DIETARY FIBER AND ITS CONSTITUENTS IN DESI AND KABULI CHICKPEA (CICER ARIETINUM L.) CULTIVARS

U. Singh

International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru P.O., Andhra Pradesh 502 324, India.

ABSTRACT

The concentrations of crude fiber (CF), acid detergent fiber (ADF), neutral detergent fiber (NDF) and dietary fiber (DF) were significantly higher in the seed and dhal of desi cultivars than in those of kabuli cultivars, except for dhal (dehusked dry split cotyledons) CF and ADF which were the same in the two seed types. This indicated that the levels of these fiber constituents in whole seeds are determined mainly by the husk. In both desi and kabuli types, dhal was richer in hemicellulose (NDF-ADF) than in the husk whereas cellulose (CF) and lignin (ADF-CF) were mostly located in the husk. Hemicellulose constituted a large proportion (about 55%) of the total dhal dietary fiber of both the types. Whole seed and dhal of desi cultivars contained much higher amounts of cellulose and hemicellulose than those of kabuli types which may be disadvantageous for utilization.

INTRODUCTION

Grain legumes have occupied an important place in human nutrition as rich sources of proteins, vitamins and minerals, particularly in developing countries where they are grown and consumed along with cereals. Chickpea (Cicer arietinum L.) is India's most important grain legume. It is consumed as a whole seed and in the form of dhal (decorticated dry split seeds). Two types of chickpea are cultivated : 1) desi types which are generally small seeded with testa colour other than salmon white (brown to bright yellow testa colour is common), and 2) kabuli types which are large seeded with salmon white testa colour. Although desi and kabuli cultivars have been distinguished for centuries, limited information is available regarding their chemical and nutritional characteristics. Our earlier studies of antinutritional factors and *in vitro* digestibility have shown considerable differences between these two groups of chickpea cultivars (1,2).

Dietary fiber (the remnants of plant cells resistant to hydrolysis by human alimentary enzymes) can be fractionated into various components based on their solubility

---

Submitted as J.A. No.355 by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

characteristics (3). The nutritional significance of dietary fiber components has received considerable attention in recent years (4,5). The determination of total unavailable carbohydrates as an index of dietary fiber in several cereals and food legumes has revealed large variation among the cultivars (6). Foy et al reported variation among different species (7) in neutral-detergent fiber (NDF), acid-detergent fiber (ADF), hemicellulose, cellulose, lignin and ash in 30 foodstuffs commonly ingested by man. The purpose of this paper is to assess the variation in crude fiber (CF), acid-detergent fiber (ADF), neutral-detergent fiber (NDF) and dietary fiber (DF) of seed, dhal and husk among desi and kabuli chickpea cultivars and its implications for utilization.

MATERIALS AND METHODS

Seeds of seven desi and seven kabuli cultivars were pooled from single plots grown at Hissar (29 N) during the rabi (post-rainy) season of 1977-78 (Table I). Dhal (dehusked dry split cotyledons) samples were prepared by soaking whole seeds in an excess of distilled water at 5 C overnight. After decanting excess water, the husk was removed manually and samples were dried overnight at 70 C. Dhal, husk, and whole seed samples were ground in a Udy cyclone mill to pass through a 60 mesh sieve, and were defatted in a Soxhlet apparatus using n-hexane.

Table I. List of desi and kabuli chickpea cultivars used in the experiment.

Desi		Kabuli	
Cultivar	100-seed wt (g)	Cultivar	100-seed wt (g)
USA-613	16.9	K-4	20.0
850-3/17	28.4	C-104	25.8
Pant-114	11.5	L-550	23.4
CPS-1	17.2	Rabat	22.3
T-3	20.6	GL-629	20.1
Annigeri	18.5	Giza	15.8
BG-203	12.6	No 501	31.7

Crude fiber (CF) and acid-detergent fiber (ADF) were determined by the standard procedure of AOAC (8). Neutral detergent fiber (NDF) was determined by the method of Goering and Van Soest (9). Dietary fiber as an estimate of unavailable carbohydrates was determined according to the procedure described earlier (10). The values for hemicellulose, lignin and pectic substances were calculated by using "the difference" method as follows :

Cellulose = CF; Hemicellulose = NDF-ADF; Lignin = ADF-CF; and pectic substances and others = DF-NDF. Differences between mean values were compared using a 't' test.

RESULTS AND DISCUSSION

The results of the fiber analyses of seed, dhal and husk of desi and kabuli cultivars are shown in Table II. There were wide differences in CF contents of whole seeds within and between the desi and kabuli groups and in their ADF and NDF contents. The concentrations of CF, ADF, NDF and DF were significantly higher ($P \leq 0.01$) in the whole seeds of desi cultivars than in those of kabuli cultivars. For CF percent, the whole seeds of desi cultivars were about three times more than those of kabuli cultivars. Differences of a similar magnitude were observed for ADF concentrations ((Table II). There was no noticeable difference in CF and ADF of dhal samples of desi and kabuli cultivars and the variation among cultivars was small. So the husk must play a significant role in seed fiber components. The NDF and DF contents of dhal were significantly higher in desi than in kabuli cultivars (Table II) and this was associated with a higher hemicellulose content in desi dhal samples (Table III).

Desi husk was richer in fibre than kabuli husk. The dietary fiber percent of desi husk ranged from 73.8 to 78.4 compared with 61.8 to 72.0 for kabuli cultivars. The seed coat thickness and percentages of desi types are significantly higher than those of kabuli types and this information can be used to distinguish desi and kabuli cultivars (11,12). The present study indicates that the concentrations of different dietary fibers are also significantly higher in desi than in kabuli cultivars.

The individual fiber components cellulose, hemicellulose, lignin and pectic substances of desi and kabuli cultivars also differed (Table III). The whole seeds of desi types were higher in cellulose and lignin concentrations than the whole seeds of kabuli types and their dhal samples were higher in hemicellulose indicating qualitative differences for these constituents among cultivars. Hemicellulose was the major constituent of dietary fiber of dhal and seed of kabuli cultivars. Cellulose was the predominant component of dietary fiber of desi seed, located mainly in the husk. Cellulose followed by lignin were the major components of both desi and kabuli husk. Kabuli husks were richer in lignin and pectic substances than desi husks but had lower lignin and hemicellulose. Husk accounted for about 75 and 95 percent of the total CF of seeds of desi and kabuli cultivars, respectively, and 30 and 55 percent of the total seed DF. This indicated that the dhal of both contained considerable amounts of dietary fiber.

Table II. The sizes, husk contents and fiber compositions of seeds of desi and *kabuli chickpea cultivars*

Constituent	Group	Whole seed			Dhal			Husk		
		Range	Mean	SD	Range	Mean	SD	Range	Mean	SD
100-seed weight (g)	Desi	11.5-28.4	17.96	3.07	-	-	-	-	-	-
	Kabuli	15.8-31.7	22.73							
Husk	Desi	12.8-17.6	15.93	0.61**	-	-	-	-	-	-
	Kabuli	5.7-8.8	7.11							
Crude fiber	Desi	7.1-9.7	8.96	0.34**	1.1-1.7	1.45	0.08	52.6-58.0	55.13	2.46**
	Kabuli	2.6-4.7	3.20		1.1-1.2	1.17		31.1-46.4	36.66	
Acid-detergent fiber	Desi	9.6-14.8	12.66	0.58**	1.6-2.0	1.74	0.10	67.8-72.8	70.26	1.74**
	Kabuli	4.0-6.7	4.87		1.3-1.9	1.67		51.2-62.4	55.04	
Neutral-detergent fiber	Desi	15.6-20.0	18.44	0.36**	7.4-9.9	8.97	0.47**	72.2-75.3	73.50	1.77**
	Kabuli	8.2-11.7	10.39		5.5-8.8	7.16		52.6-64.1	57.17	
Dietary fiber	Desi	19.0-22.7	21.49	0.39**	10.6-13.3	12.27	0.43**	73.8-78.4	76.14	1.94**
	Kabuli	10.6-15.2	13.70		8.8-12.3	10.27		61.8-72.0	66.01	

** Difference significant at 1% level (P = 0.01); a Standard deviation of the difference;

b g/100g sample.

Table III. Cellulose, hemicellulose, lignin and pectic compositions (g/100g sample) of seeds of desi and kabuli chickpea cultivars

		Whole seed			Dhal			Husk		
Constituent	Group	Range	Mean	SD	Range	Mean	SD	Range	Mean	SD
Cellulose (CF)	Desi	7.1-9.7	8.96	0.34**	1.1-1.7	1.24	0.08	52.6-58.0	55.13	2.46**
	Kabuli	2.6-4.7	3.20		1.1-1.2	1.17		31.1-46.4	36.66	
Hemicellulose (NDF-ADF)	Desi	3.5-8.7	5.79	0.85	5.5-8.3	7.23	0.51**	0.1-4.9	3.24	1.10
	Kabuli	4.0-7.3	5.51		3.7-6.9	5.49		0.9-5.1	2.13	
Lignin (ADF-CF)	Desi	2.2-5.9	3.70	0.44**	0.1-0.8	0.50	0.00	9.8-18.0	15.13	1.66
	Kabuli	1.1-2.1	1.67		0.1-0.7	0.50		12.6-22.6	18.39	
Pectic substances (DF-NDF)	Desi	1.5-3.8	3.04	0.46	2.9-4.1	3.30	0.20	1.0-4.7	2.64	0.48**
	Kabuli	2.4-4.1	3.31		2.9-3.5	3.11		7.4-9.8	8.84	

** Difference significant at 1% level (P = 0.01); a Standard deviation of difference.

Together, cellulose and hemicellulose accounted for about 60 to 70 percent of total seed dietary fiber. Hemicellulose accounted for about 55% of the dietary fiber of dhal whereas cellulose contributed about 10%, in both desi and kabuli cultivars (Table IV). These components were much higher in desi than in kabuli cultivars in both whole seed and dhal samples. Cellulose has a direct effect on the utilization of dietary nutrients (5). Utilization of ingested protein decreases with increasing levels of cellulose regardless of the quality of protein ingested (13). Also, cellulose has been reported to be the least digestible component of dietary fiber (14,15). Interestingly, hemicellulose of chickpea produces a considerable amount of gas in both in-vitro and in-vivo systems (16). These observations are considered important from utilization point of view.

Table IV. Percentage contributions of fibre components towards total dietary fiber of whole seed, dhal, and husk of desi and kabuli chickpea cultivars

	Whole seed		Dhal		Husk	
Constituent	Desi	Kabuli	Desi	Kabuli	Desi	Kabuli
Cellulose	41.69	23.35	10.11	11.39	72.41	55.53
Hemicellulose	26.94	40.25	58.92	53.46	4.26	3.23
Lignin	17.22	12.20	4.07	4.87	19.87	27.86
Pectic substances	14.15	24.18	26.89	30.28	3.47	13.38
Total dietary fiber (%)	21.49	13.69	12.27	10.27	76.14	66.02

a Mean values.

CONCLUSION

The dietary fiber components of dhal and seed of desi and kabuli cultivars differ qualitatively and quantitatively. In terms of calorific value and utilization of dietary nutrients, both dhal and seed of kabuli cultivars are preferred for consumption to those of desi cultivars as the latter contain higher amounts of dietary fiber and particularly, cellulose and hemicellulose. Further studies are required to examine the effect of DF on the calorific values and bioavailability of nutrients of different diets.

ACKNOWLEDGEMENTS

Author thanks Dr. R. Jambunathan for discussion and comments on the earlier draft and Dr. Jagdish Kumar for providing seed material. Technical assistance of

M.S. Kherdekar, P.V. Rao and R. Seetha is gratefully acknowledged.

REFERENCES

1. Singh, U. and Jambunathan, R. Studies on desi and kabuli chickpea (Cicer arietinum L.) cultivars. The levels of protease inhibitors, levels of polyphenolic compounds and in vitro protein digestibility. J. Food Sci. 46, 1364-1367 (1981).

2. Singh, U., Kherdekar, M.S. and Jambunathan, R. Studies on desi and kabuli chickpea (Cicer arietinum L.) cultivars. The levels of amylase inhibitors, levels of oligosaccharides and in vitro starch digestibility. J. Food Sci. 47, 510-513 (1982).

3. Van Soest, P.J. Dietary fibers: their definition and nutritional properties. Am. J. Clin. Nutr. 31, 512-520 (1978).

4. Spiller, G.A. and Amen, R.J. Dietary fiber in human nutrition. CRC. Crit. Rev.Food Sci. Nutr. 7, 39-52 (1975).

5. Ali, R., Staub, H., Coccodrilli, G. and Schanbachert, L. Nutritional significance of dietary fiber: Effect of nutrient bioavailability and selected gastrointestinal functions. J. Agri. Food Chem. 29, 465-470 (1981).

6. Kamath, M.V. and Belavady, B. Unavailable carbohydrates of commonly consumed Indian foods. J. Food Sci. & Agri. 31, 194-202 (1980).

7. Foy, W.L. Jr., Evans, J.L. and Wohlt, J.E. Detergent fiber analyses of thirty foodstuffs ingested by man. Nut. Rep. Int. 24, 575-580 (1981).

8. Association of Analytical Chemists (AOAC). Official methods of analysis, 12th ed. The Association, Washington, D.C. (1975).

9. Goering, H.K. and Van Soest, P.J. Forage fiber analysis. Agricultural Handbook # 379, Agr. Res. Serv. USDA, U.S. Govt. Printing Office, Washington, D.C. (1970).

10. Southgate, D.A.T., Hudson, G.J. and Englyst, H. The analysis of dietary fiber - The choices for the Analyst. J. Sci. Food Agric. 29, 979-988 (1978).

11. Jambunathan, R. and Singh, U. Studies on desi and kabuli chickpea (Cicer arietinum L.) cultivars. 1. Chemical composition. In Proc. International Workshop

on Chickpea, ICRISAT, Patancheru, A.P., India, (1980).

12. Singh, U., Kumar, J., Jambunathan, R. and Smithson, J.B. Variability in seed coat content of desi and kabuli chickpea cultivars. Int. Chickpea Newsletter 3, 18 (1981).

13. Wojcik, J. and Delrome, C.B. The effect of dietary cellulose level on the utilization of amino acid supplemented bread protein by weanling rats. Nut. Rep. Int. 25, 709-720 (1982).

14. Southgate, D.A.T. Fiber and other available carbohydrates and their effects on the energy value of the diet. Proc. Nutr. Soc. 32, 131-138 (1973).

15. Salvin, J.L., Brauer,P.M. and Marlett, J.A. Neutral detergent fiber, hemicellulose and cellulose digestibility in human subjects. J. Nutr. 111, 287-297 (1981).

16. El Faki, H.A., Bhavanishankar, T.N., Tharnathan, R.N. and Desikachar, H.S.R. Flatus effect of chickpea (Cicer arietinum), cowpea (Vigna sinensis) and horse gram (Dolichus biflorus) and their isolated carbohydrate fractions. Nutr. Rep. Int. 27, 921-930 (1983).

Accepted for publication: November 23, 1983.