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Preliminary communication

DIETARY FIBER CONTENT OF BULGUR AS AFFECTED BY WHEAT VARIETY

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Dietary fiber content of bulgurs prepared from different wheat varieties was investigated. Grains of 29 Turkish wheat cultivars and advanced breeding lines (23 of durum and 6 of common wheat) were used in this study. The average values for ADF and NDF (+amylase) contents of investigated durum wheats were 3.4% and 9.9%, respectively and the corresponding values of common wheats were 3.4% and 11.5%. In this study, the average values for ADF and NDF (+amylase) contents of bulgurs made of durum wheats were found to be 5.4% and 10.3%, respectively and the corresponding values of bulgurs made of common wheats were 5.8% and 11.7%. The minimum and maximum values for ADF and NDF (+amylase) contents of bulgurs made of durum wheats were found to be 4.1%–6.8% and 7.9%–11.8%, respectively and the corresponding values of bulgurs made of common wheats were 5.1%–6.4 and 10.6%–12.4%. The processing of wheat into bulgur generally increased the levels of ADF and NDF(+amylase) contents. It can be concluded that bulgur is at least as good as a raw wheat in terms of dietary fibre content. Although there is no essential change in the total protein content, ash and β-carotene contents of the bulgurs were lower than the ones in the original wheats as a result of debranning.

Keywords: dietary fiber, bulgur, wheat

Bulgur is one of the oldest cereal-based staple foods in Turkey and Near Eastern countries (WILLIAMS et al., 1984; BAYRAM, 2000). In 1996, 950 thousand tons of bulgur was produced in Turkey (ANON, 1996). Bulgur has been processed by a series of steps of soaking, cooking, drying, milling to remove the outer bran coating, and cracking. Therefore, bulgur is a parboiled, dry and partially debranned whole wheat product. Traditionally, bulgur has been made by boiling or simmering whole wheat in open pans for 1–3 hours, then drying the product in the sun or in simple dryers. To avoid leaching of soluble nutrients, minimum amount of water is used. The loose outer bran is removed by beating in a large stone mortar with a wooden pestle. The dried kernels are cracked

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and sieved to obtain a coarse, a medium and a fine granulation. In the modern, large-scale and continuos bulgur production method, pressure is used for cooking wheat for bulgur (PENCE et al., 1964; SMITH et al., 1964; HARRIS et al., 1978). Since it is a relatively unrefined product, its nutritional value has been regarded as similar to that of whole wheat (ÖZKAYA et al., 1996). That means the nutritive value of bulgur remains relatively unaltered. According to NEUFELD and co-workers (1957), debranning was generally continued until about 7% – by weight –, of the kernels had been removed. In addition, removal of part of the outer bran from cooked and dried wheats and subsequent cracking and size-grading led to a 15–20% decrease in crude fiber (PENCE et al., 1964). The importance of the intake of dietary fiber in relation to health and disease prevention has been the subject of a great deal of researches (TROWELL, 1976; SOUTHGATE et al., 1978; ANON, 2001) but there is no published information on the dietary fiber (DF) contents of bulgur. Therefore, the objective of this study is to compare the dietary fiber contents and the chemical composition of the bulgur samples and the wheats which are used in the bulgur production. The increasing interest in recent years in the consumption of dietary fiber rich foods attracted us to this study on the dietary fiber contents of bulgur.

1. Materials and methods

1.1. Materials

Grains of 29 Turkish wheat cultivars and advanced breeding lines (23 of durum and 6 of common wheat) were used in this study.

1.2. Bulgur-making process

The wheat (1 kg) was soaked to raise the moisture content to about 45% by adding water and kept in water bath at 60 °C for 3 h. The soaked grain was cooked in an autoclave (Funke Gerber, Webeco, Germany) under a steam pressure of 20 p.s.i., at 121 °C for 15 min, which was sufficient to gelatinize the starch completely. After cooling for 10 min, cooked product was dried at 60±2 °C to a moisture content of 10–12%. Dried product was conditioned with 2% additional water for half an hour. The loose outer bran was removed by beating in a plastic mortar. The debranned product was cracked by using Falling Number Laboratory Mill Type-KT 30 (adjusted to produce the coarsest particle size), aspirated to remove residual bran material and sifted through a 0.5 mm sieve to remove the fine particles (ÖZKAYA et al., 1996).

1.3. Analytical methods

Moisture, protein, ash and β-carotene contents of the wheat and bulgur samples were determined by A.A.C.C. methods (1990). Acid-detergent fiber (ADF) was determined according to the original procedure (VAN SOEST, 1963). Neutral-detergent fiber (NDF) content was determined by using additional amylase enzymes in order to remove starch (NDF+amylase). For NDF+amylase determination (BAŞMAN & KÖKSEL, 1999), samples of known moisture content were weighed accurately (≈0.5 g) into polypropylene tubes and 10 ml of phosphate buffer (0.08 mol l^{-1}, pH 6.0) and 100 μl of Termamyl 120L (Novo, Denmark) were added. Tubes were capped and incubated in a water bath (93 °C) for 0.5 h with stirring every 5 min. They were cooled and 250 μl of HCl (to adjust to pH 4.1–4.8) and 150 μl of amyloglucosidase 300L (Novo) were added. They were incubated at 60 °C for 20 min with stirring in every 5 min and centrifuged at 2000 r.p.m. (Heraeus Sepatech Labofuge Ae) for 5 min. The supernatants were discarded and the residue was treated with neutral detergent solution according to the original NDF procedures (VAN SOEST & WINE, 1967). All analyses were performed on wheat and bulgur samples. The values represent means of duplicate analyses. The data were analyzed using the SPSS for Windows Release 5.0.1 (SPSS, Inc., Chicago, IL).

2. Results and discussion

2.1. Composition of wheat and bulgur samples

The mean, minimum and maximum values of the protein, ash and β-carotene contents of wheats and the bulgurs are given in Table 1.

When wheat was converted to bulgur under the conditions used in this study, which minimize leaching of soluble nutrients, there was essentially no change in the total protein content (Table 1). The outer bran tissues are normally removed and discarded during bulgur manufacture. These tissues have higher fiber and ash contents than the deeper layers of bran that are normally retained in bulgur. Unavoidably, ash and β-carotene contents of the bulgurs were lower than the ones in the original wheats as a result of debranning and leaching (Table 1). The degree of debranning, of course, will also affect retention of these factors (PENCE et al., 1964; SHAMMAS & ADOLPH, 1954).

Table 1

The mean, minimum and maximum values of the protein, ash and β-carotene contents of wheat (durum and common) and bulgur samples

Samples		Mean ± S.D.		Minimum		Maximum	
		Durum n=23	Common n=6	Durum n=23	Common n=6	Durum n=23	Common n=6
Protein[a] (Nx5.7) (%)	W	14.0±1.40	12.6±1.13	11.4	11.5	16.6	14.4
	B	14.0±1.31	12.6±1.23	11.5	11.3	16.6	14.5
Ash[a] (%)	W	1.58±0.32	1.72±0.28	1.12	1.34	2.08	1.98
	B	1.51±0.30	1.58±0.28	1.11	1.18	2.02	1.80
β-carotene (ppm)	W	3.80±0.72	2.30±0.39	2.90	1.50	5.90	2.50
	B	3.40±0.60	2.10±0.34	2.20	1.40	4.60	2.30

[a] Dry basis; W: wheat; B: bulgur

2.2. Dietary fiber contents of wheat samples

The ADF and NDF(+amylase) contents of durum (n=23) and common wheat (n=6) samples are given in Tables 2 and 3, respectively. The average values for ADF and NDF(+amylase) contents (dry basis) of durum wheats were 3.4% and 9.9%, respectively and the corresponding values of common wheats were 3.4% and 11.5%.

The ADF contents reported in the present study (3.4% for both durum and common wheats) were slightly higher than the literature values (DONG & RASCO, 1987). The NDF values published by SOUTHGATE and co-workers (1978) and VAN SOEST & WINE (1967) were 10.3%, and 12.5%, respectively, and respective values of DONG & RASCO (1987) and MOSS & MUGFORD (1986) were in the range of 10.9–14.5% and 11.7–13.7%.

2.3. Dietary fiber contents of the bulgur samples

The ADF and NDF(+amylase) contents of bulgurs produced from durum (n=23) and common wheat (n=6) samples are presented in Tables 2 and 3, respectively. Previous workers have reported that partial removal of the outer bran from bulgur led to a 15–20% decrease in crude fiber (PENCE et al., 1964). However, there is no published information on the DF contents of bulgur. In this study, the average values for ADF and NDF(+amylase) contents of bulgurs made of durum wheats were found to be 5.4% and 10.3%, respectively and the corresponding values of bulgurs made of common wheats were 5.8% and 11.7%. To assess the potential of dietary fibre contribution of selected commercial foods and home-prepared breads over 50 samples were analyzed for their NDF+amylase content (JWUANG & ZABIK, 1979). Results showed that the NDF+amylase content in cereals ranged from 3.8–34.0%, in European crispbreads from 16.4–36.3% and in whole wheat bread from 5.2–13.5%. In another study, whole wheat bread has been reported to contain 14.9% NDF (SPILLER & AMEN, 1975).

Table 2

Dietary fiber contents of durum wheat and bulgur samples[a]

Sample (n=23)	Acid detergent fiber (%)		Neutral detergent fiber + amylase (%)	
	Wheat	Bulgur	Wheat	Bulgur
1	4.1	6.0	11.0	11.2
2	2.0	5.2	10.4	11.1
3	3.8	5.0	10.3	10.5
4	3.9	4.9	8.7	9.7
5	4.0	6.2	9.7	9.9
6	1.9	4.7	9.5	9.4
7	1.9	4.5	11.5	11.6
8	4.3	5.7	10.9	11.2
9	5.0	6.8	11.0	11.3
10	4.3	6.3	10.7	11.0
11	4.0	6.3	9.7	9.5
12	3.8	6.1	9.3	11.2
13	4.1	5.7	8.3	9.1
14	3.8	6.1	11.9	11.8
15	4.0	5.7	9.5	9.6
16	2.1	4.6	8.0	9.3
17	5.3	4.9	9.6	10.6
18	4.1	5.1	9.6	9.8
19	2.0	4.6	7.8	7.9
20	4.1	4.9	9.5	11.4
21	2.1	4.1	11.1	11.0
22	1.9	6.1	8.7	9.2
23	2.0	5.0	9.9	9.9
min	1.9	4.1	7.8	7.9
max	5.3	6.8	11.9	11.8
mean	3.4±1.12	5.4±0.73	9.9±1.11	10.3±1.01

[a] Dry basis

Table 3

Dietary fiber contents of bread wheat and bulgur samples[a]

Sample (n=6)	Acid detergent fiber (%)		Neutral detergent fiber + amylase (%)	
	Wheat	Bulgur	Wheat	Bulgur
1	4.3	5.4	12.2	12.4
2	2.1	5.1	10.5	10.6
3	3.9	5.5	10.4	11.1
4	2.1	6.4	11.8	11.7
5	3.9	6.2	11.6	11.8
6	4.0	6.1	12.2	12.4
min	2.1	5.1	10.4	10.6
max	4.3	6.4	12.2	12.4
mean	3.4±1.00	5.8±0.52	11.5±0.81	11.7±0.71

[a] Dry basis

High NDF values in the cereal based products are generally due to the interference from unremoved starch (SCHWEIZER & WÜRCH, 1979). Lower results were obtained after a pretreatment with amylase enzymes (NDF+amylase) due to the digestion of starch in endosperm material. MOSS and MUGFORD (1986) reported that bran particles contained small pockets of starch granules surrounded by endosperm cell walls adjacent to the aleurone layers. The retention of these walls during analysis might have been prevented the complete digestion of starch.

There are various studies investigating the changes in the DF content of the cereal products during processing (SOUTHGATE et al., 1978; BJÖRCK et al., 1984). These researchers have reported that 1.5% and 20% increases in DF content during baking and drum drying, respectively. However, we have not encountered any research studying the changes in DF content in bulgur processing. In the present study, the processing of raw wheat into bulgur was found to have no detrimental effect on the dietary fiber content of the bulgur. In order to determine whether or not bulgur production is effective on the dietary fiber content of wheat samples, DF content of samples were determined before and after bulgur production and the data were evaluated by using t-test for paired-samples. From the results, we rejected the hypothesis of no effect at the 5% level for ADF and NDF values of durum wheat samples and ADF value of common wheat samples. It can be concluded that the bulgur production has increased the ADF and NDF contents of durum wheat and ADF content of common wheat samples ($P<0.05$). For the common wheat samples, we can conclude that bulgur production has no significant effect on the NDF value.

The increase in the dietary fiber contents of bulgurs might also be explained by the formation of enzyme resistant starch (RS) (RANHOTRA et al., 1999). The effect of drum-drying on starch availability in white wheat flour was studied and compared with boiling and pressure cooking (BJÖRCK et al., 1984). The process conditions with respect to steam pressure and drum speed were as follows: 4.9 bar, 13 r min^{-1} for mild conditions and 9.8 bar, 4 r min^{-1} for severe conditions. In this study, they have found that the dietary fiber content in raw wheat flour and in wheat flour processed under mild conditions was similar. However, under severe drying conditions, the dietary fiber content in wheat flour increased by about 20%. They have suggested that the increase in dietary fibre resulting from severe drum-drying conditions was due to the formation of a form of starch that was resistant to digestion by the alpha-amylase (Termamyl) used in the dietary fiber assay. The mechanism behind the formation of RS during processing is believed to be related to the retrogradation of amylose. In another study, the amount of RS formed during baking (≤3%) or autoclaving (≤10%) covers the range of dietary fibre contents in most staple foods (BJÖRCK et al., 1987).

3. Conclusions

Previous studies have shown that bulgur is a product which resembles, in its nutritional properties (e.g. mineral, vitamin, protein contents), whole wheat more closely than refined white flour. It has therefore been given a good deal of attention by nutritionists. Effects of bulgur processing on the DF contents of wheats were investigated in detail for the first time in the present study. Bulgur is found to be at least as good as raw wheat in terms of ADF and NDF(+amylase) contents. Despite the removal of bran during bulgur production, the NDF(+amylase) contents of bulgurs were usually higher than the corresponding wheat samples which can be explained by the formation of RS during bulgur production. Hence, further studies are needed on this matter.

Cereal products are important components in the diet of most people around the world. However, new and more appealing products are required in the market, to increase the consumption of cereal based foods. Ethnic cereal foods have a potential to provide healthier diets to the people around the world. Hence, the research on the ethnic foods such as bulgur, couscous and flat breads etc. might give the opportunity to increase the dietary fiber consumption.

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