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Nutritional evaluation of desi and kabuli chickpeas and their products commonly consumed in Pakistan

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Physicochemical and nutritional quality of five improved cultivars of desi and kabuli chickpeas and their products were studied. The kabuli chickpea had larger seed (26 g/100 seeds) than desi type (21 g/100 seeds). The hydration capacity per seed of desi (0.16 g) was lower than kabuli type (0.26 g). A positive correlation ($r = 0.87$) between seed weight and hydration capacity was observed. The mean cooking time of dry desi vs kabuli seed (124.5 vs 113.8 min) was reduced to 37.5 vs 32.8 min and to 28.8 vs 22.5 min when soaked overnight in water and in 0.5% solution of sodium bicarbonate respectively. The mean value of protein (25.4 vs 24.4%), fat (3.7 vs 5.1%), carbohydrate (47.4 vs 55%), crude fibre (11.2 vs 3.9%), ash (3.2 vs 2.8%) and caloric value (327 vs 365 kcal/100 g) were for desi vs kabuli chickpeas respectively. There was no difference in the essential amino acid contents and in chemical scores of desi (65) and kabuli (67) chickpeas. The order of limiting amino acid was methionine + cystine, threonine and valine in both types. The chickpeas products contained 8.9–21.1% protein (N × 6.25), 3.1–21.8% fat, 53.4–75.9% carbohydrate, 1.6–11.1% crude fibre, 1.2–5.9% ash, 226–360 mg Ca, 126–315 mg P, 3.8-8.2 mg Fe, 1.8–5.4 mg Zn, 1.5–5.4 mg Mn, 0.6–1.1 mg Cu and 370–490 kcal per 100 g. All chickpea products provided 7–23%, 7–40% and 52–78% of the total calories from protein, fat and carbohydrates respectively. The nutritional quality of all products except Halwa was adequate to meet the protein requirements of all age groups when compared with reference protein energy ratios.

Introduction

Despite the nutritional importance of legumes in the diet of 700 million people in the world, lack of availability, consequent high price and certain antinutritonal factors reduce the frequency of their consumption in developing countries (Elias & Bressani, 1974; Khan & Ghafoor, 1978; Khan, 1987). The nutritional contribution of legumes to the diet could be raised by increasing yields and by improving the quality and quantity of seed protein and their food use qualities (Khan *et al.*, 1979, 1987; Khan, 1991a).

In Pakistan, cereals constitute the bulk of the average diet (Khan, 1989). They are known to be limited in the amino acid lysine content (Khan & Eggum, 1978a; Khan, 1981). In contrast, legumes are a rich source of lysine but are limited in sulphur amino acids (Khan *et al.*, 1979; Khan, 1980). Combinations of cereals and legumes have been reported to meet the

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protein requirement of various age groups in the population (Khan *et al*., 1976, 1977, 1979; Khan & Eggum 1978b; Khan & Eggum, 1979a).

The per capita consumption of legumes in Pakistan is 15.7 kg per annum (National Nutrition Survey, 1988). Desi and kabuli chickpeas (Bengal gram) are the main legumes used in many forms from fresh green seed to dried whole seed, dhal and flour (Khan, 1990). Adequate information on the nutritional quality of these products is not available. The present paper deals with physicochemical characters and nutritional quality of some newly developed cultivars of desi and kabuli chickpeas and some of their products commonly consumed in Pakistan.

Materials and methods

Chickpea samples

Seeds of two desi (CM-1 and CM-72) and three kabuli (ILC-195, ILC-3279 and Cholla) chickpea (*Cicer arietinum*) cultivars were procured

Table 1. Ingredients and Methods of preparation of some Pakistani chickpea products

Product	*Ingredients*		*Method of preparation*
Curry sabat chana	Chickpea whole (kabuli)	200 g	Soak chickpea overnight and boil. Mix with fried onion and spices and cook with some water for 10–30 min. Serve with bread or boiled rice
	Corn oil	30 g	
	Onion	38 g	
	Chilies	3 g	
	Salt	8 g	
	Spices	2 g	
	Water	1000 ml	
Curry dhal chana	Chickpea dhal (desi)	140 g	Soak chickpea dahl overnight, mix with fried onion and spices and cook it with some water for 10–30 min. Serve with bread or boiled rice
	Corn oil	16 g	
	Onion	28 g	
	Chilies	3 g	
	Salt	8 g	
	Spices	2 g	
	Water	500 ml	
Missi roti	Chikpea flour (desi)	100 ml	Make dough by mixing both flours with water add onion chilies and salt. Make into roti by baking (2–3 min) on hot plate (220–250°C). Consume as meal
	Wheat flour	200 g	
	Onion	15 g	
	Chilies	10 g	
	Salt	2 ml	
	Water	200 ml	
Pakoray	Chickpea flour (desi)	200 g	Make thin batter with chickpea flour mix with chopped vegetable and spices. Fry (2–3 min) in oil. Serve as a snack
	Potato	50 g	
	Corn oil	250 g	
	Onion	30 g	
	Chilies	2 g	
	Salt	9 g	
	Water	150 ml	
Chaat	Chickpea whole (kabuli)	200 g	Soak chickpea overnight, boil for 10–30 min, mix with boiled potato, chopped onion, salt and chilies. Consume as a snack
	Potato	50 g	
	Onion	30 g	
	Chilies	1 g	
	Salt	8 g	
Halwa baysen	Chickpea flour (desi)	200 g	Brown the flour in ghee, and add sugar and water cook into thick paste. Serve as sweet dish
	Vegetable ghee	110 g	
	Sugar	150 g	
	Water	100 ml	
Bhunay chanay	Chickpea whole (desi)	200 g	Soak and then roast (puff) in heated sand (240–250°C) for 2–3 min. Dehusk and conume as a snack

from the Food Legume Programme, and their quality parameters were tested in Food Technology and Nutrition Laboratories at the National Agricultural Research Centre, Islamabad, Pakistan.

Physicochemical measurements
Parameters including seed size (weight/100 seeds), hydration capacity (per seed) and cooking time of desi and kabuli chickpeas (dry and soaked overnight with or without 5% sodium bicarbonate solution), were measured according to Williams *et al.* (1982). Seeds were ground in a cyclotec mill to pass a 1.0 mm screen for further analysis.

Selection and preparation of chickpea products
Seven common dishes, prepared from desi (CM-72) and kabuli (Cholla) chickpea commonly consumed in Pakistan were selected for this study. The products were prepared according to the traditional cooking methods and then freeze dried, ground and stored in a deep freeze for further analysis. The ingredients and methods of preparation are given in Table 1.

Chemical analysis
Moisture content was determined by drying a 2 g sample of ground chickpea or chickpea product at 130°C for 70 min, cooled and weighed (Khan *et al.*, 1987). Protein (N $\times$ 5.7 for chickpea variety and N $\times$ 6.25 for chickpea products), crude fat, crude fibre, ash and mineral elements were determined by the official methods (AOAC, 1984). Carbohydrate content was calculated by difference. Gross energy value was calculated by multiplying protein, fat and carbohydrate contents with factors of 4, 9 and 4 respectively. Trace elements were determined by using a Model 400 Perkin-Elmer atomic absorption spectrometer. After hydrolysis of protein (Mattern *et al.*, 1968), the amino acids were determined with Beckman 6300 amino acid analyser (Khan & Eggum, 1979b). All the assays were performed in duplicate. The chemical score was calculated by comparing the essential amino acids of desi and kabuli chickpeas with standard reference amino acids pattern (FAO/WHO, 1973). The data were subjected to statistical analysis, using analysis of variance technique (Steel & Torrie, 1980).

Results and discussion

Physicochemical parameters
The physical and cookability characters of desi and kabuli chickpeas are given in Table 2. The kabuli chickpea varieties had larger seeds (26 g/100 seeds) than desi varieties (21 g/100 seeds) and the difference was statistically significant ($P < 0.05$). The largest seed size of 26.2 g was found in kabuli chickpea (ILC-3279). Similar results have been reported by Jambunathan & Singh (1980) for desi (17.9 g/100 seeds) and kabuli (23.1/100 seeds) chickpea varieties grown in India. Chickpeas varied in size from 20 g/100 seeds for desi type to more than 60 g/100 seeds for the large kabuli type (Williams & Singh, 1987). However, Khan *et al.*, (1987), found no significant difference between the mean seed size of some kabuli

Table 2. Physicochemical characters of desi and kabuli chickpeas

Varieties	*Seed weight (g/100 seeds)*	*Hydration capacity (g/seed)*	*Cooking time (min)*		
			Dry	*Soaked in water*	*Soaked in NaHCO3*
Desi					
CM-1	20.1	0.18	127.0	32.5	29.5
CM-72	21.8	0.15	122.0	42.5	28.0
Mean	21.0	0.16	124.5	37.5	28.8
Kabuli					
ILC-195	25.8	0.25	111.0	31.0	22.5
ILC-3279	26.2	0.27	116.5	34.0	22.5
Mean	26.0	0.26	113.8	32.8	22.5

(22.6 g) and desi (20.9 g) types grown in Pakistan, indicating an improvement in the seed size of some desi chickpeas. Seed size is an important parameter for the selection of genetic material, processing operations and in general, the larger seed is considered of better quality and preferred for consumption and export (Khan, 1991a). The hydration capacity (g/seed) of desi and kabuli types varied from 0.15 to 0.18 g and 0.25 to 0.27 g respectively (Table 2). The difference was statistically significant ($P < 0.05$). Rapid uptake of water is a desirable attribute of legume grain used for food. The rate of penetration of water is affected by seed size, seed hardness and permeability of the seed coat to water (Williams & singh, 1987). In the present study, the hydration capacity was highest in kabuli chickpea (ILC-3279). A highly significant ($P < 0.01$) positive correlation (r = 0.87) between seed weight and hydration capacity of chickpeas was found. The hydration has also been reported to be correlated with cooking time (Williams *et al.*, 1983). Cooking time is one of the important parameters in evaluating the quality of legumes. The cooking process makes hard seed soft by improving the plasticity of the cell wall and gelatinization of the starch. The mean cooking time of dry desi and kabuli chickpeas in the present study were 124.5 and 113.8 min respectively (Table 2) and the difference was statistically significant ($P < 0.05$). Seeds of ILC-195 (kabuli) were the quickest to cook (111.0 min), whereas seeds of CM-1 (desi) took an average of 127.0 min to cook. However, cooking time was reduced significantly when seeds were soaked overnight in water with or without sodium bicarbonate. On average, it took 37.5 and 32.8 min to cook water soaked desi and kabuli chickpeas respectively and the difference was statistically significant ($P < 0.05$). The cooking time of water soaked desi type, CM-1 (32.5 min) was significantly ($P < 0.05$) shorter than CM-72 (42.5 min). The cooking time was further reduced significantly ($P < 0.05$) to 28.8 and 22.5 min for desi and kabuli types respectively, when soaked overnight with 0.5% sodium bicarbonate. The reduction in cooking time was 70 and 76% in desi and 71 and 80% in kabuli by overnight soaking in water and soaking in sodium bicarbonate (0.5%) respectively. Similar results in desi chickpea (Khan *et al.*, 1986) and kabuli types (Williams & Nakoul, 1986) have been reported. A correlation between cooking time and seed weight and hydration capacity has been reported (Williams *et al.*, 1983). In the present study, the smaller seed size and poor hydration capacity resulted in longer cooking time in desi chickpeas. It may be concluded that chickpeas should be soaked overnight with 0.5% sodium bicarbonate before cooking to reduce the cooking time and therefore, the consumption of fuel.

Chemical composition

Table 3 shows the chemical composition of desi and kabuli chickpeas on dry basis. The protein content (N × 5.7) ranged from 24.1 to 26.7% and 23.4 to 25.5% in desi and kabuli

Table 3. Chemical composition (on dry basis) of desi and kabuli chickpeas

Varieties	*Protein (N × 5.7)*	*Fat*	*Carbohydrate*	*Crude fibre*	*Ash*	*Energy (kcal) per 100 g*
	g per 100 g					
Desi						
CM-1	24.1	3.6	49.3	11.4	2.8	324 (1356)
CM-72	26.7	3.8	45.5	10.4	3.6	330 (1381)
Mean	25.4	3.7	47.4	11.2	3.2	327 (1368)
Kabuli						
ILC-195	25.5	5.0	55.0	3.2	2.8	360 (1506)
ILC-3279	23.4	5.2	56.7	4.6	2.8	369 (1544)
MEAN	24.4	5.1	55.8	3.9	2.8	365 (1525)

Figures in parentheses indicate energy values in kilojoules (kJ).

(22.6 g) and desi (20.9 g) types grown in Pakistan, indicating an improvement in the seed size of some desi chickpeas. Seed size is an important parameter for the selection of genetic material, processing operations and in general, the larger seed is considered of better quality and preferred for consumption and export (Khan, 1991a). The hydration capacity (g/seed) of desi and kabuli types varied from 0.15 to 0.18 g and 0.25 to 0.27 g respectively (Table 2). The difference was statistically significant ($P < 0.05$). Rapid uptake of water is a desirable attribute of legume grain used for food. The rate of penetration of water is affected by seed size, seed hardness and permeability of the seed coat to water (Williams & singh, 1987). In the present study, the hydration capacity was highest in kabuli chickpea (ILC-3279). A highly significant ($P < 0.01$) positive correlation ($r = 0.87$) between seed weight and hydration capacity of chickpeas was found. The hydration has also been reported to be correlated with cooking time (Williams *et al.*, 1983). Cooking time is one of the important parameters in evaluating the quality of legumes. The cooking process makes hard seed soft by improving the plasticity of the cell wall and gelatinization of the starch. The mean cooking time of dry desi and kabuli chickpeas in the present study were 124.5 and 113.8 min respectively (Table 2) and the difference was statistically significant ($P < 0.05$). Seeds of ILC-195 (kabuli) were the quickest to cook (111.0 min), whereas seeds of CM-1 (desi) took an average of 127.0 min to cook. However, cooking time was reduced significantly when seeds were soaked overnight in water with or without sodium bicarbonate. On average, it took 37.5 and 32.8 min to cook water soaked desi and kabuli chickpeas respectively and the difference was statistically significant ($P < 0.05$). The cooking time of water soaked desi type, CM-1 (32.5 min) was significantly ($P < 0.05$) shorter than CM-72 (42.5 min). The cooking time was further reduced significantly ($P < 0.05$) to 28.8 and 22.5 min for desi and kabuli types respectively, when soaked overnight with 0.5% sodium bicarbonate. The reduction in cooking time was 70 and 76% in desi and 71 and 80% in kabuli by overnight soaking in water and soaking in sodium bicarbonate (0.5%) respectively. Similar results in desi chickpea (Khan *et al.*, 1986) and kabuli types (Williams & Nakoul, 1986) have been reported. A correlation between cooking time and seed weight and hydration capacity has been reported (Williams *et al.*, 1983). In the present study, the smaller seed size and poor hydration capacity resulted in longer cooking time in desi chickpeas. It may be concluded that chickpeas should be soaked overnight with 0.5% sodium bicarbonate before cooking to reduce the cooking time and therefore, the consumption of fuel.

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Varieties	*Protein (N × 5.7)*	*Fat*	*Carbohydrate*	*Crude fibre*	*Ash*	*Energy (kcal) per 100 g*
	g per 100 g					
Desi						
CM-1	24.1	3.6	49.3	11.4	2.8	324 (1356)
CM-72	26.7	3.8	45.5	10.4	3.6	330 (1381)
Mean	25.4	3.7	47.4	11.2	3.2	327 (1368)
Kabuli						
ILC-195	25.5	5.0	55.0	3.2	2.8	360 (1506)
ILC-3279	23.4	5.2	56.7	4.6	2.8	369 (1544)
MEAN	24.4	5.1	55.8	3.9	2.8	365 (1525)

Figures in parentheses indicate energy values in kilojoules (kJ).

Table 4. Amino acid contents (mg/g protein) and chemical score of desi and kabuli chickpeas

Amino acid	*Desi* *CM-1*	*CM-72*	*Kabuli* *ILC-195*	*ILC-3279*	*FAO/WHO pattern*
Isoleucine	36.0	42.5	35.0	41.6	40.0
Leucine	78.1	82.5	71.5	81.7	70.0
Lysine	61.5	65.5	62.5	68.6	55.0
Methionine	12.0	11.5	12.6	12.2	
Cystine	10.7	11.5	10.9	11.0	
Total sulphur amino acids	22.7	23.0	23.5	23.2	35.0
Phenylalanine	53.6	56.8	49.0	61.0	
Tyrosine	28.9	32.5	27.5	35.0	
Total aromatic amino acids	82.5	89.3	76.5	96.0	60.0
Threonine	34.5	30.0	32.3	31.5	40.0
Valine	40.7	47.2	43.8	42.6	50.0
Chemical score*	65	66	67	66	

* Based on FAO/WHO (1973) scoring pattern.

chickpeas respectively. There was no significant difference between the two types. Similar results in protein contents of desi and kabuli chickpeas grown at different locations in India and Pakistan have been reported (Jambunathan & Singh, 1980; Singh *et al.*, 1981; Khan *et al.*, 1985). Factors that may cause variations in chickpea seed protein quantity and quality included growing environment, agronomic practices, processing and storage conditions (Singh *et al.*, 1974; Kumar *et al.*, 1983; Khan, 1987). The protein content of chickpeas on dry basis, is more than double that of wheat and is higher than that of meat, fish and eggs (Khan, 1987). A negative correlation between yield and protein content (Evans, 1973), between protein content and lysine, methionine + cystine and tryptophan (Khan, 1980) and a positive correlation between protein and lysine content (Bressani & Elias, 1974) was observed. The fat content of desi and kabuli chickpeas varied between 3.6 and 3.8% and between 5.0–5.2% respectively (Table 3). A significant difference ($P < 0.05$) between the two types was observed. The present results do not agree with the findings of Jambunathan & Singh (1980) who found no significant difference between the fat contents of desi (4.1%) and kabuli (4.7%) chickpeas. The hypocholestrolaemic effect of chickpea has been reported by Ghirardi *et al.* (1974) to be due to high content of essential fatty acids in the seed, particularly linoleic and linolenic acid. The carbohydrate contents of desi chickpea were lower (45.5–49.3%) than kabuli chickpea (55.0–56.7%). The difference between the two types was statistically significant ($P < 0.05$). Similar trends in carbohydrate contents in desi and kabuli chickpeas were observed by Jambunathan & Singh (1980) and Neghmana (1989). The bioavailability of carbohydrate is important for nutritive value and the proportion of unavailable carbohydrates in chickpeas was the highest among the pulses (Khan *et al.*, 1979; Kamath & Belavady, 1980). Chickpea was also reported to have the lowest carbohydrate digestibility (Williams & Singh, 1987). The mean value of crude fibre content of desi type was 11.2% while that of kabuli was 3.9% (Table 3) and the difference was significant ($P < 0.05$). The results are in line with the findings of Jambunathan & Singh (1980) and Khan *et al.* (1987). Hypocholestrolaemic effect has also been associated with legume fibre (Bender & Bender, 1982). The ash content was significantly ($P < 0.05$) higher (3.6%) in CM-72 (desi) than CM-1 (desi), ILC-195 and ILC-3279 (kabuli). The caloric values per 100 g were significantly ($P < 0.05$) higher in kabuli chickpeas 360–369 kcal than those of desi types (324-330 kcal). In terms of caloric value and utilization of dietary nutrients, kabuli chickpeas may be preferred for consumption to that of desi chickpea.

Amino acids and protein quality

In addition to the overall level of protein in chickpea seeds, the amino acid content of the protein is very important in determining nutritional quality. The amino acid contents of desi and kabuli chickpeas are given in Table 4. Lysine content (mg/g protein) ranged from 61.5 to 65.5 in desi whereas it varied between 62.5 and 68.6 in kabuli chickpeas. Among all the varieties ILC-3279 (kabuli) had the highest lysine (68.6 mg/g protein). There was no significant difference between methionine + cystine contents of desi and kabuli chickpeas. It appears to be no clear distinction between desi and kabuli varieties based on their amino acid composition. Similar results have been reported by Singh *et al.* (1981).

The chemical score, an index of protein quality was estimated by comparing the essential amino acid contents of desi and kabuli chickpeas with a reference amino acid pattern (FAO/WHO, 1973). It is evident (Table 4) that the most limiting amino acids were methionine and cystine followed by threonine and valine in both types of chickpeas. The results of the present study agree with the findings of Williams & Singh (1987) who found methionine and cystine were the first limiting amino acids in chickpea varieties. A significant correlation ($r = 0.97$) between the total sulphur containing amino acids and biological value has been reported (Khan *et al.*, 1979). The protein of desi and kabuli chickpeas also met the patterns of essential amino acid requirements for preschool child, school child and adult except methionine and cystine for preschool child, as recommended by FAO/WHO (1985).

The chemical scores were estimated to be 65 and 66 for CM-1 and CM-72 and 67 and 66 for ILC-195 and ILC-3279 respectively (Table 4). The protein score has been shown to correlate with the values of protein quality obtained with rat balance experiments (Bender, 1960; Khan & Chaudhry, 1981). The protein scores calculated in the present study were comparable with the biological values (62–69%) of chickpea varieties obtained biologically in nitrogen balance experiments with growing rats (Khan, 1980).

Nutritive value of chickpea products

In Pakistan, both desi and kabuli chickpeas are used in many forms, from green seed to dried whole seed, dhal and flour. Methods of processing used to make traditional chickpea-based products include boiling, roasting, frying and puffing to improve appearance, palatability and bioavailability of nutrients (Khan, 1991a).

The chemical composition (on dry basis) of some products made from desi and kabuli chickpeas is given in Table 5. The protein content (N × 6.25) ranged from 8.9% in Halwa baysen to 21.1% in Bhunay chanay. Similar protein contents of some Pakistani and Saudi dishes based on cereal and legumes have been reported (Khan & Eggum 1978b, 1979a; Al-Jebrin *et al.*, 1985). The highest fat (21.8%) in Halwa baysen and lowest (3.1%) in Missi roti may be due to the quantity of fat added. The carbohydrate content varied from 53.4% in Pakoray to 75.9% in Missi roti. High complex carbohydrates in diet has been reported to improve glucose tolerance of diabetics (Quillin,

Table 5. Chemical composition (dry basis) of some Pakistani chickpea products

Products	*Protein (N × 6.25)*	Fat	*Carbohydrate*	*Crude fibre*	*Ash*	*Energy (kcal/100 g)*	*Ca*	*P*	*Fe*	*Zn*	*Mn*	*Cu*
	g per 100 g						*mg per 100 g*					
Curry sabat chana	17.7	12.6	60.9	4.4	4.4	428 (1790)	360	315	5.3	3.9	2.6	1.1
Curry dhal chana	20.3	12.8	60.9	1.6	4.4	440 (1840)	226	273	3.9	3.3	2.6	0.7
Missi roti	14.6	3.1	75.9	4.1	2.3	389 (1628)	239	284	6.9	4.6	5.4	0.9
Pakoray	17.2	12.4	53.4	11.1	5.9	395 (1653)	239	243	7.2	2.5	2.9	0.8
Chaat	19.3	5.3	68.2	3.9	3.3	398 (1665)	328	279	5.8	3.6	1.6	0.9
Halwa baysen	8.9	21.8	63.7	4.4	1.2	490 (2050)	247	126	3.8	1.8	1.5	0.6
Bhunay chanay	21.1	5.0	60.3	10.6	3.0	370 (1548)	268	264	8.2	5.4	2.6	1.1

Figures in parenthesis indicate energy value in kilojoules (kJ).

Table 6. Nutritional quality of chickpea products

Products	*Percent calories (kcal)*		
	Protein	*Fat*	*Carbohydrates*
Curry sabat chana	16	27	60
Curry dhal chana	19	26	55
Missi roti	15	7	78
Pakoray	17	28	54
Chaat	19	12	69
Halwa baysen	7	40	52
Bhunay chanay	23	12	65

1989). Missi roti, being rich in carbohydrates (supplying 78% of the calories) is commonly used by the diabetic patients in Pakistan. The crude fibre content was highest in Pakoray (11.1%) and lowest in curry dhal chana (1.6%). The hypocholestrolaemic effect of legumes has been associated with their fibre content (Bender & Bender, 1982). The ash content ranged from 1.2 to 5.9%. The gross energy values ranged from 370 kcal/100 g in Bhunay chanay to 490 kcal/100 g in Halwa baysen.

All the products (per 100 g) appear to be good source of calcium (226–360 mg), phosphorus (126–315 mg), iron (3.8-8.2 mg) Zinc (1.8–5.4 mg), manganese (1.5–5.4 mg) and copper (0.6–1.1 mg). Highest contents of iron (8.2 mg/100 g) zinc (5.4 mg/100 g) and copper (1.1 mg/100 g) were found in puffed or Bhunay chanay whereas highest content of calcium (360 mg/100 g) and phosphorus (315 mg/100 g) in curry sabat chana and manganese (5.4 mg/100 g) in Missi roti were found. Missi roti, being high in manganese may improve glucose tolerance in diabetic patients (Hurley & Keen, 1987). However, phytic acid present in legumes may prevent the absorption of several minerals including Ca, Mg, Fe and Zn (Bender & Bender, 1982).

In a well-balanced diet 10–15% of the total energy is usually derived from protein, 15–30% from fat and 55–75% from carbohydrates (WHO, 1990). According to Table 6, all chickpea products contribute 7–23% of the total food energy from protein, indicating that the present products are more than adequate in quality in terms of protein. In practice, diets in most parts of the world, provide 7–12% of calories as protein and any food with less than 6–7% kcal as protein is presumably inadequate to assume the protein needs of a population (Bender & Bender, 1982). The present results suggest that protein does not seem to be a limiting factor in these products. The contribution of calories from fat was adequate in all chickpea products except Missi roti (7%), Chaat (12%) and Bhunay chanay (12%). The contribution of calories from carbohydrate was highest (78%) in Missi roti.

The protein energy ratio (PE%) has been used as a convenient and useful index of measuring dietary quality in human nutrition (FAO/WHO, 1985). According to Khan (1991b), the levels of protein required in terms of protein energy requirement ratio for different age/sex groups, i.e. 1–3 years, 4–6 years, 7–9 years, adult male, adult female, pregnant and lactating mothers are 7.4, 7.5, 8.4, 8.0, 8.8, 10.2 and 10.9 respectively. In comparing the required ratios with the protein energy percent of chickpea products (Table 6), all products except Halwa Baysen (PE 7%) are adequate to meet the protein requirements of all age groups, provided adequate quantity of the products is eaten to meet the energy requirements. The present results are in line with the findings of Khan & Eggum (1978b, 1979a), in similar diets consumed in Pakistan.

In conclusion, both desi and kabuli chickpeas are good sources of protein, complex carbohydrates, fibres, minerals and other nutrients and may be used in the management of hypercholestrolaemia and diabetes. In chickpea breeding programmes, greater attention needs to be given to increase yield and seed size, to improve protein and processing quality and to eliminate antinutritonal factors.

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