Food Chemistry 50 (1994) 125–131

0308-8146/94/$7.00

ELSEVIER

Effect of cooking and decortication on the physical properties, the chemical composition and the nutritive value of chickpea (*Cicer arietinum* L.)

R. S. Attia, A. M. El-Tabey Shehata,* M. E. Aman & M. A. Hamza

Department of Food Science and Technology, Faculty of Agriculture, University of Alexandria, Alexandria, El-Chatby 21526, Egypt

(Received 2 June 1993; revised version received and accepted 31 August 1993)

The whole dry seeds of two chickpea cultivars were studied before and after cooking and before and after decortication. Differences between cultivars were less pronounced than those due to cultivation in different agroclimatic regions. Decortication caused considerable losses in dietary fibre components, Ca, Zn, Mg, K, polyphenols and ash contents. Significant increases in reducing sugars, crude protein, ether extract and starch contents and in-vitro protein digestibility were noticed. Decortication made no significant changes in phytic acid content or trypsin inhibitor activity. Significant and marked losses in ash (34–40%), sugar (32–42%), oligosaccharide (30–34%), mineral and antinutritional factor contents occurred upon cooking the seeds. Losses in minerals varied from 6·3 to 50·6 depending upon the element, the cultivar and the growing region. Percentage losses in phytic acid, polyphenols and trypsin inhibitor activity were in the ranges 24–34·5%, 58·7–62·2% and 53·6–59·9%, respectively. However, significant increases in dietary fibre components (8–20%) and in-vitro protein digestibility (10%) were observed.

INTRODUCTION

Chickpea is one of the oldest and most widely grown legumes in the Middle and Far East. Kabuli chickpeas, with large and beige-coloured seeds, are grown mainly in the Mediterranean region and in the Americas (Singh *et al.*, 1990). Legumes are a rich source of protein, carbohydrate, dietary fibre, some vitamins and minerals. Legumes are low in fat and sodium; they have no cholesterol, but contain good amounts of oligosaccharides and antinutritional substances. The use of legumes as part of the dietary treatment of various illnesses has been proposed (Gupta, 1983; Hughes, 1991; Morrow, 1991). Chickpeas are consumed as whole or decorticated seeds which are cooked and processed in a variety of ways. The meal or the flour of decorticated seeds is used in several dishes and as a supplement in weaning food mixes, bread, biscuits and other products (Van Der Maesen, 1972).

The proximate composition and certain mineral contents of whole and decorticated chickpea seeds were reviewed by Williams and Singh (1987). The effects of decortication on the concentration of the oligosaccharides, dietary fibre components, several minerals and antinutritional factors (ANF) have not been reported in the literature. The effect of cooking on the following constituents of chickpea seeds has been reported: oligosaccharides (Rao & Belavady, 1978), available carbohydrates (Jood *et al.*, 1986), dietary fibre components (Vidal-Valverde & Frias, 1991) and protein quality and (ANF) (Gupta, 1983; Williams & Singh, 1987; Duhan *et al.*, 1989).

The chemical composition and the nutritive value of legumes are affected by environmental factors, agronomic practices and methods of processing (Gupta, 1983; Singh, 1985). Mineral contents in raw legumes differed markedly in different countries (Meiners *et al.*, 1976). The present investigation describes the effect of decortication and cooking on the physical properties, the chemical composition and the nutritive value of the two cultivars of chickpea which are cultivated in Egypt.

MATERIALS AND METHODS

Materials

Samples of dry chickpea seeds of two kabuli cultivars, namely Giza 1 and Giza 2, were collected directly from farms after harvesting. Giza 1 was cultivated only in Lower (northern) Egypt, while Giza 2 was grown in Lower and Upper (southern) Egypt. Therefore, two

* To whom correspondence should be addressed.

samples of Giza 2 were obtained, Giza 2-L (from a farm in lower Egypt) and Giza 2-U (from a farm in Upper Egypt).

Processing

The clean, dry seeds were decorticated by abrasion using a PRL mini-dehuller (National Research Council, Canada). A sample of 500 g was dehulled for 45 s for Giza 1 and for 30 s for Giza 2 which was relatively smaller seeds. The clean, dry whole seeds were cooked by boiling in tap water until soft. The cooked seeds were drained and mashed in a blender before drying at 50°C. The dry seeds, the dry decorticated seeds and the dried mashed cooked seeds were ground in an electric mill.

Physical properties

The weight of 100 seeds was determined, while the volume of 100 seeds was measured by absolute displacement using distilled water. Apparent density was calculated. Hydration coefficient (HC) and swelling coefficient (SC) were determined by soaking 50 g of seeds in 150 ml distilled water. The weight and the volume of soaked seeds were estimated at definite intervals (1–16 h). The HC is calculated as the percentage increase in the weight of seeds, while SC is calculated as the percentage increase in the volume of seeds. The percentage of seed coat was calculated by manually decorticating 100 seeds. The seed size distribution was carried out by sieving 200 g of sample using sieves of decreasing pore size (10–5 mm in diameter).

Chemical analysis

A part of each of the milled samples was defatted with petroleum ether before using for certain analyses. The moisture (14·004), crude protein (N × 6·25, 2·057), fat (7·056) and ash (14·006) were estimated following the procedures described by AOAC (1980). Reducing sugars were determined after extracting the meal with hot 80% ethanol using the Somogyi–Nelson method as described by Plummer (1978). Partition paper chromatography (Singh & Jambunathan, 1982) was used for separating oligosaccharides whose concentrations were estimated colorimetrically using the phenol–sulphuric acid method (Dubois *et al.*, 1956). Starch content was determined by the direct acid hydrolysis method followed by glucose determination by the Lane and Eynon method (AOAC, 1980; method 31.036) using 0·9 as a conversion factor. Mineral analysis was done by dry ashing followed by the determination of Ca, Cu, Fe, Mg, Mn and Zn with an atomic absorption spectrophotometer (Perkin Elmer 2380, Perkin Elmer Ltd, USA). A flame photometer (Gallenkamp Flame Analyser, FGA 330) was used for the determination of Na and K. Total phosphorus was assayed colorimetrically at 630 nm using a Spekol spectrophotometer (Carl Zeiss, Jena 32-G34). The method of Goering and Van Soest (1970) as modified by Baker (1977) to remove starch by α-amylase (Fungamyl, FAU/800, Novo Industries, Denmark) was used to determine neutral detergent fibre (NDF), acid detergent fibre (ADF), cellulose (CL) and lignin (LN). Insoluble hemicellulose (HCL) was calculated by difference. Pepsin (hog stomach mucosa, Koch Light Laboratories, UK) and pancreatin (hog pancrease, Koch Light Laboratories, UK) digestion procedures, as described by Akeson and Stahman (1964), were used to determine in-vitro protein digestibility. The caseinolytic procedure (Kakade *et al.*, 1969) was used to estimate the trypsin inhibitor activity (TIA). One trypsin unit is equivalent to an increase of 0·01 absorbance unit at 280 nm in 20 min/10 ml of the reaction mixture. The Wheeler and Ferrel (1971) method was followed to estimate phytic acid content. Polyphenolic compounds were determined according to the method of Singh and Jambunathan (1981). These compounds were estimated as tannic acid equivalents according to the Folin–Denis procedure as described by Swain and Hills (1959).

Statistical analysis

Results are expressed as the mean values ± standard deviation (SD) of three separate determinations, except for the mineral contents which were determined in duplicate. Data were subjected to analysis of variance using a completely randomised design. Differences between any two means were determined using LSD with a $P < 0{\cdot}01$ significance level (Steel & Torrie, 1980). Data concerning the effect of treatment on the physical properties were analysed by a *t*-test (paired) as described by Steel and Torrie (1980).

RESULTS AND DISCUSSION

Physical properties

The properties of the dry and the cooked seeds were affected by the cultivar and the growing location.

Table 1. Physical properties of dry and cooked seeds of chickpea cultivars[a]

Cultivar/seed	100 Seed weight (g)	100 Seed volume (ml)	Seed coat (%)	Apparent density (g/ml)
Giza 1				
Whole, dry	29·3b ± 0·6	22·7b ± 0·6	6·7b ± 0·04	1·292a ± 0·020
Cooked	68·1a ± 0·1	62·0a ± 0·0	14·4a ± 0·40	1·098b ± 0·002
Giza 2-L[b]				
Whole, dry	21·4b ± 1·6	16·7b ± 1·2	6·8b ± 0·04	1·284a ± 0·005
Cooked	48·5a ± 0·1	41·8a ± 0·3	12·7a ± 0·25	1·159b ± 0·008
Giza 2-U[c]				
Whole, dry	14·6b ± 0·14	11·2b ± 0·03	9·6b ± 0·04	1·305a ± 0·020
Cooked	30·1a ± 0·15	26·0a ± 0·0	18·3a ± 0·12	1·157b ± 0·006

[a] Means in the same column with different following letters for each cultivar are significantly different ($P < 0{\cdot}01$).
[b] Grown in Lower Egypt (cool climate).
[c] Grown in Upper Egypt (hot and dry climate).

Table 2. Effect of decortication and cooking on the hydration coefficient (HC) and swelling coefficient (SC) of chickpea cultivars[a]

Cultivar/seed	HC			SC		
	Soaked for 4 h	Soaked for 12 h	After cooking	Soaked for 4 h	Soaked for 12 h	After cooking
Giza 1						
Whole, dry	209a ± 1·2	224a ± 0·4	231 ± 0·3	244a ± 5·2	256a ± 2·5	268 ± 1·7
Decorticated	163b ± 0·8	192b ± 0·2	—	201b ± 5·4	237a ± 5·7	—
Giza 2-L[b]						
Whole, dry	195a ± 0·8	215a ± 1·1	225 ± 0·7	231a ± 1·6	248a ± 1·4	254 ± 1·2
Decorticated	164b ± 1·7	192b ± 0·4	—	192b ± 2·6	226a ± 7·5	—
Giza 2-U[c]						
Whole, dry	186a ± 0·4	216a ± 0·8	230 ± 0·1	250a ± 3·7	259a ± 3·6	274 ± 0·7
Decorticated	177b ± 1·4	193b ± 1·4	—	205b ± 4·9	243a ± 4·8	—

[a] Means in the same column with different following letters for each cultivar are significantly different ($P < 0{\cdot}01$).
[b] Grown in Lower Egypt (cool climate).
[c] Grown in Upper Egypt (hot and dry climate).

The whole dry seeds of Giza 1 were large (88·2% of the seeds were over 6 mm and less than 10 mm in diameter), while those of Giza 2-L (i.e. grown in Lower Egypt) were of medium size (85% of the seeds were over 5 mm and less than 7 mm in diameter). Giza 2-U (i.e. grown in Upper Egypt) had very small seeds (100% of the seeds were less than 6 mm in diameter). These results are reflected in the weight, volume and apparent density of the seeds as well as in the seed coat percentage (Table 1). Differences among the cooked samples were more or less similar to those among the whole dry seeds.

The rates of hydration and swelling were high during the first 4 h of soaking and approached zero after 12 h. The HC and SC after soaking for 4 and 12 h are shown in Table 2. The whole seeds of Giza 1 had higher HC than those of Giza 2 cultivar. However, Giza 2-U had the highest SC, whether for whole dry, decorticated or cooked seeds. Contrary to reports that the seed coat may act as a barrier for water migration (Rolston, 1978), the decorticated seeds of chickpea cultivars had a significantly lower HC than did the whole seeds. This may be due to the higher fibre content of the seed coat (see Table 5 below). Singh (1984) reported a high pectin content (8·8%) in the seed coat as compared to that of the whole chickpea seeds (3·3%).

Nutrient content

Tables 3–6 show the effects of cultivar and environmental conditions on the chemical constituents of whole dry seeds. Variation between the two cultivars that were grown in the same region (Giza 1 and Giza 2-L) were relatively slight as compared with variation due to agroclimatic regions (Giza 2-L and Giza 2-U). The whole dry seeds of Giza 2-U had appreciably higher ether extract, dietary fibre components, Ca, P and markedly lower contents of ash, sugars, starch, K and Mg than those of Giza 2-L. Dodd and Pushpamma (1980) reported that the effect of location

Table 3. Effect of decortication and cooking of the proximate composition of chickpea cultivars[a]

Cultivar/seed	g per 100 g on a dry weight basis			Moisture (%)
	Crude protein (N × 6·25)	Ether extract	Ash	
Giza 1				
Whole, dry	20·7b ± 0·10	6·41b ± 0·13	3·96a ± 0·03	11·41b ± 0·07
Decorticated	21·4a ± 0·12	6·77a ± 0·08	3·54b ± 0·01	10·61c ± 0·05
Cooked	20·3c ± 0·06	6·48c ± 0·06	2·35c ± 0·01	64·70a ± 0·20
Giza 2-L[b]				
Whole, dry	23·3b ± 0·13	6·23b ± 0·05	3·47a ± 0·01	9·64c ± 0·04
Decorticated	24·6a ± 0·06	6·56a ± 0·07	3·25b ± 0·01	10·28b ± 0·04
Cooked	23·0b ± 0·11	6·40ab ± 0·07	2·18c ± 0·00	63·85a ± 0·09
Giza 2-U[c]				
Whole, dry	23·4b ± 0·51	6·69a ± 0·07	2·64a ± 0·02	9·50b ± 0·08
Decorticated	24·7a ± 0·33	6·73a ± 0·16	2·41b ± 0·03	9·45b ± 0·10
Cooked	22·3c ± 0·21	6·72a ± 0·11	1·73c ± 0·01	64·73a ± 0·13

[a] Means in the same column with different following letters for each cultivar are significantly different ($P < 0{\cdot}01$).
[b] Grown in Lower Egypt (cool climate).
[c] Grown in Upper Egypt (hot and dry climate).

Table 4. Effect of decortication and cooking on sugars and oligosaccharides of chickpea cultivars[a] (g per 100 g on a dry weight basis)

Cultivar/seed	Reducing sugars	Non-reducing sugars	Sucrose	Raffinose	Stachyose and verbascose
Giza 1					
Whole, dry	0·48b ± 0·01	8·20a ± 0·06	2·04a ± 0·09	1·69a ± 0·05	2·68a ± 0·07
Decorticated	0·56a ± 0·01	8·21a ± 0·07	2·11a ± 0·07	1·76a ± 0·07	2·76a ± 0·06
Cooked	0·27c ± 0·01	5·24b ± 0·16	1·39b ± 0·08	1·14b ± 0·02	1·79b ± 0·06
Giza 2-L[b]					
Whole, dry	0·52b ± 0·01	7·78b ± 0·05	2·01a ± 0·10	1·67a ± 0·05	2·52a ± 0·07
Decorticated	0·64a ± 0·01	8·12a ± 0·16	2·14a ± 0·05	1·75a ± 0·05	2·72a ± 0·08
Cooked	0·30c ± 0·01	4·90c ± 0·08	1·26b ± 0·04	1·11b ± 0·10	1·80b ± 0·10
Giza 2-U[c]					
Whole, dry	0·44b ± 0·02	7·34a ± 0·11	1·92a ± 0·06	1·58a ± 0·02	2·47a ± 0·06
Decorticated	0·47a ± 0·01	7·51a ± 0·15	1·95a ± 0·04	1·65a ± 0·03	2·54a ± 0·03
Cooked	0·27c ± 0·01	4·65b ± 0·15	1·17b ± 0·04	1·04b ± 0·07	1·63b ± 0·04

[a] Means in the same column with different following letters for each cultivar are significantly different ($P < 0{\cdot}01$).
[b] Grown in Lower Egypt (cool climate).
[c] Grown in Upper Egypt (hot and dry climate).

Table 5. Effect of decortication and cooking on starch and dietary fiber components of chickpea cultivars[a] (g per 100 g on a dry weight basis)

Cultivar/seeds	Starch	Dietary fibre components[b]				
		NDF	ADF	HCL	CL	LN
Giza 1						
Whole, dry	43·13b ± 0·31	11·20b ± 0·21	5·32b ± 0·07	5·88a ± 0·19	3·58b ± 0·06	1·65b ± 0·011
Decorticated	44·78a ± 0·49	3·52c ± 0·13	1·80c ± 0·11	1·72b ± 0·17	1·24c ± 0·07	0·53c ± 0·10
Cooked	40·80c ± 0·50	12·12a ± 0·23	6·21a ± 0·03	5·91a ± 0·23	4·13a ± 0·09	1·98a ± 0·14
Giza 2-L[c]						
Whole, dry	47·97b ± 0·38	11·73b ± 0·08	5·61b ± 0·06	6·12a ± 0·11	3·65b ± 0·07	1·78a ± 0·06
Decorticated	54·11a ± 0·43	3·56c ± 0·10	1·75c ± 0·12	1·81b ± 0·23	1·18c ± 0·07	0·49b ± 0·08
Cooked	46·13c ± 0·25	12·08a ± 0·07	6·22a ± 0·08	5·86a ± 0·03	4·20a ± 0·05	1·94a ± 0·10
Giza 2-U[d]						
Whole, dry	43·67b ± 0·29	15·51b ± 0·12	7·20b ± 0·07	8·31a ± 0·15	4·89b ± 0·08	2·15b ± 0·05
Decorticated	47·24a ± 0·32	3·72c ± 0·07	1·78c ± 0·13	1·94b ± 0·06	1·15c ± 0·05	0·56c ± 0·09
Cooked	40·52c ± 0·44	16·80a ± 0·16	8·52a ± 0·10	8·28a ± 0·14	5·83a ± 0·11	2·60a ± 0·09

[a] Means in the same column with different following letters for each cultivar are significantly different ($P < 0{\cdot}01$).
[b] NDF, neutral detergent fibre; ADF, acid detergent fibre; HCL, hemicellulose; CL, cellulose; LN, Ligin.
[c] Grown in Lower Egypt (cool climate).
[d] Grown in Upper Egypt (hot and dry climate).

Table 6. Effect of decortication and cooking on the mineral composition of chickpea cultivars[a] (mg per 100 g on a dry weight basis)

Cultivar/seed	Macroelements					Microelements			
	K	Ca	P	Mg	Na	Fe	Zn	Mn	Cu
Giza 1									
Whole, dry	1 264	213	202	173	108	6·42	3·86	2·10	1·04
Decorticated	1 157	43	210	158	103	6·15	2·14	1·83	0·93
Cooked	638	165	188	146	90	5·27	3·27	1·93	0·91
Giza 2-L[b]									
Whole, dry	1 185	221	223	195	95	7·51	4·11	2·65	0·97
Decorticated	1 062	41	259	136	91	7·26	2·61	2·41	0·92
Cooked	613	178	208	173	83	6·68	3·85	2·37	0·89
Giza 2-U[c]									
Whole, dry	1 132	272	256	165	93	7·10	4·42	2·38	1·08
Decorticated	1 038	76	275	131	86	6·92	3·16	1·92	0·94
Cooked	559	223	227	154	82	6·54	3·53	2·14	0·91

[a] Means of duplicates.
[b] Grown in Lower Egypt (cool climate).
[c] Grown in Upper Egypt (hot and dry climate).

was more pronounced than that of the variety on several nutrient contents of chickpeas. The concentration of the main constituents (protein, fat, ash, starch and certain minerals) agree well with the mean values given by Williams and Singh (1987) except that the Zn content was higher in the studied cultivars.

Effect of decortication

Despite the variations which were noticed among the cultivars and between growing locations, decortication showed the following trends (Tables 3–6).

(1) Significant increases in crude protein, ether extract, reducing sugars, starch and P; similar trends were obtained by Jambunathan and Singh (1980) and Verma *et al.* (1964).
(2) Appreciably significant decreases in ash, dietary fibre components, Ca, Mg, Zn and K.

Jambunathan and Singh (1981), Rao and Deosthale (1981) and Singh (1984) reported similar trends but different values. The percentage increase or decrease in the chemical constituents of the chickpea seeds caused by decortication is summarised in Table 7. Decortication significantly improved the in-vitro protein digestibility and reduced the polyphenols contents, but had no significant effect on the TIA and the phytic acid content (Table 8). Losses due to decortication were reported to be 10·5% in phytic acid (Hussain *et al.*, 1989), 8·7% in TIA and 5·5% in polyphenols (Singh & Jambunathan, 1981).

Effect of cooking

Cooking whole dry seeds of chickpea caused the following changes (Tables 3–6): significant decreases in protein and starch; significant and great losses in ash, reducing and non-reducing sugars, and oliosaccharides; noticeable reductions in mineral contents, especially in K and Ca contents; significant and large increases in NDF, ADF and CL. Similar trends but different values were reported for minerals (Meiners *et al.*, 1976), and dietary fibre components (Vidal-Valverde & Frias, 1991). A significant increase (100%) occurred in oligosaccharide content upon cooking (Rao & Belavady, 1978; Jood *et al.*, 1988). Such contradicting results may be due to different methods of cooking,

Table 7. Increase (+) or decrease (–) in the chemical and nutrient constituents of chickpea cultivars due to decortication (as a percentage of whole, dry seeds)

		Chickpea cultivars		
		Giza 1	Giza 2-L	Giza 2-U
Crude protein	+	3·0	5·5	5·4
Ether extract	+	5·6	5·3	0·59
Reducing sugars	+	16·6	23·0	6·8
Phosphorus	+	3·9	16·1	7·4
In-vitro protein digestibility	+	3·2	1·8	2·5
Starch	+	3·8	12·8	8·2
Ash	–	10·6	6·4	8·7
Dietary fibre				
NDF	–	31·1	30·3	24·0
ADF	–	33·8	31·2	24·7
HCL	–	29·2	29·6	23·3
CL	–	34·6	32·3	23·5
LN	–	32·1	27·5	26·0
Minerals				
K	–	8·5	10·4	8·4
Ca	–	79·8	81·5	72·1
Mg	–	8·7	30·3	20·6
Na	–	4·6	4·2	7·6
Fe	–	4·2	3·3	3·5
Zn	–	44·6	36·5	28·5
Mn	–	12·9	9·1	19·3
Cu	–	10·6	5·2	13·0

Table 8. Effect of decortication and cooking on the protein digestibility and antinutritional factors of chickpea cultivars[a] (on a dry weight basis)

Cultivar/seed	In-vitro protein digestibility (%)	Trypsin inhibitor (U/mg sample)	Phytic acid (%)	Polyphenols (mg/g sample)
Giza 1				
Whole, dry	71·0c ± 0·22	8·11a ± 0·15	1·00a ± 0·07	3·24a ± 0·02
Decorticated	73·3b ± 0·34	8·61a ± 0·09	1·01a ± 0·05	2·89b ± 0·04
Cooked	77·5a ± 0·33	3·76b ± 0·19	0·76b ± 0·04	1·34c ± 0·05
Giza 2-L[b]				
Whole, dry	68·7c ± 0·41	9·64a ± 0·18	0·84a ± 0·06	3·34a ± 0·03
Decorticated	69·9b ± 0·35	9·90a ± 0·14	0·81a ± 0·07	2·89b ± 0·06
Cooked	76·4a ± 0·19	4·42b ± 0·15	0·59b ± 0·11	1·37c ± 0·05
Giza 2-u[c]				
Whole, dry	69·5c ± 0·24	9·77a ± 0·11	0·58a ± 0·08	3·58a ± 0·02
Decorticated	71·2b ± 0·35	10·15a ± 0·09	0·64a ± 0·06	3·01b ± 0·03
Cooked	76·8a ± 0·32	3·92b ± 0·22	0·38b ± 0·03	1·34c ± 0·03

[a] Means in the same column with different following letters for each cultivar are significantly different ($P < 0·01$).
[b] Grown in Lower Egypt (cool climate).
[c] Grown in Upper Egypt (hot and dry climate).

Table 9. Losses in the chemical constituents of chickpea cultivars due to cooking (as percentage of the whole dry seeds)

Constituents	Chickpea cultivars		
	Giza 1	Giza 2-L	Giza 2-U
Crude protein (N × 6·25)	2·3	1·3	4·1
Ash	40·7	37·2	34·5
Reducing sugars	43·8	42·3	38·6
Non-reducing sugars	36·1	37·0	36·7
Sucrose	31·9	37·3	39·1
Raffinose	32·6	33·5	34·2
Stachyose and verbascose	33·2	30·3	34·0
Starch	5·4	3·8	7·2
Minerals			
K	49·5	48·3	50·6
Ca	32·5	19·5	12·0
P	7·0	6·3	11·3
Mg	15·6	11·3	6·4
Na	16·4	12·6	11·8
Fe	17·9	11·1	7·9
Zn	15·3	6·3	20·1
Mn	8·1	10·6	10·1
Cu	12·5	8·3	15·8

and to the removal of the cooking liquid from the cooked seeds. The main quantitative effects of cooking on the changes in the chemical constituents of seeds are summarised in Table 9. Cooking significantly improved the protein digestibility (9·9–11·8%) and considerably reduced the TIA (53·6–59·9%), the phytic acid (24·0–34·5%) and the polyphenol contents (58·7–62·6%) (Table 7). Losses of 40–46% in TIA (Sotelo *et al.*, 1987), 20–26% in phytic acid content (Gad *et al.*, 1982; Khan *et al.*, 1988; Duhan *et al.*, 1989) and about 70% in tannin content (Rao & Deosthale, 1982) occurred upon cooking chickpeas.

This study reveals that simple processing (e.g. decortication or cooking) of chickpea seeds tends to modify their physical properties, chemical composition, nutrients and ANF contents. While decortication markedly reduced the dietary fibre and calcium contents, cooking caused considerable losses in minerals, TIA and phytic acid and a slight increase in dietary fibre components. Losses during normal cooking can be controlled by the amount of cooking water and its drainage. The data obtained will be useful for ascertaining the possible potential utilisation of the decorticated and cooked seeds.

REFERENCES

Akeson, W. R. & Stahman, M. A. (1964). A pepsin pancreatin digest index of proteins. *J. Nutr.*, **83**, 257–61.

AOAC (1980). *Official Methods of Analysis.* Association of Official Analytical Chemists, Washington, DC, USA.

Baker, D. (1977). Determining fiber in cereals. *Cereal Chem.*, **54**, 360–5.

Dodd, N. K. & Pushpamma, P. (1980). Effect of location and varieties on protein, amino acids and mineral contents of chickpea. *Indian J. Agric. Sci.*, **50**, 139–44.

Dubois, M., Gilles, K. A., Hamilton, J. K., Rebers, P. A. & Smith, F. (1956). A colorimetric method for determination of sugars and related substances. *Anal. Chem.*, **28**, 350–6.

Duhan, A., Chauhan, B. M., Punia, D. & Kapoor, A. C. (1989). Phytic acid content of chickpea (*Cicer arietinum*) and black gram (*Vigna mungo*): varietal differences and effect of domestic processing and cooking methods. *J. Sci. Food Agric.*, **49**, 449–55.

Gad, S. S., Mohamed, M. S., El-Zalaki, E. M. & Mohasseb, Z. (1982). Effect of processing on phosphorus and phytic acid contents of some Egyptian varieties of legumes. *Food Chem.*, **8**, 11–19.

Goering, H. K. & Van Soest, P. J. (1970). *Fiber Analysis (Apparatus, Reagents, Procedures and Some Applications)* (Agric Handbook, 379). USDA, Washington, DC, USA.

Gupta, Y. P. (1983). Nutritive value of food legumes. In *Chemistry and Biochemistry of Legumes*, ed. S. K. Arora. Edward Arnold, London, UK, pp. 287–327.

Hughes, J. S. (1991). Potential contribution of dry bean dietary fiber to health. *Food Technol.*, **45**(9), 122, 124–6.

Hussain, B., Khan, S., Ismail, M. & Statter, A. (1989). Effect of roasting and autoclaving on phytic acid content of chickpea. *Nahrung*, **33**, 343–8.

Jambunathan, R. & Singh, U. (1980). Studies on Desi and Kabuli chickpea (*Cicer arietinum* L.) cultivars 1. Chemical composition. In *Proc. International Workshop on Chickpea Improvement*, ICRISAT, Hyderabad, A. P., India, pp. 61–6.

Jambunathan, R. & Singh, U. (1981). Studies on Desi and Kabuli chickpea (*Cicer arietinum* L.) cultivars 3. Minerals and trace element composition. *J. Agric. Food Chem.*, **29**, 1091–3.

Jood, S., Mehta, U. & Singh, R. (1986). Effect of processing on available carbohydrates in legumes. *J. Agric. Food Chem.*, **34**, 417–20.

Jood, S., Chauhan, B. M. & Kapoor, A. C. (1988). Contents and digestibility of carbohydrates of chickpea and black gram as affected by domestic processing and cooking. *Food Chem.*, **30**, 113–27.

Kakade, M. L., Simons, N. & Liener, I. E. (1969). An evaluation of natural vs synthetic substrates for measuring the antitryptic activity of soyabean samples. *Cereal Chem.*, **46**, 518–26.

Khan, N., Zaman, R. & Elahi, M. (1988). Effect of processing on the phytic acid content of bengal gram (*Cicer arietinum*) products. *J. Agric. Food Chem.*, **36**, 1274–6.

Meiners, C. R., Derise, N. L., Lau, H. C., Crew, M. G. & Ritchey, S. J. (1976). The content of nine mineral elements in raw and cooked mature dry legumes. *J. Agric. Food Chem.*, **29**, 1126–30.

Morrow, B. (1991). The rebirth of legumes. *Food Technol.*, **45**(9), 96, 121.

Plummer, D. T. (1978). *An Introduction to Practical Biochemistry.* McGraw-Hill Book Co., UK, pp. 184–5.

Rao, P. U. & Belavady, B. (1978). Oligosaccharides in pulses: varietal differences and effect of cooking and germination. *J. Agric. Food Chem.*, **26**, 316–19.

Rao, D. S. S. & Deosthale, Y. G. (1981). Mineral composition of four Indian food legumes. *J. Food Sci.*, **46**, 1962–3.

Rao, P. U. & Deosthale, Y. G. (1982). Tannin content of pulses: Varietal differences and effect of germination and cooking. *J. Sci. Food Agric.*, **33**, 1013–16.

Rolston, M. P. (1978). Water impermeable seed dormancy. *The Bot. Rev.*, **44**, 365–96.

Singh, K. B., Williams, P. C. & Nakkoul, H. (1990). Influence of growing season, location and planting time on some quality parameters of kabuli chickpea. *J. Sci. Food Agric.*, **53**, 429–41.

Singh, U. (1984). Dietary fiber and its constituents in desi and kabuli chickpea (*Cicer arietinum* L.) cultivars. *Nutrit. Rep. Int.*, **29**, 419–26.

Singh, U. (1985). Nutritional quality of chickpea (*Cicer arietinum* L.). Current status and future research needs. *Qual. Plant Food Hum. Nutr.*, **35**, 339–51.

Singh, U. & Jambunathan, R. (1981). Studies on Desi and Kabuli chickpea (*Cicer arietinum* L.) cultivars. Level of protease inhibitors, level of polyphenolic components and in-vitro protein digestibility. *J. Food Sci.*, **46**, 1364–7.

Singh, U. & Jambunathan, R. (1982). Changes in starch, oligosaccharides and soluble sugars in developing pod wall and seed of chickpea. *Phytochemistry*, **21**, 297–9.

Sotelo, A., Flores, F. & Hernandez, M. (1987). Chemical composition and nutritional value of Mexican varieties of chickpea (*Cicer arietinum* L.). *Plant Foods For Hum. Nutr.*, **37**, 299–306.

Steel, R. G. D. & Torrie, J. H. (1980). *Principles and Procedures of Statistics. A Biometrical Approach.* McGraw-Hill Book Co., New York, USA.

Swain, T. & Hills, W. E. (1959). The phenolic constituents of *Prumus domestica* 1. The quantitative analysis of phenolic constituents. *J. Sci. Food Agric.*, **10**, 63–68.

Van Der Maesen, L. J. G. (1972). *Cicer L. A Monograph of the Genus with Special References to the Chickpea* (Cicer arietinum L.), *Its Ecology and Cultivation.* Meded Landbouwhogeschool, Wageningen, The Netherlands, pp. 275–91.

Verma, S. C., Lal, B. M. & Parkash, V. (1964). Changes in the chemical composition of the seed parts during ripening of bengal gram (*Cicer arietinum* L) seed. *J. Sci Food Agric.*, **15**, 25–31.

Vidal-Valverde, C. & Frias, J. (1991). Legume processing effects on dietary fiber components. *J. Food Sci.*, **56**, 1350–2.

Wheeler, E. L. & Ferrel, R. E. (1971). A method for phytic acid determination in wheat and wheat fractions. *Cereal Chem.*, **48**, 312–20.

Williams, P. C. & Singh, U. (1987). The chickpea: Nutritional quality and the evaluation of quality in breeding programmes. In *The Chickpea*, ed. M. C. Saxena & K. B. Singh. CAB International, Wallingford, Oxon, UK, pp. 329–56.