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Bulgur Milling Quality with Stone Mills

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Abstract: In this study, the effect of two different stone mills (fixed top stone-FTS and fixed bottom stone-FBS) on the selected quality parameters of bread wheat bulgur (13.6% w.b.) was researched. For each milling system bulgur particles were examined for dimensions (max., min., mean, standard deviations and coefficient of variance), particle size distribution, bulk density and thousand particle mass. Sieve analyses were done with 3.5, 3.0, 2.5, 2.0, 1.5, 1.0 and 0.5 mm circular sieve. The products obtained were classified as coarse (+/3.5), pilaf (3.5/2.5), medium (2.5/1.5), fine (1.5/0.5) and flour (0.5/-). The yield values of samples from the FTS mill were obtained between 98.9% and FBS mill 98.7% at the same gap (2.5 mm) adjustments. The coarse, pilaf, medium and fine bulgur were obtained using the FTS mill at the percentage of 68.4, 23.5, 4.3 and 2.8%, respectively. Corresponding values are 14.5, 51.5, 23.5 and 9.1% at FBS mill. The 1000-particle weights from FTS and FBS mills were 23.56 and 14.91 g, respectively. The FTS and FBS milled bulgur had bulk densities of 74.84 and 67.67 g/100 ml, respectively.
Key words: Wheat, bulgur, stone mill, sieve

INTRODUCTION and LITERATURE REVIEW

Bulgur is an excellent food source due to its low cost, long shelf life, ease of preparation, and high nutritional value, which resists mould contamination and attack by insects and mites. Bulgur is also important due to its high dietary fibre content, having 18.3 g dietary fibre per 100 g. Its dietary fibre content is 3.5, 6.8, 1.1, 1.8, 7.0, 15.3, 9.2, 2.3, 1.3 and 4.3 times higher than rice, wheat flour, barley, oat meal, spinach, tomato, turnip, whole wheat bread, soybean and pasta, respectively (Dreher, 2001). Bulgur is generally produced from Triticum durum using cleaning, cooking, drying, milling and classification operations. The production of this ancient grain product recently reached to important level around the world. One million ton of bulgur is produced in Turkey. There is also important amount of bulgur production out of Turkey. 250,000–300,000 tones in the United States plus Canada, 60,000–80,000 tones in the EU and 100,000–120,000 tones in the Arabic countries are produced. The consumption of bulgur is also important to understand its economical and nutritional properties. It is approximately 2.5 and 2.0 times higher than that of pasta and rice in Turkey, respectively. The average annual consumption of bulgur is about 12 kg/person. This consumption is significantly huge in the East and South Parts of Turkey (25 kg/person) and in Syria, Iraq, Iran, Israel, Lebanon, Arabia, i.e., Middle East countries (30–35 kg/person) (Bayram&Öner, 2007).

The milling operation, one of the most important steps in bulgur production, is different from milling to produce other granular food products such as flour and semolina. On the contrary, bulgur is milled from cooked wheat to give particles with a range of dimensions which are then classified by size.

There is no universal milling method or system for producing bulgur. The two most popular, the Antep and Karaman systems, are basically different. Dehulling and milling of cooked/dried wheat in the Antep system is achieved separately using a vertical emery dehuller and disc or hammer mills, respectively, while it is used stone mill in the Karaman system (Bayram&Öner, 2005).

There are some studies related to durum wheat bulgur milling (Bayram&Öner, 2005; Bayram&Öner, 2007; Özboy&Köksel, 2002; Yıldırım et al. 2008), but there is no study related to the milling properties of bread wheat bulgur in different stone mills. In the present study, the different stone mills were investigated to determine their effects on the milling quality of bulgur and to find the optimum stone mill type.

MATERIAL and METHODS

Materials

In this study, bread wheat was used (Figure 1.) It was bought from Ozbereket Milling Co. in Kastamonu province. The grains were cleaned manually and foreign matter such as stones and straws were removed. Cooking operation was carried out at boiling temperature for 40 min (Bayram, 2005) and they were dried at room temperature during 5 day (Figure 2). Some physical properties of bulgur before milling showed at Table 1. Moisture content was determined through an oven method at 105 °C during 24 h. The average moisture content of dried samples was found to be 13.6% (w.b.).

Figure 1. Sample of bread wheat

Figure 2. Sample of cooked bread wheat (bulgur)

Table 1. Some physical properties of bulgur sample

Properties	min	max	mean	S.D.	%CV
major axis (mm)	4.66	6.95	5.91	0.45	7.63
medium axis (mm)	2.75	3.90	3.34	0.28	8.42
minor axis (mm)	2.08	3.27	2.74	0.27	9.77
ρ_b (g/100 ml)	73.74	76.13	74.82	1.214	1.62
Thousand grain mass	36.12	38.44	37.25	1.161	3.12

Methods

Two stone mills were used in this study. One of the mills has a fixed bottom stone (F.B.S.) and turning top stone and top stone is able to vertical move while it turns due to its moving articulation. It was operated at 155 rpm, and mill was powered by a 30 kW motor. Its stones diameter was 120 cm. The other one has a fixed top stone (F.T.S.) and turning bottom stone that is always horizontal while it turns. It was operated at 355 rpm, and mill was powered by a 7.5 kW motor. Its stones diameter was 80 cm. The rotation of the both stone mills was controlled using pulleys and belts. The gap between stones was 2.5 mm. Both milling gaps fixed up rising from zero.

The dimensions of thousand particle mass were measured using digital vernier calipers to an accuracy of 0.01 mm. Ellipsoidal particle volumes (V) were calculated using the following equation (Bayram&Öner, 2005):

$V = 4/3 \times \pi \times$ (radius of width) $\times$ (radius of thickness) $\times$ (radius of length) ....(1)

The weight of one thousand of bulgur particles were measured using an analytical balance to an accuracy of 0.01g. Bulk densities (hectolitreweight) were determined using a graduated cylinder and an analytical balance. Sieve analyses were performed using 3.5, 3.0, 2.5, 2.0, 1.5, 1.0, and 0.50 mm circular sieves. Bulgur was classified into four sizes after the milling, such as coarse, pilaf, medium and fine. The coarse bulgur was collected over a 3.5 mm screen. The pilaf bulgur was collected between 3.5 and 2.5 mm. The middle and fine bulgur were obtained between 2.5 and 1.5 mm, and 1.5 and 0.5 mm screens, respectively. Bulgur below 0.5 mm of screen was classified as 'by-product' and used to calculate the overall milling yield (TSE, 2003).

RESULTS and DISCUSSION

In this study, two stone mills were used to compare their effects on bulgur quality. Stone mills effects are different due to compression and rubbing action compared to disc (compression, rubbing and cutting action) and hammer (impact action) mills. Stone mills also have a various type as vertical and horizontal. Horizontal type mills can be two different models as fixed top stone and fixed bottom stone that were investigated in this study. Picture of FTS milled bulgur show at Figure 3. and FBS milled bulgur show at Figure 4.

In comparing milling systems it was important to analyze the length, width and thickness of the bulgur particles. Minimum, maximum, mean, standard deviation and coefficient of variance values of the dimensions (x, y, z), volumes (V) of one hundred bulgur particles, bulk density (ρ_b) and thousand particles weight are given in Table 2. The highest standard deviations in dimensions are on both x with 1.14 from FTS and 1.25 from FBS. But, highest CV is on z (30.58%) from FTS and x (29.18%) from FBS. According to volume results it is clearly seen that FTS milled particles (14.96 mm^3) is greater than FBS milled particles (8.39 mm^3).

Figure 3. FTS milled bulgur

Figure 4. FBS milled bulgur

The bulk densities of bulgur obtained from FTS and FBS mills were 74.84 and 67.67 g/100 ml, respectively ($p<0.05$). The FTS milled bulgur had higher bulk density due to the high amount of coarse particles and the FBS milled bulgur had lower bulk density due to the irregular shape caused a high void volume. This result is similar with Bayram&Öner, (2005). These results correlate with the largest standard deviations and CV values for 1000 particle weight are shown by the FBS milled particles.

The 1000-particle weights of the bulgur particles obtained from FTS and FBS mills were 23.56 and 14.91 g, respectively ($p<0.05$). These results were parallel to the results of sieve analyses and volume calculations.

Bulgur is used in a different size for various meals. For this, it was made sieve analyses. Percentage distribution of sieve analyses can be seen at Figure 5. For FTS mill sieve analysis results are 68.4, 17.2, 6.3, 2.7, 1.6, 1.5, 1.3, 1.1% from above 3.5, 3.0, 2.5, 2.0, 1.5, 1.0, 0.5, 0.0 mm sieve, respectively. Corresponding values are 14.5, 31.5, 20.0, 14.4, 9.1, 5.8, 3.3, 1.3 % for FBS mill.

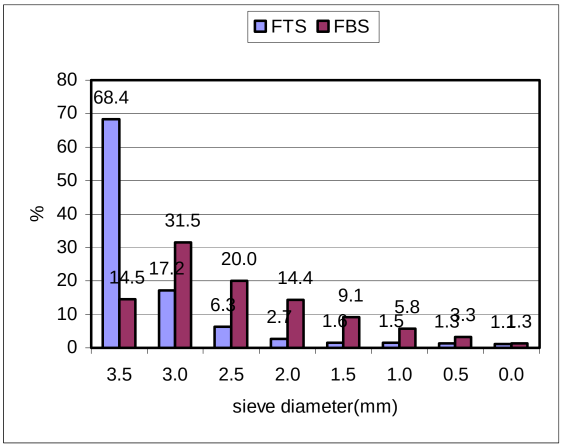
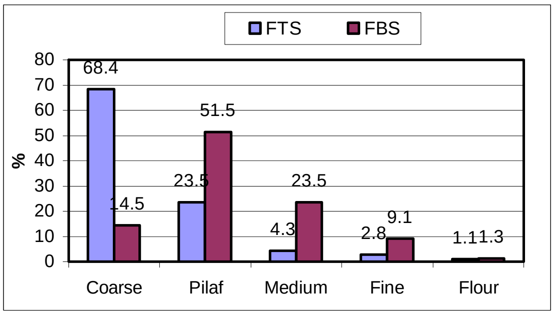


Figure 5. Percentage distribution after sieve analyses

Sieve analyses results were used for classification of bulgur. 8 different sieve percentages were collected to 5 sizes (Figure 6).



Figures 6. Classification of bulgur

Table 2. Some properties of milled bulgur

	FTS mill					FBS mill				
	min	max	mean	S.D.	%CV	min	max	mean	S.D.	%CV
major axis (mm)	1.97	6.78	4.70	1.14	24.31	1.60	7.21	4.28	1.25	29.18
medium axis (mm)	1.29	3.94	2.78	0.57	20.63	1.18	3.25	2.31	0.59	25.54
minor axis (mm)	0.46	3.18	1.98	0.61	30.58	0.42	2.45	1.48	0.37	24.94
V (mm^3)	1.12	36.93	14.96	8.50	56.78	0.92	20.39	8.39	4.89	58.36
ρ_b (g/100 ml) *	74.32	75.25	74.84	0.48	0.63	65.25	68.52	67.67	1.69	2.50
1000 particles weight (g)*	22.32	24.67	23.56	1.18	5.01	12.41	17.51	14.91	2.56	17.16

*$p<0.05$

The yield of coarse bulgur from the FTS mill (68.4%) was higher than the FBS mill (14.5%). The yield of the pilaf bulgur fraction was 23.5% from the FTS and 51.5% from FBS mill. The medium size bulgur yields were also 4.3% and 23.5%, respectively. Alike, fine bulgur yields were 2.8% and 9.1%, respectively. It is clear that FBS mill breaks to different small size. The overall yield (0.5/-) for the FTS and FBS mills were 98.9% and 98.7%, respectively. Due to the moving articulation effect of FBS, its yield was lesser than the FTS.

In other study (Bayram&Öner, 2005), the yield of coarse bulgur of durum wheat from the stone mill was determined 83.10% (over 2.2 mm on square sieve) and overall yield was determined 97.38%. In this study particles percentage over 2.5 mm is 91.9% from FTS mill and 66.0% from FBS mill. This difference may explain with more permeable square sieve type.

CONCLUSION

As a result, in the present study two horizontal stone mills' bulgur milling quality were determined. It was seen that FTS mill's bulgur particles are bigger than FBS mill, also fine and flour account is fewer in FTS mill. CV values show also that the FTS mill product is more uniform. FBS product's irregularity can be explained with top stone compression and vertical moving ability of FBS mill. In bulgur production, it is important to obtain homogeny particle size and big grain. Due to this aim it can be say that FTS mill performance is better than FBS mill.

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