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Effect of Dehulling on Nutrient Losses in Chickpea (*Cicer arietinum* L.)*

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Chickpea cotyledons were dehulled (scarified) for different lengths of times (0, 2, 4, 8, and 12 min) using a Tangential Abrasive Dehulling Device (TADD). The resulting decorticated dry split cotyledons (dhal) and powder fractions were then analyzed for protein, sugar, starch, fiber, minerals, and amino acids. Protein, soluble sugar, and ash of dhal (scarified cotyledons) fraction decreased with increasing dehulling time, but starch content increased. Considerable amounts of calcium, iron, and zinc were removed by dehulling for 4 min. This time is assumed to be an equivalent of traditional dehulling in terms of quantitative losses of powder fraction. No notable differences were observed in the amino acids of dhal and powder fractions of cotyledons dehulled for different intervals. Albumin and glutelin fractions were considerably reduced due to dehulling, while the globulin fraction increased. It is concluded that the dehulling process (4 min) would incur considerable losses in protein, calcium, iron, and zinc, whereas it would not adversely affect the protein quality in terms of amino acids.

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is the most important pulse crop in India from production and consumption points of view. In fact, India accounts for over 70% of the world's total chickpea production and consumption. This crop is also important in many countries in Asia, Africa, Europe, and the Americas. Chickpea is consumed in a variety of food preparations in the form of decorticated dry split cotyledons (dhal) or as whole seed. The nutrient compositions of chickpea including nutritional and antinutritional factors have been recently reviewed (Williams and Singh, 1987; Singh, 1988). Dehulling chickpea—also called primary processing—is an important operation that converts whole seed into dhal. In India, various procedures are employed for this purpose ranging from commercially operated dhal mills in cities to manually operated stone *chakkis* in the villages. Attrition-type dehullers and roller mills are particularly suitable for dehulling and splitting legume grains with loose seed coats; whereas abrasive-type dehullers are suitable for dehulling grains with more tightly adhering seed coats (Kurien, 1984). According to Ehiwe and Reichert (1987), a considerable variability in the dehulling quality of cowpea, pigeonpea, and mung bean cultivars was observed when these legumes were dehulled using a Tangential Abrasive Dehulling Device (TADD). Outer layers of pigeonpea cotyledons were scarified by the abrasive action of the dehulling process resulting in considerable nutrient losses (Singh *et al.*, 1989).

The distribution of various nutrients in different anatomical parts of legume and cereal seeds has been reported. The outer layers of pigeonpea cotyledon are richer

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sources of protein than are inner layers (Reddy *et al.*, 1980). These outer layers are removed during traditional dehulling which results in considerable protein losses (Singh and Jambunathan, 1981). Processing methods are known to significantly affect the composition of cereal products. Considerable amounts of nutrients—protein, amino acids, minerals, and vitamins—may be lost if refined cereal products are consumed instead of whole grain products (Pederson and Eggum, 1983a). The objectives of the present investigation were to study nutrient (principal chemical constituents, minerals, and amino acids) losses due to dehulling chickpea cotyledons and to examine the distribution of such nutrients in dhal (dehulled) and powder fractions of chickpea.

EXPERIMENTAL

Materials

A popular Indian chickpea cultivar (Annigeri) was grown at ICRISAT Center, Patancheru, Andhra Pradesh, India, during the postrainy season 1985–1986. This light brown seed-coated cultivar has an average 100-grain mass of about 20 g. After harvest, the bulked seeds were cleaned and stored for about 2 months at room temperature (25 ± 2°C). This is a common practice before processing chickpea in India. Two samples for each treatment were drawn from the bulked seed material and processed for dehulling as separate samples as below.

Dehulling

Dehulling, referred to as scarification in the present study, was carried out using a TADD that was developed to simulate large-scale abrasive dehullers (Reichert *et al.*, 1986). Although it is difficult to compare the TADD with a commercially operated dhal mill commonly employed for dehulling chickpea in India, the abrasive action involved in these two pieces of dehulling equipment appears to be comparable. The TADD was used to obtain different percentages of dhal (decorticated cotyledons) and powder fractions, since it would have been difficult to achieve these fractions using a commercial dhal mill. Powder fraction in the present study is defined as the fine flour obtained as a result of successive removal of the outer layers of cotyledons during the dehulling operation in TADD. For the 0-min dehulling treatment, seeds were not subjected to mechanical abrasive dehulling in TADD. Rather, the seed coat was removed manually from the air-dried seeds using forceps. The manually dehulled, unsplit seeds were successively dehulled in TADD for 2, 4, 8, and 12 min to obtain different dhal and powder fractions. This was carried out in order to remove the outer portions (layers) of cotyledons in increasing proportions. For chemical analysis, the dhal (decorticated cotyledons) fraction was further ground to a fine powder in a Udy cyclone mill, whereas the powder fraction was used as such for chemical analysis.

Chemical Analysis

Two processed samples of each treatment of dhal and powder fractions were collected and analyzed as separate samples. All chemical analyses were made on two samples of each treatment except the amino acid composition for which a single composite sample was analyzed. All results are expressed on a moisture-free basis.

To determine the protein content, the Technicon autoanalyzer (TAA) procedure was used (Singh and Jambunathan, 1980). Fat, crude fiber, and ash contents were

estimated by AOAC procedures (AOAC, 1975). Soluble sugars and starch were determined according to Thivend *et al.* (1972). Samples were extracted with 80% hot (70°C) ethanol for soluble sugar estimation. After evaporating the extract to dryness, the residue was dissolved in distilled water for estimating the soluble sugars by the phenolsulfuric acid method (Dubois *et al.*, 1956).

For mineral and trace element analyses, the samples were digested using a triacid mixture which contained nitric acid, perchloric acid, and sulfuric acid in the ratio of 20:4:1. For digestion, 0.5 g of defatted samples were weighed and transferred to a block digester glass tube. After adding 6 ml of the 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. Following digestion, the mixture was cooled and dissolved in glass distilled water and the volume was made to 50 ml. Suitable aliquots were analyzed for calcium, magnesium, zinc, iron, and manganese in an atomic absorption spectrophotometer, Varian Tectron Model 1200 (Piper, 1966).

Protein Fractionation

The defatted flour samples were successively extracted with 0.5 *M* sodium chloride in 0.01 *M* phosphate buffer (pH 7.0) and 0.1 *N* sodium hydroxide to separate the proteins into albumin and globulin fractions together and glutelin fraction alone. The flour sample (1.0 g) was extracted first with 15 ml of 0.5 *M* sodium chloride solution for 1 h at room temperature. The content was centrifuged and reextracted twice with 10 ml solvent each time and supernatants were collected and made up to 50 ml. The same procedure was carried out using 0.1 *N* sodium hydroxide. Albumin was separated from the globulin fraction by dialysis against distilled water. The protein content of all three fractions was determined according to the method of Lowry *et al.* (1951).

Amino Acid Analysis

A 50-mg flour sample was refluxed for 24 h in 50 ml 6 *N* HCl. The HCl was removed from the hydrolyzate by evaporation, and residue was dissolved in citrate buffer (pH 2.2). The resulting amino acids were analyzed in a Beckman 119 CL amino acid analyzer.

Statistical Analysis

For statistical analysis, two samples for each treatment were drawn from the bulked seed material, analyzed as separate samples, and considered as replications for statistical analysis for the determination of each constituent. Standard error was determined by one way analysis of variance (Snedecor and Cochran, 1967). Standard error indicated in the tables is the pooled error of replications.

RESULTS AND DISCUSSION

As a result of dehulling, the outer layers of the cotyledons were increasingly scarified and removed in the form of powder fraction. This resulted in reduced size and weight of the unsplit cotyledons. Figure 1 shows the size and shape of unsplit cotyledons dehulled in TADD for different time intervals. The quantitative yield losses incurred due to dehulling (scarification) after removal of seed coat are shown in Table 1. The powder fraction increased from 5.2% for 2 min dehulling to 39.2% for 12 min dehulling.

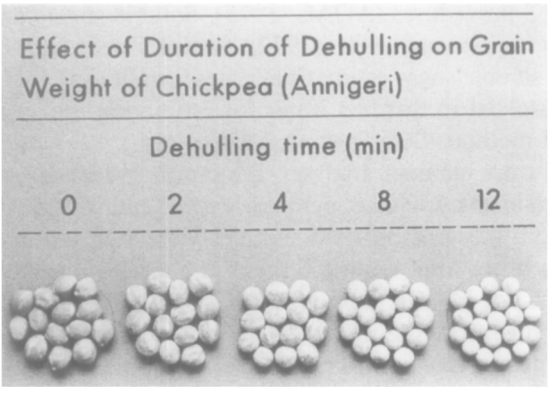

FIG. 1. Effect of dehulling on size and shape of chickpea cotyledons.

The dhal yield primarily depends on the type of machine used for dehulling operations. According to a survey on chickpea dehulling methods in the major chickpea growing states of India (Haryana, Punjab, Rajasthan, and Madhya Pradesh), powder fraction losses were nearly 7% in dhal mills and nearly 12% in villages—chakki chickpea dehulling operations (unpublished data). In the present study, such losses were noted when chickpea was dehulled for 2 to 4 min. In addition to the type of machine and abrasive action, other characteristics such as size, shape, and hardness of the grain seem to play an important role in determining dehulling losses of pulses, particularly pigeonpea in India (Singh and Jambunathan, 1981).

Table 2 presents the concentrations of protein, sugar, starch, fiber, and ash in dhal and powder fractions of chickpea dehulled for different time intervals. Protein and sugar contents decreased and starch content increased in dhal fractions as the dehulling

TABLE 1

EFFECT OF DURATION OF DEHULLING ON dhal AND POWDER YIELDS OF CHICKPEA CULTIVAR ANNIGERI[a]

Dehulling time (min)	100-grain mass (g)	Recovery (%)		
		Dhal	Powder	Total
0	18.5	100.0	-	100.0
2	17.2	92.5	5.2	97.7
4	16.3	84.6	12.7	97.3
8	13.0	70.4	26.2	96.4
12	10.8	56.3	39.2	94.5
SE ±	0.34	1.28	2.03	0.54

Note. For each treatment, results are averages of two samples drawn from the bulked seed material and processed as separate samples. Results are expressed on a moisture-free basis.

[a] Using the tangential abrasive dehulling device, Reichert *et al.* (1986).

TABLE 2

EFFECT OF DEHULLING ON CHEMICAL CONSTITUENTS (g/100 g SAMPLE) OF dhal AND POWDER FRACTIONS OF CHICKPEA CULTIVAR ANNIGERI[a]

Dehulling time (min)	Dhal					Powder				
	Protein	Sugar	Starch	Fiber	Ash	Protein	Sugar	Starch	Fiber	Ash
0	18.6	6.8	56.2	1.2	2.8	-	-	-	-	-
2	18.0	6.5	57.8	1.1	2.6	23.6	12.1	48.0	1.7	4.1
4	17.5	6.3	57.8	1.0	2.7	21.8	10.5	50.3	1.4	3.6
8	17.5	6.0	58.0	0 9	2.5	19.8	9.5	52.0	1.2	3.4
12	16.4	6.1	60.8	1.0	2.6	18.9	8.6	55.4	1.0	3.3
SE ±	0.18	0.21	0.31	0.08	0.14	0.21	0.13	0.51	0.09	0.12

[a] For each treatment, results are averages of two samples obtained as in Table 1 and analyzed separately. Results are expressed on a moisture-free basis.

time increased. Protein, soluble sugars, and ash content of powder fractions were considerably higher than those of the dhal fractions obtained at different time intervals; whereas the reverse was true for starch (Table 2). The starch concentration of cotyledons increased with the removal of outer layers. These differences were more pronounced with the 2-min dehulling time compared to samples of the 4- to 12-min dehulling time. The observed results indicated that dehulling would incur considerable losses in terms of protein, sugar, and ash because the outer portions of chickpea cotyledons containing these constituents would be lost during dehulling operation. This observation is in agreement with a similar finding in pigeonpea by Singh *et al.* (1989). However, the additional studies involving the histochemical analysis would be very helpful in this direction. In pigeonpea, outer layers of cotyledons contained higher concentrations of protein as revealed by the histochemical analysis (Reddy *et al.*, 1980).

The effects of dehulling on minerals and trace elements of dhal and powder fractions are shown in Table 3. The nutritionally important minerals such as calcium, iron, zinc, and manganese significantly changed as a result of dehulling (Table 3). Powder fraction contained higher concentrations of these constituents. After 2 to 4 min of dehulling, calcium, iron, zinc, and manganese contents were nearly two times higher in the powder fraction. As mentioned above, the yield losses in the form of powder fraction by the traditional dehulling methods vary from 7 to 12%, which is comparable to 2 to 4 min of dehulling in the present study. This indicated that calcium and iron losses would range from 10 to 25% depending on the dehulling method. In cereals, calcium has been reported to be uniformly distributed; whereas iron is in the outer portions of the endosperm (Pederson and Eggum, 1983b). Our study clearly indicated that these minerals were higher in the outer layers of chickpea cotyledons and would be lost during dehulling.

TABLE 3

EFFECT OF DEHULLING ON MINERAL AND TRACE ELEMENT CONTENT (mg/100 g SAMPLE) OF dhal AND POWDER FRACTIONS OF CHICKPEA CULTIVAR ANNIGERI[a]

Dehulling time (min)	Dhal				Powder			
	Calcium	Iron	Zinc	Manganese	Calcium	Iron	Zinc	Manganese
0	43.0	5.7	3.6	1.3	-	-	-	-
2	39.5	5.0	3.0	1.2	85.0	12.0	8.2	2.4
4	38.0	4.8	2.7	1.1	65.5	10.5	7.4	2.2
8	35.5	4.3	2.6	1.0	45.0	8.5	6.7	1.9
12	35.0	3.8	2.5	1.0	45.0	7.0	5.8	1.6
SE ±	1.8	0.4	0.2	0.1	2.9	0.3	0.2	0.1

[a] For each treatment, results are averages of two samples obtained as in Table 1 and analyzed separately. Results are expressed on a moisture-free basis.

Protein fractions and amino acid composition play a very important role in determining the protein quality of grain legumes. Chickpea cotyledons constitute about 83% of the total seed dry weight and the globulins are their predominant proteins contributing about 35% of their total protein sulfur amino acids (Singh, 1985). Notable differences in the relative proportion of albumin, globulin, and glutelin of dhal and powder fractions were obtained (Table 4). The albumin and glutelin fractions were higher in the powder fraction than in the dhal fraction and the reverse was true for the globulin fraction. The albumin fraction in the manually decorticated grain (0 min) was higher than that in the dehulled cotyledons. This indicated that the outer layer of cotyledons contained higher amounts of albumin fraction. The concentration of major amino acids of chickpea—glutamic acid, aspartic acid, leucine, and phenylal-

TABLE 4

EFFECT OF DEHULLING ON PROTEIN FRACTIONS (g/100 g PROTEIN) OF dhal AND POWDER FRACTIONS OF CHICKPEA CULTIVAR ANNIGERI[a]

Dehulling time (min)	Dhal			Powder		
	Albumin	Globulin	Glutelin	Albumin	Globulin	Glutelin
0	10.5	62.3	21.4	-	-	-
2	9.5	65.4	19.5	12.8	61.7	23.6
4	8.4	64.8	20.7	10.9	62.8	22.5
8	8.5	65.0	18.8	11.4	61.4	20.8
12	8.3	63.8	19.0	10.3	61.5	21.3
SE ±	1.23	1.54	0.46	0.32	0.57	0.28

[a] For each treatment, results are averages of two samples obtained as in Table 1 and analyzed separately. Results are expressed on a moisture-free basis.

anine—did not vary between the dhal and powder fractions. Lysine, threonine, methionine, and cystine of dhal and powder fractions of cotyledons dehulled for different intervals also did not reveal notable differences. These results indicated that protein quality in terms of amino acids might not be adversely affected, even though net protein loss was apparent as a result of dehulling. According to Pederson and Eggum (1983b), glutamic acid, proline, aspartic acid, glycine, and serine were concentrated in the inner parts of the endosperm of cereals as their concentration increased in the refined flours. But the results of the present study indicated that these amino acids might be uniformly distributed in the cotyledons of chickpea since no notable differences were observed when the cotyledons were dehulled for different intervals. Similar observations have been reported in pigeonpea (Singh *et al.*, 1989).

CONCLUSION

Although our results are based on analysis of one pea cultivar, it is evident that the dehulling process would remove considerable amounts of important nutrients such as protein, calcium, iron, and zinc. Additional efforts would be useful to study nutrient losses as a result of dehulling chickpea by commerical dhal mills. Further efforts may be made to minimize dehulling losses by developing a suitable methodology and machines for this purpose.

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