of dhal reduced the cooking time from 22 min (control, C 11 dhal) to 5 min with sodium carbonate treatment. Further, we plan to study this aspect using more number of cultivars. Also, the effect of chemical coating using sodium chloride, sodium tripolyphosphate solutions on reducing the cooking time of pieonpea dhal will be examined.

2. Market survey

This survey was conducted in collaboration with the Economics unit to study the market grain quility and dhal millers' preferences of pigeonpea in Andhra Pradesh, Karnataka, Maharashtra, Madhya Pradesh, and Uttar Pradesh. Important pigeonpea growing districts of these states were surveyed as shown in Table 5. In total, 386 seed samples were collected and these samples were analysed for protein content, seed size, seed coat, floatation value, cooking time, and seed damage. Ranges and means of these characteristics are shown in Table 6. Some important observations of this survey are as follows. Traders and dhal mill owners prefer pigeonpeas with

white seed coat, round shape, and bold seed size. They purchase pigeonpeas from the farmers by paying higher prices for these grain characteristics. Therefore, it appears that there is a strong positive relationship between seed color (bright/white) and price. Also bolder pigeonpea grain fetch more price in the market. It was noted during the survey that some farmers sold white pigeonpeas in the market to get more money and kept red/brown pigeonpeas for household consumption, irrespective of preferences for cooking and dehulling quality. Generally, it is reported that white pigeonpeas are almost round in shape and yield higher dhal recovery as compared to red/brown pigeonpeas. Majority of the respondents observed that eating quality of dhal of red pigeonpeas are better than those of white pigoenepas. No large difference in cooking time between short and long duration pigeonpeas was observed by the villagers. Long duration pigeonpeas is reported to taste better than the early maturing pigeonpeas.

3. Vegetable pigeonpeas

Two genotypes (T 15-15 and ICP 7035) with different morphological and chemical characteristics were grown during the rainy season 1988 in Vertisols at ICRISAT Center. Cultivar T 15-15 has a green developing pod color with medium seed size and is widely grown in Gujarat State of India for its vegetable and dry seeds. ICP 7035 has a dark brown developing pod color with bold seeds containing high soluble sugars. Nearly 3000 flowers of each genotype were tagged at the pollination stages and subsequently developing pods were sampled at 24, 26, 28, 30, 32 and days after tagging. Freshly harvested pods were shelled out and green seeds separated. Suitable portions of the green seed samples were used for moisture estimation and the remaining samples were freeze-dried. Moisture determinations were made by drying the samples in an oven at 55°C for 16 h.

For chemical analysis, freeze-dried samples were finely ground in a Udy cyclone mill and passed through a 0.4 mm screen.

3.1 Dry matter accumulation

Changes in dry and fresh weight observed for cultivars T 15-15 and ICP 7035 are given in Table 7 and Table 8, respectively. On fresh weight basis, a large increase in seed size was noticed between 24 and 26 days after flowering, although it continued to increase up to 32 days after flowering. This trend was observed in both the genotypes though increase in seed size was more pronounced in ICP 7035. Expectedly, the moisture content of the seeds decreased with maturation in both the cultivars. When the results were expressed on dry weight basis, dry matter accumulation continued to increase up to 32 days after flowering in both the cultivars. However, the rate of dry matter accumulation was faster in ICP 7035 than in T 15-15 as the seeds matured. This is apparent by the differences in their dry seed weight at 24 and 32 days after flowering. Keeping in mind the color of developing green seeds for use as a vegetable, and the results of this study on dry matter accumulation, it may be mentioned that green seeds could be harvested at nearly 30 days after flowering for use as a vegetable.

3.2 Chemical changes at different stages of seed development

The changes in the levels of protein, soluble sugars, starch and crude fiber in freeze-dried seed samples of these cultivars are summarised for T 15-15 in Table 7, and for ICP 7035 in Table 8. These tables also contain information on 100-seed mass and moisture content of these cultivars. Soluble sugars, and protein, as percent of fresh weight and dry weight, continuously decreased, and starch content increased with the maturation in ICP 7035, whereas protein content considerably decreased between 24 and 26

days after flowering in T 15-15. However, when results were expressed as mg seed^{-1}, an increasing trend in soluble sugars, protein, and starch content was observed as the seed matured in both genotypes. Crude fiber, as percent of the sample weight, continuously decreased in T 15-15 and slightly increased in ICP 7035 as the seeds matured. When the results were expressed as mg seed^{-1}, crude fiber content increased with maturation in both the cultivars, but increase was faster in ICP 7035 than in T 15-15. As shown in Table 8, ICP 7035 contained remarkably higher amounts of soluble sugars as compared to T 15-15 at all stages of seed development studied. These two cultivars did not differ noticeably with respect to starch content during this period of maturation. This indicates that the developing green seeds of ICP 7035 has better biochemical activity for synthesis and accumulation of soluble sugars and hence contribute towards sweetness of the seed for vegetable purpose.

.3 Minerals and trace elements

Minerals and trace elements particularly calcium, iron and zinc are important nutrients but are usually deficient in the diets of low income people in the developing countries. The levels of calcium, magnesium, zinc, iron and copper of developing green seeds showed noticeable differences between T 15-15 and ICP 7035. Calcium and magnesium were considerably higher in T 15-15 than in ICP 7035 and reverse was true for copper content at all the stages of seed development (Tables 7 and 8). Calcium content of T 15-15 was remarkably higher than in ICP 7035 at all stages of seed development. Zinc and iron contents of these genotypes did not show large differences. No definite trends in the concentration of these constituents were observed with seed development in both genotypes, excepting magnesium content which gradually decreased as the seed matured

in ICP 7035. When consumed, developing green seeds are a richer source of iron, copper and zinc on a dry matter basis than mature seed. Results of present study show that green seeds of T 15-15 are a richer source of calcium and magnesium as compared to ICP 7035. Also the results suggest that green seed when plucked between 26 and 32 days after flowering for use as a vegetable would not show large variation in calcium, magnesium, zinc, iron, and copper contents.

Although it is not clear what quality factors are important in selecting genotypes for vegetable purpose, some years ago the researchers at ICRISAT have started to develop sweet large-seeded cultivars that also give stable production. Results of this study indicate that the levels of protein, sugars, and starch would considerably vary, but minerals and trace elements would not change depending on the stage of harvesting of pigeonpea green seeds for vegetable purpose. Also, there would be noticeable differences among the genotypes for this purpose. For vegetable purpose and from nutrition point of view, protein, soluble sugars, starch and crude fiber are important constituents. It may be mentioned that harvesting of pigeonpeas for sale as a vegetable is more common near cities where green pods can be readily marketed, and cultivars with different maturity may be preferred. Additional studies in this direction using early, medium and late maturing cultivars of pigeopea will be useful.

4. Floatation value, seed size, and protein content

The floatation test which is used to determine the hardness of cereal seeds was standardized for pigeonpea. Sodium nitrate solution having a density of 1.272 at 25°C was found suitable for this purpose. One hundred and twenty one whole seed samples were studied for seed floatation value,

protein content, and 100 seed mass. Protein content of these samples ranged between 12.5 and 22.0% whereas seed floatation values varied from 4 to 96% showing a large variability (Table 9). Interestingly, we observed that seed floatation values were negatively and significantly correlated ($r=-0.85^{**}$) with whole seed protein content implying that heavier seeds (less floatation value) will contain more protein. There was also a significant and negative correlation ($r=-0.40^{**}$) between 100 seed mass and seed floatation values. Unexpectedly 100 seed mass was positively and significantly correlated ($r=0.49^{**}$) with protein content.

5. Dehulling quality

We have initiated some collaborative studies on noodle and tempeh quality with food research laboratories in Thailand and Indonesia. Six cultivars of pigeonpea differing in morphological and seed characteristics were identified for this collaborative work. As a first step, we studied the dehulling quality of these cultivars by using Tangential Abrasive Dehulling Device (TADD) in our laboratory. Dhal yield of these cultivars ranged between 72.4 and 81.0% showing a large variation (Table 10). Dhal yield was highest in ICPL 87053 and followed by C 11 as shown in Table 10.

6. Monitoring grain quality of newly developed cultivars

6.1 Chemical composition and cooking quality

It has been our endeavour to analyse the newly developed cultivars for cooking quality and chemical composition including amino acids, minerals and trace elements. During this year, we received 10 cultivars from the breeding unit and analysed these for various constituents as given in Tables 11 and 12. Cooking time of dhal samples of these cultivars ranged between 18 and 27 min (Table 11). These differences in cooking time were supported by the differences in amounts of solids dispersed during cooking

of these cultivars. Earlier, our results have indicated a highly significant and negative correlation between cooking time and amount of solids dispersed in cooking water. There were no large differences in water absorbing capacity of these genotypes (Table 11). Protein content of these genotypes varied between 20.5 and 23.9% whereas no noticeable variation were observed in the levels of sugars, fat and ash contents of these cultivars (Table 11).

6.2 Minerals and trace elements

Minerals and trace elements are important dietary constituents. Calcium, magnesium, potassium, zinc, iron and manganese contents of the newly developed cultivars are shown in Table 12. Calcium content of these genotypes ranged between 54.4 and 85.6 mg 100 g^{-1} sample, while no large differences in iron content of these cultivars were observed (Table 12). It may be mentioned that calcium content of ICPL 87 was the lowest among these cultivars. Calcium and iron are the important minerals from nutrition point of view and these two constituents are generally deficient in the diet of people, particularly of low income group people. It will be useful to study the effect of environments and field conditions on mineral content of some cultivars, particualrly of ICPL 87 which contains lowest amount of calcium (Table 12).

6.3 Biological evaluation and amino acid composition

Biological evaluation, true protein digestibility and utilizable protein values of these cultivars were determined by conducting rat feeding trials. The results of this study are summarised in Table 13. Protein digestibility values ranged between 87.6 and 92.8%. These values were slightly higher than those of other cultivars of pigeonpea reported

earlier. Biological value of these cultivars varied from 61.0 to 70.6%. However, these differences in biological value did not result in a large variation for utilizable protein which varied from 12.1 to 14.8% (Table 13). Biological value of legume grain protein is greatly influenced by sulphur containing amino acids, methionine and cystine. These amino acid along with other amino acids were determined in cooked dhal samples of these cultivars. No large differences in the levels of various nonessential and essential amino acids including methionine and cystine were observed among these cultivars (Table 14).

7. Variability in fat content and grain hardness

We have observed that pigeonpea tempeh is harder than soybean tempeh and differences in fat content of these two legumes might contribute to tempeh hardness. Also, grain hardness might be responsible for such an effect. We selected 200 germplasm accessions to know variation in their fat content and subsequently study the tempeh quality of low and high fat containing genotypes. During this year, we screened these accessions for their fat content as follows.

7.1 Method of fat extraction

Fat was extracted using n-hexane in a Soxhlet apparatus. We compared different durations of fat extraction. As shown in Table 15, there were no large differences in fat values of cultivars extracted for 8 and 16 hr. Therefore, to speed up the analysis we followed 8 hr extraction period for analysis of our germplasm accessions.

7.2 Analysis of germplasm accessions

As shown in Annexure I, fat content of whole seed of these genotypes varied from 1.0 to 3.2 with the mean being 1.9. These genotypes were also

analysed for 100 seed mass and protein content. 100 seed mass of these genotypes ranged between 4.5 and 22.5 g showing a large variation. Protein content of whole seed of these genotypes varied from 16.5 to 23.6%, with the mean being 20.6%.

Table 1. Sensory evaluation of tempeh prepared by using whole seed and dhal samples of pigeonpea[1].

Cultivar	Color	Texture	Flavor	Taste	General acceptability
Whole seed					
C 11	3.1	2.7	2.8	3.0	3.2
ICPL 87	2.3	2.9	1.9	1.7	1.9
HPL 40	3.1	3.1	2.7	2.8	3.1
T 7	3.2	2.8	2.5	2.2	2.4
NP (WR) 15	2.9	2.6	2.9	3.1	3.0
LRG 30	2.6	2.8	2.4	2.5	2.5
BDN 2	2.9	3.1	2.9	3.1	3.0
SE	±0.19	±0.21	±0.22	±0.19	±0.19
Dhal					
C 11	3.5	2.9	2.9	2.8	2.9
ICPL 87	3.1	2.9	3.1	2.9	2.9
HPL 40	2.9	3.0	2.7	2.6	2.7
T 7	3.1	3.3	2.8	2.8	2.8
NP (WR) 15	3.0	3.0	3.0	3.1	3.1
LRG 30	3.1	3.3	2.7	2.8	2.8
BDN 2	3.2	3.1	3.0	2.8	2.8
SE	±0.11	±0.18	±0.19	±0.20	±0.17

1. Based on evaluation by ten panel members.

Table 2. Effect of fermentation on protein and starch contents of C 11 and Nylon, ICRISAT Center, rainy season 1987[1]

	Protein (%)		Soluble nitrogen (%)[2]		Starch (%)		Sugars (%)	
Cultivar	Control	Fermented[3]	Control	Fermented[3]	Control	Fermented[3]	Control	Fermented[3]
C 11	24 8	29 8	2.6	25.6	58.7	51.8	0.6	1.9
Nylon	23.5	26.3	2.9	14.7	57.7	54.3	0.5	1.4
SE	±0.26	±0.27	±0.04	±0.35	±0 92	±1.03	±0.02	±0.06

1. Based on two determinations of freeze dried sample for each treatment

2. g 100^{-1} g protein.

3 Fermented with *Rhizopus oligosporus* for 24 hr at 30°C

Table 3. Effect of fermentation on amino acid (g 100 g^{-1} protein) composition of pigeonpea cultivars

Amino acid	C 11			Nylon		
	Control	Fermented	Fermented and fried	Control	Fermented	Fermented and fried
Lysine	7.3	7.3	7.1	7.3	6.9	6.7
Histidine	4.1	4.1	4.3	4.2	4.2	4.0
Arginine	6.5	6.3	6.2	6.3	5.7	5.6
Aspartic acid	9.2	9.3	9.3	9.3	9.2	9.0
Threonine	3.8	3.9	3.8	4.0	3.8	3.8
Serine	4.7	4.6	4.6	4.9	4.7	4.7
Glutamic acid	18.9	19.0	18.8	18.7	18.7	18.5
Proline	5.2	5.2	5.1	5.7	5.0	4.9
Glycine	3.1	3.3	3.5	3.5	3.4	3.4
Alanine	4.2	5.0	4.9	5.0	5.5	5.1
Half cystine	1.2	1.2	1.4	1.2	1.2	1.1
Valine	4.3	4.6	4.8	5.0	5.0	4.9
Methionine	1.7	1.6	1.6	1.7	1.6	1.7
Isoleucine	4.3	4.4	4.5	4.3	4.5	4.7
Leucine	7.5	7.6	7.7	7.9	7.7	7.7
Tyrosine	3.6	3.5	3.4	3.5	3.2	3.1
Phenylalanine	7.0	6.9	6.9	7.1	6.9	7.0
Total	96.6	97.7	97.9	99.6	97.2	95.9

Table 4. Variability in starch content and its extraction rate in pigeonpea cultivars[1]

Cultivar	Starch (%)	Starch yield (%)
ICPL 151	60.0	73.3
ICPL 87	56.3	73.7
C 11	58.7	74.6
ICPL 270	56.2	70.8
ICP 8863	58.4	74.7
ICPL 366	60.0	64.3
ICPL 87051	56.8	82.0
ICPL 87063	56.8	79.6
ICPL 87067	58.2	72.2
BDN 2	58.4	68.5

1. preliminary results based on single analysis

Table 5. Variation in 100 seed mass of survey samples collected from different States in India

State/location	Number of samples	100 seed mass (g)	
		Range	Mean
Andhra Pradesh			
Tandoor	6	8.4-12.5	10.8
Karnataka			
Gulbarga	43	8.1-13.3	9.6
Bidar	35	4.2-14.0	9.7
Maharashtra			
Nanded	21	8.2-10.2	9.2
Parbhani	22	7.5-10.7	8.7
Akola	21	7.5-10.5	9.7
Malkapur	25	8.8-10.9	9.8
Jalgoan	13	9.0-10.3	9.8
Jalna	26	7.7-11.0	9.4
Latur	32	8.2-13.2	9.6
Madhya Pradesh			
Kandwa	30	8.6-12.5	9.6
Indore	20	7.9-10.2	9.0
Burhanpur	26	7.9-10.4	9.6
Jabalpur	7	7.3-12.3	9.2
Narasingpur	10	7.1-11.5	8.9
Uttar Pradesh			
Allhabad	22	6.3-10.4	8.0
Fatehpur	11	5.6- 6.8	6.3
Kanpur	16	6.1-11.3	7.1
Total	386	4.2-14.0	9.1

Table 6. Ranges and means of various grain characteristics of market survey samples[1]

	Range	Mean
Protein (%)	17.3-24.3	20.1
Cooking time (min)	58-86	72
Floatation value (%)	13-73	41
Seed coat (%)	9.3-21.2	13.2
Seed damage (%)	1.5-54.2	9.3

1. Based on analysis of 386 whole seed samples

Table 7. 100-seed mass, moisture content, and chemical constituents at different stages of seed development in T 15-15[1]

Days after flowering	100-seed mass (g)		Moisture	Protein	Sugars	Starch	Crude fiber	Calcium	Magnesium	Zinc	Iron	Copper
	Fresh	Dry	(%)	(%)	(%)	(%)	(%)	[mg(100 g)$^{-1}$]				
24	9.0	2.1	77.2	29.2 (6.2)[2]	9.8 (2.0)	29.2 (6.2)	10.6 (2.1)	91.8	140.4	2.8	3.9	0.7
26	13.5 -	3.2 -	76.3 -	25.6 (8.2)	8.2 (2.6)	43.6 (14.0)	9.8 (3.2)	80.2	142.8	2.8	3.6	0.8
28	13.4 -	3.3 -	75.5 -	25.5 (8.4)	9.5 (3.1)	43.3 (14.2)	9.1 (3.0)	84.3	142.8	2.5	3.7	0.6
30	14.8 -	4.8 -	67.7 -	25.7 (12.3)	8.1 (3.4)	45.8 (22.0)	8.9 (4.3)	88.5	145.4	2.8	3.3	0.7
32	19.0 -	6.6 -	65.2 -	24.8 (16.2)	6.1 (4.0)	48.0 (31.7)	8.6 (5.7)	87.5	144.1	2.8	2.9	0.7
SE ±	0.39 -	0.20 -	0.87 -	0.32 (0.18)	0.08 (0.05)	0.55 (0.25)	0.18 (0.11)	3.89	4.30	0.15	0.14	0.08

1. Averages of two determinations on freeze-dried samples and results are expressed on moisture-free basis.

2. Values within parenthesis indicate mg seed^{-1}

Table 8. 100-seed mass, moisture content, and chemical constituents at different stages of seed development in ICP 7035[1]

Days after flowering	100-seed mass (g)		Moisture	Protein	Sugars	Starch	Crude fiber	Calcium	Magnesium	Zinc	Iron	Copper
	Fresh	Dry	(%)	(%)	(%)	(%)	(%)	---------- (mg(100 g)$^{-1}$) ----------				
24	9.8	1.9	80.3	26.8	21.1	35.8	6.6	59.5	137.6	4.2	3.9	1.0
	-	-	-	(5.0)[2]	(4.0)	(5.6)	(1.3)					
26	16.2	3.2	80.1	25.8	10.2	30.2	7.4	52.9	135.2	3.7	3.6	0.9
	-	-	-	(8.2)	(6.2)	(12.5)	(2.4)					
28	23.8	5.3	77.6	23.1	15.8	42.7	7.5	50.9	130.7	2.7	3.3	1.1
	-	-	-	(12.3)	(8.4)	(22.8)	(3.9)					
30	27.7	6.6	76.1	23.2	13.7	45.9	7.9	53.9	127.8	2.5	3.0	1.2
	-	-	-	(15.3)	(9.0)	(30.2)	(5.3)					
32	33.8	9.2	72.9	21.4	12.9	50.7	7.8	58.0	123.8	3 1	3.1	1.0
	-	-	-	(19.7)	(11.9)	(46.7)	(7.2)					
SE ±	0.29	0.43	0.56	0.53	0.38	0.52	0.09	2.78	3.35	1.02	0.09	0.03
	-	-	-	(0.38)	(0.30)	(0.47)	(0.05)					

1. Averages of two determinations on freeze-dried samples and results are expressed on moisture-free basis.

2. Values within parenthesis indicate mg seed^{-1}

Table 9. Variability in floatation value, 100 seed mass, and protein content of pigeonpea genotypes[1].

Number of samples[2]	Floaters (%)	100 seed mass (g)	Protein (%)
31	8.5 (4-16)	8.0 (6.5-11.8)	19.8 (18.2-22.0)
30	25.0 (18-34)	8.5 (5.8-12.5)	18.7 (15.9-20.7)
29	43.9 (36-52)	8.2 (5.8-12.8)	16.5 (14.8-19.8)
31	69.5 (54-96)	6.9 (5.2-10.5)	15.0 (12.5-18.5)

1. Means and (ranges) of samples analysed.
2. Shown as 4 groups based on differences obtained on floaters test

Table 10. Dhal yield of different cultivars[1]

Cultivar	Whole seed left undehulled	Dhal	Brokens	Husk	Powder
	(%)				
C 11	2.3	79.1	2.6	13.1	4.0
BDN 2	12.3	73.2	0.9	11.1	3.1
T 15-15	8.7	75.8	0.7	11.4	3.7
ICPL 87052	4.1	78 2	0.8	11.9	4.4
ICPL 87053	1.8	81.0	1.4	13.6	3.9
ICPL 87075	13.2	72.4	2.5	7.3	4.7
SE	±1.68	±2.22	±0.45	±0.64	±0.19

1. Whole seed was dehulled in the TADD mill and results are averages of two determinations

Table 11. Chemical constituents and cooking quality parameters of dhal of some newly developed cultivars, ICRISAT Center, rainy season 1988[1].

Cultivar	Protein (%)	Total soluble sugars (%)	Ash (%)	Fat (%)	Cooking time dhal (min)	Water absorption ($g\ g^{-1}$)	Solids dispersed (%)
ICPL 151	20.5	6.6	3.5	2.0	24	1.9	23.5
ICPL 87	20.5	6.8	3.7	2.0	19	2.1	29.0
C 11	23.4	7.0	3.5	2.3	22	1.7	28.9
ICPL 270	21.5	6.9	4.0	2.0	18	2.3	28.6
ICP 8863	21.8	6.9	3.4	1.9	21	1.9	29.4
ICPL 366	22.7	6.3	3.7	2.3	20	1.9	28.2
ICPL 87051	23.1	6.5	3.8	2.0	24	1.7	22.5
ICPL 87063	22.7	7.0	3.5	1.9	26	1.8	19.3
ICPL 87067	23.9	6.9	3.9	2.0	27	1.7	21.1
BDN 2	22.6	7.1	3.6	2.0	23	1.8	26.9
SE	±0.23	±0.05	±0.05	±0.06	±0.062	±0.05	±1.25

1. Based on two determinations for each constituents

Table 12. Minerals and trace elements [mg(100 g)$^{-1}$] of dhal of some newly developed cultivars, ICRISAT Center, rainy season 1988[1].

Cultivar	Calcium	Magnesium	Potassium	Zinc	Iron	Manganese
ICPL 151	60.0	83.2	1480	2.83	4.75	1.20
ICPL 87	54.4	106.9	1570	3.33	4.02	1.10
C 11	67.5	120.0	1560	2.65	4.20	1.73
ICPL 270	61.3	113.2	1770	2.75	3.68	1.02
ICP 8863	66.9	117.6	1540	2.63	4.02	1.40
ICPL 366	71.3	142.5	1500	3.18	4.35	1.45
ICPL 87051	73.8	151.9	1560	2.73	3.73	1.48
ICPL 87063	67.6	146.3	1410	2.72	3.65	1.75
ICPL 87067	85.6	148.8	1580	2.55	3.80	1.65
EDN 2	67.5	135.7	1410	2.60	4.15	1.75
SE	±4.59	±4.98	±25.08	±0.05	±0.174	±0.021

1. Based on two determinations for each constituents using cooked dhal samples

Table 13. Biological value (BV), protein digestibility (TD), net protein utilization (NPU), and utilizable protein (UP) of pigeonpea cultivars, ICRISAT Center, rainy season 1988[1].

Cultivar	BV	TD	NPU (%)	UP
ICPL 151	68.2	88.3	60.2	12.3
ICPL 87	66.0	89.1	58.9	13.8
C 11	69.7	88.8	61.9	12.7
ICPL 270	64.7	87.6	56.6	12.1
ICP 8863	67.9	87.6	59.5	13.0
ICPL 366	70.6	92.4	65.4	14.8
ICPL 87051	66.7	90.6	60.5	14.0
ICPL 87063	65.3	87.9	57.4	13.0
ICPL 87067	61.0	92.8	56.6	13.5
BDN 2	64.8	89.6	58.0	13.2
SE	±2.35	±1.42	±2.30	±0.52

1. Based on five determinations for each treatment using cooked dhal samples

Table 14. Amino acid composition [g(100 g)$^{-1}$] of some newly developed cultivars[1], ICRISAT Center, rainy season 1988[1].

Amino acid	ICPL 151	ICPL 87	C 11	ICPL 270	ICP 8863	ICPL 366	ICPL 87051	ICPL 87063	ICPL 87067	BDN 2
Aspartic acid	9.1	9.4	9.6	9.5	9.5	9.5	9.4	9.3	9.5	9.5
Threonine	3.2	3.0	3.1	3.3	3.1	3.2	3.2	3.1	3.1	3.2
Serine	4.3	4.5	4.2	4.6	4.7	4.6	4.6	4.7	4.5	4.5
Glutamic acid	21.3	22.0	21.5	21.4	21.4	21.6	21.5	21.4	21.4	21.5
Proline	5.5	5.5	5.6	5.5	5.4	5.7	5.7	5.7	5.7	5.5
Glycine	3.5	3.3	3.3	3.5	3.3	3.3	3.6	3.2	3.1	3.4
Alanine	4.4	4.4	4.4	4.4	4.5	4.4	4.3	4.6	4.4	4.3
Cystine	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Valine	4.4	4.7	4.7	4.7	4.5	4.5	4.3	4.4	4.4	4.5
Methionine	1.4	1.3	1.3	1.3	1.4	1.3	1.3	1.2	1.2	1.3
Isoleucine	3.5	3.6	3.5	3.4	3.7	3.5	3.6	3.3	3.3	3.2
Leucine	6.9	6.5	6.8	7.0	6.9	6.7	6.7	6.8	6.9	6.9
Tyrosine	3.5	3.6	3.5	3.5	3.6	3.5	3.4	3.4	3.5	3.4
Phenylalanine	8.5	8.6	8.7	8.7	8.5	8.6	8.4	8.3	8.5	8.4
Histidine	4.9	3.7	3.6	3.7	3.7	3.7	3.5	3.7	3.6	3.6
Lysine	6.7	6.9	6.9	6.7	6.8	6.8	6.6	6.9	6.5	6.7
Arginine	6.7	6.3	6.6	6.5	6.5	6.6	6.5	6.7	6.5	6.6

1. based on analysis of cooked dhal samples.

Table 15. Effect of duration of extraction on fat content (%) in pigeonpea[1]

Duration	ICP 3349	ICP 3383	ICP 4544	ICP 4715	ICP 5347	ICP 5433
8 h	2.9	1.7	2.2	2.0	2.7	1.9
16 h	2.9	1.7	2.2	1.9	2.6	2.0
SE	±0.02	±0.01	±0.02	±0.02	±0.01	±0.01

1. Based on analysis of two determinations

ANNEXURE - I

Analysis of pigeonpea germplasm accessions for protein and fat contents

Accession	Color	100 seed mass (g)	Protein (%)	Fat (%)
ICP608	Brown	8.51	20.2	2.68
ICP1299	Black	7.05	20.2	1.81
ICP2577	Brown	7.22	20.7	1.39
ICP2586	Black	7.79	23.1	2.24
ICP2594	Brown	7.73	20.1	2.10
ICP2812	White	9.49	20.5	1.84
ICP3347	Brown	8.06	19.9	2.94
ICP3833	Brown	8.04	21.5	1.72
ICP4544	Brown	8.33	20.1	2.18
ICP4715	Light brown	8.79	16.7	2.00
ICP5347	Brown	7.42	18.9	2.67
ICP5433	Brown	7.64	20.4	1.88
ICP6399	White	11.07	19.8	1.62
ICP6888	Brown	9.47	20.4	1.51
ICP7019	Brown	9.39	20.1	2.14
ICP7035	Dark brown	22.52	21.4	1.96
ICP7214	White	15.99	18.7	2.13
ICP7215	Brown	8.46	19.5	2.22
ICP7231	Brown	8.78	19.0	1.72
ICP7426	Light brown	5.31	19.6	1.63

Accession	Color	100 seed mass (g)	Protein (%)	Fat (%)
ICP7427	Light brown	4.51	20.4	1.34
ICP7594	Light brown	10.71	21.2	1.01
ICP7866	White	10.36	21.3	1.03
ICP8072	White	15.86	18.9	0.97
ICP8177	Brown	10.66	20.1	1.62
ICP8186	Black	8.71	19.9	1.46
ICP8334	Light brown	9.71	19.4	1.46
ICP8546	Dark brown	16.61	19.5	1.77
ICP8547	White	19.26	18.6	1.39
ICP8861	Dark brown	21.71	19.8	1.64
ICP9265	Dark brown	7.55	20.2	1.76
ICP9267	Dark brown	5.79	20.9	1.70
ICP9306	Light brown	5.56	19.9	1.74
ICP9372	Brown	5.43	21.4	1.72
ICP9406	Brown	5.78	20.5	1.45
ICP9890	Light brown	6.78	20.3	1.52
ICP9908	Light brown	10.04	19.6	1.77
ICP9911	Light brown	10.44	18.6	2.02
ICP9938	White	8.77	20.7	1.70
ICP9967	Brown	10.98	20.4	1.74
ICP9980	Light brown	10.64	22.3	1.50
ICP9887	Brown	9.14	21.9	2.50
ICP11172	Light brown	20.36	19.8	1.67

Accession	Color	100 seed mass (g)	Protein (%)	Fat (%)
ICP11222	White	8.08	22.9	1.56
ICP11341	Light brown	13.96	20.5	1.78
ICP11424	Cream	6.41	21.6	1.68
ICP11446	Brown	10.24	21.7	1.83
ICP11485	Black	6.21	20.5	1.55
ICP11537	Brown	7.79	17.3	2.15
ICP11651	Brown	12.48	16.5	2.17
ICP11767	Light brown	5.46	21.7	1.79
ICP11854	Black	8.76	21.6	1.52
ICP11868	Light brown	8.76	22.4	1.90
ICP11938	Black	15.00	21.2	2.32
ICP11975	Brown	5.68	21.4	1.76
ICP12178	Light brown	9.45	21.6	1.84
ICP12198	Brown	6.68	21.0	2.04
ICP12201	Brown	5.73	20.8	1.81
ICP12213	Black	8.37	21.7	2.03
ICP12217	Light brown	8.18	19.3	2.17
ICP12242	Black	10.15	22.1	1.96
ICP12249	Black	9.68	20.8	1.87
ICP12261	White	7.73	20.2	2.21
ICP12272	Brown	9.45	21.8	2.10
ICP12298	Light brown	7.87	20.6	2.20
ICP12300	Dark brown	8.53	21.2	1.88

Accession	Color	100 seed mass (g)	Protein (%)	Fat (%)
ICP12311	Brown	10.54	20.6	2.00
ICP12320	Black	8.41	20.7	2.01
ICP12337	Light brown	8.44	19.9	2.90
ICP12352	Dark brown	6.13	20.4	2.91
ICP12353	Brown	10.22	20.4	2.13
ICP12362	Brown	6.31	20.7	1.60
ICP12367	Cream	6.21	20.2	1.68
ICP12371	Black	8.11	21.1	1.86
ICP12375	Brown	7.59	19.3	1.89
ICP12376	Brown	7.35	20.2	1.80
ICP12394	Black	7.45	18.8	2.09
ICP12430	Brown	6.88	21.2	1.84
ICP12440	Brown	6.70	19.6	1.84
ICP12456	Black	8.07	19.4	1.74
ICP12489	Light brown	8.52	22.2	1.89
ICP12509	Black	8.21	21.1	1.41
ICP12538	Grey	7.19	22.9	1.24
ICP12540	Black	7.89	21.2	2.16
ICP12554	Brown	8.29	21.0	2.16
ICP12567	Brown	7.59	20.0	2.33
ICP12577	Grey	9.65	21.2	2.33
ICP12581	Black	8.61	19.6	1.96
ICP12587	Brown	7.62	20.4	2.00

Accession	Color	100 seed mass (g)	Protein (%)	Fat (%)
ICP12595	Brown	8.98	20.9	1.45
ICP12599	Cream	6.71	19.1	1.65
ICP12600	Brown	7.14	19.2	1.69
ICP12602	Brown	7.55	21.6	1.83
ICP12620	Brown	6.48	19.5	1.34
ICP12621	Brown	7.40	20.3	1.19
ICP12648	Brown	6.56	18.7	1.93
ICP12664	Brown	8.99	17.5	1.77
ICP12704	Black	12.19	20.1	2.02
ICP12716	Brown	10.11	19.5	1.71
ICP12770	Dark brown	7.29	18.0	2.23
ICP12795	Brown	16.20	19.7	1.62
ICP12825	Dark brown	21.71	18.6	1.91
ICP12831	Brown	9.62	19.7	1.56
ICP12833	Brown	19.50	20.7	1.50
ICP12838	Brown	11.38	19.3	2.01
ICP12841	Brown	10.33	19.5	1.92
ICP12842	Black	10.34	20.2	2.33
ICP12863	Brown	6.64	21.7	2.07
ICP12870	Light brown	8.30	18.7	2.70
ICP12885	Dark brown	17.06	19.6	2.52
ICP12886	Cream	18.69	19.7	2.72
ICP12903	Brown	6.35	20.1	2.64

Accession	Color	100 seed mass (g)	Protein (%)	Fat (%)
ICP12929	Light brown	19.08	20.5	2.38
ICP12931	Brown	7.40	21.1	3.04
ICP12942	Light brown	19.75	18.8	2.47
ICP12965	Light brown	13.21	19.6	1.70
ICP12972	Light brown	19.60	20.7	1.47
ICP12976	Light brown	5.99	21.0	1.44
ICP12979	Brown	5.88	21.4	3.20
ICP12981	Brown	5.25	20.1	1.39
ICP12982	Black	7.70	20.8	1.35
ICP12987	Light brown	5.55	21.7	1.87
ICP12989	Brown	8.05	20.7	1.50
ICP12990	White	5.91	22.3	1.68
ICP12993	Light brown	5.98	23.0	1.58
ICP12994	Light brown	5.93	22.6	1.17
ICP12995	Light brown	5.93	22.2	1.47
ICP12996	Brown	5.85	22.4	1.61
ICP12998	Brown	5.65	22.4	1.73
ICP12999	Brown	5.77	21.4	1.91
ICP13000	Brown	5.70	22.1	2.93
ICP13001	Brown	5.78	21.2	1.85
ICP13006	Brown	7.31	21.2	1.61
ICP13010	Brown	6.04	23.2	1.59
ICP13011	Brown	5.69	22.3	1.90

Accession	Color	100 seed mass (g)	Protein (%)	Fat (%)
ICP13013	Brown	6.32	22.0	2.15
ICP13020	Brown	5.99	23.6	2.09
ICP13021	Brown	5.90	21.7	2.02
ICP13022	Brown	5.88	21.4	1.68
ICP13023	Brown	6.04	22.0	1.45
ICP13024	Brown	6.33	22.5	1.96
ICP13025	Brown	5.53	22.4	1.22
ICP13030	Black	17.93	20.1	2.29
ICP13033	Light brown	15.83	18.9	1.70
ICP13037	Light brown	7.02	20.5	1.90
ICP13115	Cream	19.46	20.3	2.42
ICP13119	Cream	19.40	20.6	2.21
ICP13130	Cream	18.32	19.1	2.51
ICP13143	Cream	17.22	19.1	2.40
ICP13160	Cream	16.91	20.5	2.18
ICP13175	Cream	19.37	20.4	2.77
ICP13152	Black	11.28	19.3	1.72
ICP13258	Cream	14.51	19.3	1.72
ICP13270	Brown	12.97	19.8	1.12
ICP13294	Light brown	6.90	21.6	1.40
ICP13297	Light brown	6.89	18.8	1.70
ICP13302	Light brown	19.12	20.4	2.00
ICP13303	Cream	6.19	20.4	1.66

Accession	Color	100 seed mass (g)	Protein (%)	Fat (%)
ICP13313	Black	10.90	21.5	1.89
ICP13315	Brown	12.15	22.9	1.97
ICP13316	Cream	11.94	21.2	1.48
ICP13329	Cream	17.90	19.5	1.38
ICP13330	Cream	18.40	20.8	1.72
ICP13369	Cream	18.64	19.7	1.67
ICP13379	Light brown	16.02	20.4	1.44
ICP13388	Light brown	17.66	20.5	1.48
ICP13400	Light brown	14.07	21.7	1.48
ICP13436	Cream	17.30	20.5	1.72
ICP13470	Dark brown	13.44	22.0	1.84
ICP13540	Dark brown	12.86	21.6	1.19
ICP13550	Brown	10.89	22.0	1.57
ICP13551	Light brown	9.19	23.5	1.74
ICP13552	Cream	15.55	22.4	1.94
ICP13558	White	15.89	21.4	1.40
ICP13562	White	9.87	20.4	1.66
ICP13572	Brown	9.37	21.0	2.45
ICP13574	White	7.94	22.0	1.93
ICP13576	White	10.40	20.5	2.37
ICP13631	Cream	11.98	18.7	2.46
ICP13644	Black	10.29	20.8	2.28
ICP13655	Dark brown	8.25	18.6	1.97

Accession	Color	100 seed mass (g)	Protein (%)	Fat (%)
ICP13669	Dark brown	6.43	21.2	1.18
ICP13671	Light brown	6.21	18.5	1.83
ICP13688	Brown	6.39	20.7	1.86
ICP13796	White	14.85	20.2	2.23
ICP13819	White	15.70	20.7	1.67
ICP13820	Cream	17.85	20.4	1.85
ICP13849	Cream	10.48	21.6	2.89
ICP13866	Light brown	13.85	20.5	1.98
ICP13867	Cream	15.14	20.8	2.06
ICP13868	Brown	11.98	20.9	2.00
ICP13874	Light brown	10.61	20.8	2.48
ICP13907	Brown	7.53	22.5	1.35
ICP13911	White	11.30	20.5	2.53
ICP13913	Black	7.35	19.5	2.26
ICP13924	Black	12.55	21.6	2.18
ICP13987	Brown	12.63	19.9	2.40
ICP13993	Light brown	7.72	20.6	2.91
ICP13996	Brown	6.47	19.6	2.85
ICP14165	Cream	8.72	20.2	2.90