CP 766

45. Grain Quality of Pigeonpea

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India produces over 90 per cent of the world's total of pigeonpea and this provides a necessary protein supplement to the largely cereal-based diet of the Indian population. In India, pigeonpea is consumed mostly in the form of decorticated split cotyledons known as *dal*, while in other semi-arid tropical countries of the world such as the Caribbean Island it is consumed in the form of green peas. Although increasing the yield and its stability are of obvious priority, grain quality also deserves consideration in a breeding programme.

The grain quality of a crop has several components, including nutritional quality, antinutritional factors, digestibility and bioavailability of nutrients, cooking quality, consumer acceptability, and storage stability. The progress that has been made in studies of some components of grain quality at ICRISAT is reported in this paper.

Nutritional quality

PROTEIN QUANTITY

One of the recommendations in the plenary session of the earlier International Workshop on Grain Legumes, held at ICRISAT in 1975, was that the yield be expressed in terms of protein per unit area of land per unit of time. Then increasing the yield at constant protein content or selecting genotypes of superior protein content with average yield capability would be advantageous. A method for the determination of the protein content using the Technicon Auto Analyser has been standardised (Singh and Jambunathan, 1981). The precision of the method was routinely monitored by including check samples with every analysis. The coefficient of variation (C.V.) of analysis of check samples varied between 1.30 and 2.34 per cent. In the initial stages, breeders also included hidden blind samples along with the routine samples for analysis. The mean protein content of pigeonpea *dal* is about 23 per cent. Analyses of germplasm accessions of pigeonpea seed revealed that the protein content ranged from 15.5 to 28.6 per cent (Table 1), indicating the possibility of some high protein

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Table 1: Analyses of pigeonpea germplasm accessions for protein content

Year	No. of samples	Per cent protein (N×6.25)	
		Range	Mean
1975-76	1,745	16.3-28.0[a]	21.0
1976-77	1,087	19.1-28.6[a]	22.8
1977-78	1,867	15.5-26.8[b]	19.6
1978-79	964	16.8-25.9[b]	20.5

[a]*Dal*, [b]Whole seed.

sources. However, the results include the analyses of samples that were obtained from unreplicated trials, and no attempt was made to study the influence of environmental or seasonal effects on protein content. Another source of high protein was identified in the wild species. Some of the species of Atylosia, a related genus, were found to have higher protein levels (Reddy et al., 1979). Atylosia species showed that a few lines had more than 30 per cent protein. Amino acid profiles of pigeonpea and Atylosia species revealed no important differences in any of the essential amino acids.

PROTEIN QUALITY

Methionine, cystine, and tryptophan are the important amino acids that are deficient (limiting) in grain legumes. Twenty-four pigeonpea *dal* samples were analysed for methionine and cystine by performic acid oxidation procedure. The total sulphur amino acid content as a percentage of protein ranged from 1.76 to 2.55 per cent, with a mean of 2.11 per cent. When these values were used to calculate the chemical score using the formula:

$$\frac{\text{mg of amino acid in 1 g of test protein}}{\text{mg of amino acid in reference pattern}} \times 100,$$

the chemical scores ranged from 50 to 73, with a mean of 60.

Attempts were made to identify suitable rapid procedures for the estimation of methionine and cystine. The relationship between sulphur and sulphur amino acids was studied. Total sulphur was determined using a Leco sulphur analyser and by using the wet digestion procedure. A comparison showed that the amount of sulphur in amino acids accounted for 75.5 per cent of total sulphur in pigeonpea, and the indi[illegible]al values ranged from 59.2 to 84.6 per cent. Table 2 shows the correlation coefficients among protein, cystine, methionine, total sulphur, and cystine plus methionine. The correlation coefficient between protein content and sulphur amino acids when expressed as per cent protein was negative but insignificant. The correlation coefficient between total sulphur as per cent of sample and methionine and cystine as per cent of protein was positive [illegible] (r=0.65**) indicating the possibility of using total

[illegible]elation coef[illegible] [illegible]otal sulphur, and sulphur amino acids in p[illegible] cultivars[a]

	Protein (%)	Cystine	Methionine	Cystine + Methionine	Cystine	Methionine	Cystine + Methionine
		(g/100 g sample)			(g/100 g protein)		
Protein (%)		0.269	0.48[illegible]*	0.392*	−0.30[illegible]	−0.262	−0.214
Total sulphur (g/100 g sample)	−0.150	0.554**	0.4[illegible]3*	0.534**	0.[illegible]16**	0.612**	0.651**
Cystine (g/100 g protein)						0.780**	0.958**

[a]Based on analyses of 24 *dal* samples.

The presence of S-methyl-L-cystine in pigeonpea seeds has been reported by earlier workers (Evans and Boulter, 1975). It would be useful to pursue other modified methods such as the removal of S-methyl-L-cystine using ethanol, in order to study if the correlation between sulphur and sulphur amino acids could be further improved. Also, methionine and cystine when expressed as per cent of protein were correlated (r=0.78**) with each other, indicating some possibilities of screening for either of these two amino acids when samples are many and facilities are limited.

Protein fractionation studies of one cultivar of pigeonpea (HY-3C) showed that of the four protein solubility fractions, albumin, which accounted for less than 10 per cent of total nitrogen, had the highest concentration of cystine and methionine as per cent of protein. The globulin fraction, comprising about 65 per cent of total nitrogen, had less than half the concentration of these amino acids when compared with albumin. The glutelin fraction seems to be moderately high in these amino acids, while the prolamine fraction contained relatively small amounts of sulphur amino acids. If a similar trend is obtained in other cultivars, then it would be useful to identify pigeonpeas containing normal protein levels but with a higher proportion of albumin and gutelin fractions.

Tryptophan, which is another amino acid of nutritional importance in pigeonpea, is destroyed during acid hydrolysis and hence cannot be determined along with other amino acids. Therefore, analyses of *dal* samples of 10 cultivars were carried out in amino acid analyser after alkaline hydrolysis and were compared with the results obtained from the colorimetric procedures of Concon (1975) and Spies and Chambers (1949). Tryptophan values obtained using the amino acid analyser ranged from 0.47 to 0.63 when expressed as per cent of protein and the mean [illegible] When expressed as a chemical score, the values ranged from 47 to 63. The mean values obtained by two colorimetric procedures were about 30 per cent higher, and further work is in progress to determine a suitable methodology.

Pigeonpea also provides several other essential nutrients like carbohydrates, and the chemical composition of some commonly utilised pigeonpea cultivars are shown in Table 3. The protein per cent in *dal* samples ranged from 21.4 to 25.4 per cent while the starch content ranged from 52.5 to 59.9 per cent. It is important to ensure that the advanced lines of pigeonpea bred for higher yields and better nutritional quality do not suffer a reduction in the concentration of essential minerals and vitamins.

Table 3: Chemical composition of *dal* samples of some pigeonpea cultivars[a]

Cultivar	Protein (%)	Starch (%)	Soluble sugars (%)	Fat (%)	Crude fibre (%)	Ash (%)
HY-3C	21.5	57.2	4.9	2.0	1.0	3.1
ICP-1	23.0	56.9	4.5	1.1	1.1	3.7
ST-1	21.4	57.3	4.8	1.3	1.0	3.4
No. 148	22.8	58.9	5.3	1.3	1.1	3.6
T-7	24.2	59.9	5.1	1.3	1.1	3.5
T-17	25.4	53.6	4.4	1.6	1.1	3.8
T-21	22.9	55.0	4.9	1.4	1.0	3.7
BDN-1	22.4	56.2	5.0	1.7	0.9	3.6
C-11	22.1	57.8	4.8	1.4	1.1	3.9
Gwalior-3	24.8	52.5	4.7	1.4	1.1	4.0

[a]As is basis

ANTINUTRITIONAL FACTORS

Of the several antinutritional factors that are reported to be present in legumes, the trypsin and chymotrypsin inhibitors have been studied in detail (Liener, 1979). Although pigeonpea has lower levels of trypsin and chymotrypsin inhibitor activities as compared with soybeans, some of the side relatives of pigeonpea have been found to contain higher concentration of these inhibitors (Table 4). The highest trypsin and chymotrypsin inhibitor activities were observed in *Rhynchosia rothii*, and this species also showed the lowest value for *in vitro* protein digestibility. Some of the antinutritional constituents are destroyed on cooking, . . t this has not been tested in the case of wild species of pigeonpea. However, the presence of some of these inhibitors may have a role in insect or disease-resistance characteristics.

There is little available information on the presence or absence of other undesirable components in pigeonpea, such as oligosaccharides, which are reported to cause flatulence, lectins, and goiterogens, and there is a need to carry out more investigations in this area. Similarly, the digestibility of starch and protein in pigeonpea and their role in human nutrition needs careful evaluation.

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Species	No. of samples (*dal*)	Protein (N × 6.25) (%)	Trypsin inhibition: Units/mg meal	Trypsin inhibition: Units/mg protein[a]	Chymotrypsin inhibition: Units/mg meal	Chymotrypsin inhibition: Units/mg protein	*In vitro* protein digestibility (%)
Cajanus cajan							
Mean	3	24.6	13.5	69.4	4.2	22.1	60.5
Range		23.1-26.2	12.5-15-1	67.1-71.3	3.5-5.0	15.3-27.8	57.9-64.1
Wild species *Atylosia* spp.							
Mean	6	28.4	17.6	76.0	14.2	61.8	61.1
Range		27.1-29.3	13.3-25.8	54.5-121.4	5.9-22.0	24.2-92.4	52.6-68.1
Rhynchosia spp.	1	27.6	82.4	445.7	20.9	113.2	40.9

[a]Based on the amount of protein extracted.

Table 5: The distribution of polyphenolic compounds in the seed components of pigeonpea cultivars

Cultivar	Testa colour	Seed coat (% w/w)	Polyphenols (mg/g samples): Seed coat	Polyphenols (mg/g samples): *dal*	Polyphenols (mg/g samples): Whole seed
BDN-1	Dark-red	15.2	106.9	1.9	15.1
C-11	Light-red	15.7	92.3	1.7	14.2
NP (WR)-15	White	16.4	37.2	1.4	6.0
HY-3C	White	13.0	27.0	1.6	3.7

The role of polyphenolic compounds (loosely termed as tannins) in the bioavailability of nutrients of pigeonpea needs to be investigated. This is particularly important in those areas where pigeonpea is consumed as whole green peas. Analysis of four pigeonpea cultivars with different seed-colours showed that the seed-coat contained the highest proportion of polyphenols and red seed appears to have a higher concentration of polyphenols than white (Table 5). Preliminary *In vitro* studies indicated that the polyphenolic compounds may affect some of the digestive enzymes. This again needs a more detailed examination.

Cooking quality and consumer acceptability

Consumers are the end users of pigeonpea, and cooking quality and consumer acceptability are two aspects of vital importance to any crop improvement programme.

Cooking Quality

The cooking time of 25 pigeonpea *dal* samples showed a variation from 24 to 68 minutes. The *dal* samples were analysed for various physico-chemical characteristics and the ranges and means of these values are presented in Table 6. Negative and highly significant correlation coefficients were obtained between the cooking time and solids dispersed, water absorption characteristics of *dal* or whole grain, nitrogen solubility index, and nitrogen content in dispersed solids. Further work is being carried out with more samples. There is still a need to develop a suitable method to objectively test the cooking time of pigeonpea.

Table 6: Relationship between the physico-chemical characteristics and cooking time in 24 cultivars of pigeonpea

Constituent	Range	Mean	Correlation coefficient (*r*) with cooking time
Cooking time (min.)	24-68	38	
Seed weight (g/100 seeds)	6.2-20.7	9.6	−0.434*
Solids dispersed[a] (%)	20.8-54.7	37.4	−0.813**
Water absorption			
(g/g *dal*)[a]	1.69-2.65	2.25	−0.807**
(g/g whole grain)[a]	0.63-1.34	1.02	−0.695**
Increase in volume			
(v/v *dal*)[a]	1.18-1.86	1.51	−0.052
(v/v whole grain)[a]	0.91-1.54	1.13	+0.163
Gelatinisation temp. of starch (°C)	73-81	76	−0.267
Water-soluble amylose (%)	7.3-12.0	9.8	+0.042
Total amylose (%)	19.2-24.0	21.8	−0.049
Starch (%)	51.5-63.4	58.6	+0.216
Soluble sugars (%)	3.6-5.3	4.8	+0.178
Protein (%)	19.7-25.2	22.1	+0.388
Nitrogen solubility index (%)	28.7-42.5	36.4	−0.634**
Nitrogen content in solids dispersed (%)	19.6-31.8	27.3	−0.756**

*Significant at 5% level.
**Significant at 1% level.
[a]Boiled at 100°C for 25 min.

Consumer Acceptability

Most of the pigeonpeas that are grown in India are first processed and only the *dal* samples enter the market channels for consumer use. Therefore, for pigeonpea utilisation, milling and processing characteristics of whole seed, as well as the consumer's preferences, are important.

A survey [illegible] the three States—Madhya Pradesh, Uttar Pradesh, and Maharashtra—that account for more than 75 per cent of the total production of pigeonpea in India. Several *dal* mill owners were interviewed, and their opinions and impressions regarding the milling characteristics of various types of pigeonpea were obtained. Several villagers were interviewed in areas where pigeonpea processing is done at home with a stone grinder. In addition, consumers' preferences for *dal* material were obtained. Only the important findings are listed here. When a mechanical mill is used for the dehulling process, white pigeonpea seed is reported to give higher *dal* yields. Light-red or red seed is also preferred because of the uniformity of seed size and shape. Although the *dal* yield is reported to vary from one mill to another, depending on the processing method used, important criteria in general are seed size, shape, and hardness; round seed of medium size, with greater hardness, have been reported to give better recoveries of *dal*, village-level home processing appeared to give lower *dal* recoveries (about 62 per cent as compared to 71 per cent obtained in a mechanically operated mill). This again is subject to variation, depending on the processing techniques used.

Consumers seem to prefer the local varieties grown in their own fields. There is a wide variation in the preferences for colour because of long-term association with a particular colour in a particular village. The choice of colour varies from black to red to white. However, interestingly, taste seems to have a higher priority than cooking time, and more data need to be obtained to verify this observation.

The results on this survey have given us some ideas about the preferences of consumers and mill owners. It would be helpful to gather additional data to obtain a better understanding of the needs of the consumers. There is a need to carry out a survey in other countries where green pigeonpeas are consumed.

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