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Insoluble dietary fibre components of food legumes as affected by soaking and cooking processes

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Abstract

Effects of soaking and cooking methods were studied on neutral detergent fibre (NDF), acid detergent fibre (ADF), cellulose, hemicellulose and lignin contents of five food legumes. Black grams, chickpeas, lentils, and red and white kidney beans were soaked in tap water and sodium bicarbonate solution (1% w/v). Slight but significant increases in ADF (0.85–4.57%) and cellulose (344–6.59%) were observed on soaking food legumes in tap water. Soaking in sodium bicarbonate solution led to appreciable increase of hemicellulose (44.43–58.86%) and cellulose (5.67–12.5%) but lignin contents remained unchanged. The insoluble dietary fibre components were reduced to various contents on cooking water-presoaked legumes, by three different methods. However, pressure cooking showed a more pronounced effect on the reduction of these insoluble dietary fibre components than ordinary and microwave cooking methods. Pressure cooking caused reduction in NDF (28.5–35.3%), ADF (11.6–21.8%), cellulose (17.0–35.8 and hemicellulose (37.5–42.4%) whereas increase in lignin content (15.2–27.8%) was observed. Reduction in hemicel1ulose content was distinctly more than cellulose content as a result of cooking the food legumes by these three cooking methods.

Keywords: Food legumes; Soaking; Cooking; Insoluble dietary fibre components

1. Introduction

The importance of dietary fibre in normal and therapeutic diets has been acknowledged by numerous authors in recent years (Brand, Snow, Wobhan, & Truswell, 1990; Schneeman, 1987). Dietary fibre mainly consists of soluble and insoluble fibre fractions which exert different physiological effects on human health. Soluble fibre lowers serum cholesterol and helps to reduce the risk of heart attack and colon cancer (Burkitt, Walker, & Painter, 1974; Kelsey, 1978; Trowell, 1972). However, cellulose, hemicellulose and lignin are the main components of the insoluble fraction of dietary fibre which prevent or relieve constipation due to absorption of water from the digestive tract (Hill, 1974). Similarly, dietary fibre in human diets also reduces the risk of obesity, blood pressure, appendicitis, and many other diseases. Keeping in view the beneficial clinical effects of dietary fibre, it is important to collect data on both the dietary fibre and its profile in different foods.

Food legumes are considered to be an excellent source of dietary protein and are used as a substitute for expensive animal protein in human diets. Food legumes have also been used as part of the dietary treatment of diabetes (Jenkins et al., 1981; Thorne, Thompson, & Jenkins, 1983) and for fortification of foods (Shahata, Darwish, El-Nahry, & Rarack, 1988) Food legumes are usually cooked by a boiling process before use. Pressure cookers and microwave ovens, however, can also be used for this purpose. Cooking brings about a number of changes in physical characteristics and chemical composition of food legumes. Cooking has also been shown to cause some structural changes in dietary fibre components of vegetables (Herranz, Vidal-Valverda, & Rojes-Hodelgo, 1981; Roehring, 1990). However, very little information is available in the literature regarding the dietary fibre components of cooked food legumes. Therefore, the present study was undertaken to investigate the effects of different soaking

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and cooking methods on the dietary fibre components of various food legumes.

2. Materials and methods

2.1. Materials

Chickpeas (*Cicer arietinum*) black grams (*Vigna mungo*), lentils (*Lens esculenta*), and red and white kidney beans (*Phaseolus vulgaris*) were obtained from Ayub Agricultural Research Institute, Resalewala, Faisalabad. These food legumes were cleaned from broken seeds, dust and other foreign materials and then subjected to a soaking treatment prior to cooking.

2.2. Soaking treatment

A 50 g sample of each food legume was soaked in 250 ml of tap water and other lots in sodium bicarbonate solution (1% w/v) at 30 °C. After 4 h soaking the excess water was drained, rinsed twice with distilled water and then dried in a hot air oven (Horizontal Forced air drier, Proctor and Schwartz Inc. Philadelphia PA) at 55 °C for 24 h. Presoaked food legumes (without drying) were cooked by three different cooking methods for different time periods, depending on the type of legume. Details of each cooking method are given below.

2.3. Ordinary cooking

Presoaked food legumes were put in flat-bottom flasks fitted with an air condenser. Tap water (1 g: 5 ml) was added and the samples were cooked on a hot plate for 60–120 min until the same degree of tenderness of each legume was achieved.

2.4. Pressure cooking

Presoaked food legumes were placed in 1-l beakers containing water (l g 5 m1). The tops of the beakers were covered with aluminum foil and then cooked in a pressure cooker at 15 lbs/inch^2 for 5–15 min until the same degree of tenderness of each legume was achieved.

2.5. Microwave cooking

Presoaked food legumes were placed in 1-l beakers containing water(1 g. 5 m1) and then cooked in a domestic microwave oven (Panasonic 115,550 cooking power) for 4–10 min until the same degree of tenderness of each legume was achieved.

After each cooking, excess water was drained, the food legumes were then ground in a domestic electric grinder (Maulinex, France and dried in hot air oven at 55 °C for 24 h before chemical analysis.

2.6. Chemical analysis

Neutral detergent fibre (NDF), acid detergent fibre (ADF), cellulose, hemicellulose and lignin contents in raw and cooked food legumes wore estimated according to the methods described by Van Soest and Wine (1967) and McQueen and Nicholson (1979). In accordance with those researchers, a preliminary overnight incubation with bacterial alpha amylase was employed. Triplicate determinations of all samples were performed for all parameters on a dry basis. Statistical analysis data of raw and. cooked food legumes were recorded and standard deviations (SD) were calculated according to the method of Steel and Torrie (1980). Ducan's multiple range test was used to determine significant difference.

3. Results and discussion

Table 1 shows the percentage of each dietary fibre component in black grams, cbickpeas, lentils, red and white kidney beans on a dry basis. These raw food legumes contained 23.4–29.8% NDF and 7.43–11.7% ADF whereas the amount of cellulose, hemicellulose and lignin contents had ranges of 6.22–9.70%, 12.0–20.3% and 1.08–11.7%, respectively. These values showed differences from the reported values in literature. In fact, soil, climate, collection time and botanical variety difference are factors which might be responsible for the variations observed.

Tables 2 and 3 show that soaking of food legumes in tap water and sodium bicarbonate solution caused some changes in dietary fibre components, However, these changes were more pronounced on soaking food legumes in an alkaline solution of sodium bicarbonate. Soaking of these food legumes in tap water did not significantly alter NDF, hemicellulose, or ligin contents on a dry matter basis. A slight but significant increase in ADF (0.85–4.57, Table 2) and cellulose (3.44–6.59%, Table 3) was observed as a result of soaking these food legumes in tap water. Soaking in sodium bicarbonate solution caused a sharp increase in hemicellulose (4.44–5.9%) and cellulose (5.67–12.5%) but lignin contents remained unchanged (Table 3). As a result of increase in hemicellulose and cellulose, NDF and ADF contents of these food legumes also increased by 29.2–37.4% and 3.58–9.69%, respectively after the alkali soaking process (Table 2). Earlier workers also reported significant increase in hemicellulose during soaking of lentils in sodium bicarbonate solution at room temperature for 9 h (Vidal-Valverde, Frias, & Esteben, 1992).

The contents of NDF, ADF, cellulose hemicellulose and lignin were significantly ($P < 0.05$) reduced on cooking the presoaked food legumes (Tables 4 and 5). The ordinary cooking method reduced from 21.7– 27.3% of

Table 1
Dietary fibre components in various raw food legumes

Food legumes	Percentage				
	NDF	ADF	Cellulose	Hemicellulose	Lignin
Black grams	23.4±1.01	11.7±0.55	9.70±0.53	12.0±0.42	1.70±0.11
Chick peas	25.5±1.20	9.53±0.49	8.45±0.50	16.0±0.39	1.08±0.09
Lentils	29.8±0.96	9.52±0.51	8.10±0.50	20.3±0.52	1.42±0.08
Red kidney beans	27.6±0.97	7.43 ±0.66	6.22±0.44	20.2±0.53	1.21±0.12
White kidney beans	24.3±1.00	9.32±0.60	8.00±0.41	14.9±0.32	1.32±0.10

NDF, neutral detergent fibre; ADF, acid detergent fibre; mean values±S.D. (dry basis).

Table 2
Effects of Soaking on neutral detergent fibre (NDF) and acid detergent fibre (ADF) contents of various food legumes

Food legumes	NDF%			ADF%		
	Raw	Soaking in tap water	Soaking in sodium bicarbonate solution (1% w/v)	Raw	Soaking in tap water	Soaking in sodium bicarbonate solution (1% w/v)
Black grams	23.4±1.01a	23.8±0.92a	31.1±1.30b	11.7±0.55a	11.8±0.88a	10.3±0.36b
Chickpeas	25.5±1.20a	25.8±0.77a	33.4±1.20b	9.93±0.49a	9.70±0.70a	10.3±1.22b
Lentils	29.8±0.96a	30.1±0.83a,	4O.9±1.30b	9.52±0.51a	9.90±0.55a	8.15±0.41b
Red kidney beans	27.6±0.97a	27.9±1.30a	39.8±1.11	7.43±0.66a	7.77±0.36	8.15±0.30b
White kidney beans	24.3±1.00a	24.6±0.88a	31.4±0.72b	9.32±0.60a	9.58±0.52a	9.83±0.41b

Mean values±S.D. (on dry basis). Mean values of a given fibre component (NDF or ADF) in a row with different letters are significantly different at $P<0.05$.

Table 3
Effects of soaking on cellulose, hemicellulose and Lignin contents of various food legumes

Food legumes	Cellulose			Hemicellulose			Lignin%		
	Raw	Soaked in tap water	Soaked in Sodium bicarbonate solution (1% w/v)	Raw	Soaked in tap water	Soaked in Sodium bicarbonate solution (1% w/v)	Raw	Soaked in tap water	Soaked in Sodium bicarbonate solution (1% w/v)
Black grams	9.70±0.53a	10.1±O.41a	10.3±0.36a	12.0±0.42a	12.O±0.44a	19.0±0.40b	1.70±0.11a	1.69±0.20a	1.67±0.15a
Check peas	8.45±0.50a	8.74±0.45a	9.00±0.36b	16.0±0.39a	16.1±1.0a	23.1±0.91b	1.08±0.09a	1.08±0.17	1.00±0.15a
Lentils	8.10±0.50a	8.50±0.42b	7.00±0.33c	20.3±0.52a	20.3±0.28a	31.6±0.25b	1.42±0.08a	1.40±0.15a	1.15±0.11a
Red kidney beans	6.22±0.44a	6.63±0.18b	7.00±0.18c	20.2±0.53a	20.2±0.36a	31.6±0.33b	1.21±0.12a	1.14±0.10b	1.15±0.12b
White kidney beans	8.00±0.41 a	8.29±0.35a	8.53±0.30b	14.9±0.32a	15.0±0.21a	22.1±0.26b	1.32±0.10a	1.29±0.15a	1.30±0.18a

Mean values±S.D. (on dry basis). Mean values of a given fibre component in a row with different letters are significantly different at $P<0.05$.

NDF in these food legumes whereas pressure cooking and microwave cooking caused reduction in NDF contents of 28.5–35.3% and 2l.0–24.5%, respectively. Similarly 8.79–20.6% ADF contents were reduced when food legumes were cooked by the ordinary method. However, pressure-cooking and microwave cooking reduced ADF contents of these food legumes by 11.6–23.9% and 10.4–18.0%, respectively (Table 4). Table 4 shows that reduction of NDF and ADF contents was markedly higher by pressure-cooking than by other cooking methods. It is also apparent from these results that reduction of NDF contents was comparatively more than reduction of ADF contents as a result of cooking. Reduction in NDF and ADF contents in food legumes could be attributed due to partial degradation of cellulose and hemicellulose into simple carbohydrates during each cooking method as was already observed by earlier workers (Rehman and Shah, 1994; Vidal-Valverde et al., 1992).

The cellulose, hemicellulose and lignin contents were significantly ($P<0.05$) reduced, to various extents, when food legumes were cooked by three different methods (Table 5). However, pressure cooking showed a more pronounced effect on reduction of these dietary fibre components than the other two cooking methods. As a result of pressure cooking, reductions of 17.0–35.8% cellulose and 37.6–42.4% hemicellulose contents occurred in these five food legumes (Table 5). It is apparent

Table 4
Effects of different cooking methods on neutral detergent fibre (NDF) and acid detergent fibre (ADF) of various food legumes

Food legumes	NDF%				ADF%			
	Raw	Ordinary cooking	Pressure cooking	Microwave cooking	Raw	Ordinary cooking	Pressure cooking	Microwave cooking
Black grams	23.4±1.01a	18.3±1.11b	15.7±1.25c	18.5±1.09b	11.4±0.55a	9.05±1.32b	8.82±1.06c	9.35±1.20b
Chick peas	25.5±1.20a	20.1±1.60b	16.5±1.09c	20.1±1.22b	9.53±0.49a	7.88±1.00b	7.25±0.73c	8.05±0.81c
Lentils	29.8±1.96a	22.0±0.73b	20.9±1.70b	22.5±1.32b	9.52±0.66c	8.46±0.73b	8.29±0.66c	8.44±0.49b
Red kidney beans	27.6±0.97a	20.1±0.74b	18.0±1.06c	21.3±1.01b	7.43±0.66a	6.28±0.30b	5.86±0.27c	6.27±0.60b
White kidney beans	24.3±1.00a	17.9±0.63b	17.3±0.73c	19.1±1.00b	9.32±0.60a	8.50±0.84b	8.24±0.66c	8035±0.59b

Mean values±S.D. (on dry basis). Mean values of a given fibre component (NDF or ADF) in a row with different letters are significantly different at $P < 0.05$.

Table 5
Effect of different cooking methods on cellulose, hemicellulose and lignin contents of various food legumes

Food legumes	Cellulose				Hemilcellulose%				Lignin%			
	Raw	Ordinary cooking	Pressure cooking	Microwave cooking	Raw	Ordinary cooking	Pressure cooking	Microwave cooking	Raw	Ordinary cooking	Pressure cooking	Microwave
Black grams	9.70±0.53a	7.65±0.41b	7.75±0.38b	7.55±0.42b	12.0±0.42a	9.24±0.62b	6.89±0.70c	9.10±0.88b	1.70±0.11a	1.90±0.08	2.07±0.12c	1.80±0.13b
Chick peas	8.45±0.50a	6.10±0.48b	6.00±0.45c	6.90±0.44b	16.0±0.39a	12.2±0.73b	9.23±0.48c	12.1±0.75b	1.08±0.09a	1.18±0.12a	1.25±0.11	1.15±0.16
Lentils	8.10±0.50a	6.80±0.72b	6.60±0.49c	6.75±0.33b	20.3±0.52	13.5±0.80b	12.6±0.81c	14.0±0.90b	1.42±0.08a	1.58±0.21b	1.19±0.13c	1.19±0.13c
Red kidney beans	6.22±0.44a	4.98±0.22b	4.44±0.21c	4.88±0.24b	20.2±0.53a	13.8±0.42b	12.1±0.55c	15.1±0.50b	1.21±0.12a	1.30±0.08b	1.40±0.09c	1.39±0.11c
White kidney beans	8.00±0.41a	7.00±0.70b	6.64±0.53c	6.85±0.51b	14.9±0.32a	9.41±0.85b	9.10±0.73c	10.8±0.67b	1.32±0.10a	150±0.10b	1.40±0.11c	1.50±0.14b

Mean values±S.D. (on dry basis). Mean values of a given fibre component in a row with different letters are significantly different at $P < 0.O5$.

from these findings that reduction of hemicellulose was comparatively greater than that of cellulose on cooking the food legumes. On the other hand, increase of the contents of lignins could be attributed to solubilization of polysaccharides. However, pressure cooking caused maximum increases in lignin contents by 15.7–21.8%. In general, the observed effect of the cooking process on individual dietary fibre components in the food legumes depended not only on the type of food legume but also on the cooking method involved. Reductions of cellulose, and hemicellulose contents were reflected in the lower values of NDF and ADF of the cooked food legumes. Chemical degradation of cellulose into glucose and hemicellulose into arabinose, xylose and galactose, might be reasons for the reduced contents of the dietary fibre components of the food legumes on cooking (Robinson & Lawler, 1986). The decreases in these dietary fibre components confirmed the findings of Vidal-Valverde and Frias (1991) who observed that hemicellulose content in lentils was greatly reduced as a result of cooking. These results were also in good agreement with the findings of Ellis, Dunning, and Flask (1947) who reported the conversion of cellulose and hemicellulose into simple carbohydrates as a result of steam-pressure treatment. Similarly, many other workers also found marked decreases in cellulose and hemicellulose contents of various vegetables during cooking processes. (Anderson & Clydesdale, 1980; Herranz et al., 1981).

4. Conclusion

Black grams, chick peas, lentils, and red and white kidney beans were cooked for different time periods, depending on the type of legumes, in order to achieve a uniform degree of tenderness. It is apparent from the results that dietary fibre components of these five food legumes were reduced to various extents as a result of cooking by three different methods. Ordinary and microwave cooking reduced NDF from 21.7–27.3% and 21–24.5%, respectively in these five food legumes. On the other hand, 28.5–35.3% reduction of NDF content was observed on cooking the food legumes in a pressure cooker. It is apparent from these results that maximum amount of NDF was lost from the food legumes on pressure cooking. Similar observations were also made in the case of dietary fibre components of the food legumes. In order to minimize the losses of dietary fibre, it is suggested that legumes should be cooked either by the ordinary method or in a microwave oven instead of a pressure cooker.

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