Corn Bulgur: Effects of Corn Maturation Stage and Cooking Form on Bulgur-Making Parameters and Physical and Chemical Properties of Bulgur Products

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ABSTRACT

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Effects of the maturation stage (milk, yellow, or ripe) and cooking form (on the cob or shelled) of Narman sweet corn on some selected parameters obtained in the bulgur-making process were studied, and physical and chemical properties of corn bulgur products were examined. The results obtained at statistically significant levels ($P < 0.05$) are as follows. During cooking below 95°C for approximately 60 min, there was an increase in the dry matter content and color intensity of cooking wastewater. As the grain matured, the amount of material diffused into the cooking wastewater decreased. The yellow stage corn provided the hardest and most vitreous endosperm texture to the bulgur after drying and showed the highest resistance to grinding, whereas the milky stage corn bulgur showed the lowest resistance. On a raw material basis, the yields of the pilav bulgur (>1.5 mm) and total bulgur (>0.5 mm) increased sharply with grain maturation, especially in the ripe stage. In either total or yellow color intensity of the bulgur fractions, the yellow stage corn bulgur showed the highest values with amberlike yellowness and brightness. Increasing particle size from the bulgur flour (<0.5 mm) to the pilav bulgur (>1.5 mm) increased the color intensity. Ash, fiber, and protein contents of the all bulgurs decreased with maturation, but fat content increased. In general, the finer the corn bulgur fraction, the higher the ash, fiber, protein, and fat contents. In conclusion, the best stages were yellow corn for bulgur color, appearance, and functionality; milky corn for nutritional value; and ripe corn for bulgur yield.

Corn bulgur is parboiled whole or crushed corn made by a process generally resembling that for wheat bulgur, a traditional food in Turkey. After harvest, corn is cooked on the cob and dried; the kernels are shelled from the cob and milled into coarse grist on a bulgur stone mill. The nutritive value is increased by this treatment, because the water dissolves vitamins and minerals present in the outer layers of the kernel and carries them into the endosperm (Haley and Pence 1960, Seckin 1968, Abdel-Rahman 1984). Corn bulgur has good storage properties due to enzyme inactivation and is resistant to attack by insects and mites because of the vitreous endosperm structure. According to the Turkish peasants, bulgur processed from corn harvested in the milky or yellow maturation stage is much more delicious than that in the ripe stage. Recently sweet corn has gained importance as a raw material for bulgur making. Today there is no industrial corn bulgur production; it is entirely homemade in the central and northern regions of the country.

The consumption of corn bulgur resembles that of wheat bulgur. It is used, mainly as a substitute for rice, in pilav, a common dish of our country (consisting of bulgur, meat, oil, salt, and herbs cooked together), and in several soups cooked by boiling in water or ideally in milk. Corn bulgur flour, a by-product of processing, is used as an ingredient in several cooked and baked sweet goods.

There is no published information on corn bulgur, and therefore the objectives of this study are to introduce the processing treatments of corn bulgur and to investigate the effects of the corn maturation stage (milky, yellow, or ripe) and cooking form (on the cob or shelled corn) on bulgur products. The increasing interest in recent years in the use of sweet corn for making bulgur attracted us to this study on sweet corn bulgur.

MATERIALS AND METHODS

Narman sweet corn was obtained from the experimental farm of Ataturk University in Erzurum, Turkey. The materials were sampled in three maturation stages dated September 20 (milky stage with milklike endosperm), October 1 (yellow stage with waxlike endosperm), and October 20 (ripe with dry endosperm) of the 1986 crop year.

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Experimental Design

Fifty ears were harvested from the same planting in each maturation stage (milky, yellow, and ripe) and divided randomly into two groups. The first group was cooked as corn on the cob; the second group was shelled by hand before cooking. The sampling was achieved with two replications from the different plantations in the same location.

Bulgur-Making Process

For each maturation stage, both cooking forms (on the cob and shelled) were cooked separately in water at a temperature not exceeding 95°C until the endosperm was entirely gelatinized. The cooked materials were dried at 55 ± 5°C to 10% moisture content. Before crushing, the cooked and dried corn cobs were shelled by hand. Both groups in the shelled form were conditioned with 2% additional water by mixing for half an hour, milled into coarse grist on the disk mill so that all the material passed through a 3-mm sieve, and aspirated to remove bran material.

Parameters Measured

After cooking, all excess cooking water was drained from the cooked material, and the dry matter content was determined at 70°C for 24 hr in a vacuum oven (AACC 1976) after measuring the yellow and total color intensities on a Lovibond Tintometer (Lovibond Tintometer, type D; Tintometer Ltd., Salisbury, England).

In milling experiments on the laboratory disk mill, as an index of resistance to grinding, the energy requirement of 100 g of whole corn bulgur was measured by using a clamp amperemeter and expressed as watt-hours (Whr). The ground material was classified using 2.5-, 1.5-, and 0.5-mm sieves and separated into three fractions found in everyday usage: pilav bulgur over 1.5 mm, fine bulgur between 0.5 and 1.5 mm, and corn bulgur flour under 0.5-mm screens.(Anonymous 1979). The yields were calculated as percentages of the raw material.

The moisture and ash contents were determined by ICC methods (1965); the fiber, protein, and fat contents were determined by AACC methods (1976). All analyses were determined on raw shelled corn samples and on bulgur products. Results are shown on a dry basis. In addition, the yellow and total color intensities of the bulgur fractions were obtained using a Lovibond Tintometer on a mixture of bulgur and water (2:1).

Statistics

The data were statistically analyzed by using two-way analysis of variance and Duncan's multiple range test (Steel and Torrie

1960). In this paper, only the statistically significant factors are discussed, and the results of statistical analyses are summarized in the tables. Also, the figures describe the interactions found to be statistically significant between maturation stage and cooking form.

RESULTS AND DISCUSSION

Analytical Results

Analytical data for the raw material are shown in Table I. As corn matured there was a sharp decrease in moisture content, especially after the yellow stage. Probably because of starch accumulation in the later maturation stage, the ash and protein contents decreased proportionally. Thus (without considering dry kernel yield) the milky corn kernel was a very rich protein source with 15.11% protein content. In addition, milky stage corn is more easily digested and has a higher protein efficiency ratio as reported by Reyna et al (1984).

Changes in Cooking Water

Cooking was completed in approximately 60 min for ripe shelled corn. Cooking times were shorter for corn on the cob and for early maturation stages. The ripe corn samples in both cooking forms burst after 60 min of cooking, so the cooking procedure was stopped. As seen in Table II and Figure 1, as maturation progressed from the milky to ripe stages, the dry matter content of the cooking wastewater decreased. Also, cooking of corn on the cob was superior to the shelled form, especially for the milky stage. The results showed a very high loss in soluble dry matter during the cooking of milky stage shelled corn.

Table III gives the F values and significance levels of several measured parameters. Total color intensity decreased significantly ($P < 0.01$) with maturation and/or with samples cooked on the cob (Table IV). The highest total color intensity was obtained for milky stage shelled corn, possibly, because of its high breakage susceptibility to the shelling procedure and higher content of soluble matter than those of the later maturation stages. The reasonable causes of the increase in total color intensity of the cooking wastewater could be the peroxidase activity during the initial stage of the cooking (Garnote et al 1987) as enzymic browning. However, during the entire cooking time, a Maillard reaction might occur easily between reducing sugars and the essential alpha amino acids of nitrogenous substances present in the soluble dry matter of the wastewater. Another source of the intensive color development could be the yellow colorant loss of the bulgur. In every case, the increase in dry matter content and the color intensity of the cooking wastewater indicated the loss of soluble nutrients such as essential amino acids, beta carotene, minerals, and soluble carbohydrates.

TABLE I
Analytical Data For the Corn at Different Maturation Stages

	Maturation Stage[a]		
Constituents (%)	Milky	Yellow	Ripe
Moisture	69.4	63.2	14.8
Ash[b]	2.37	2.07	1.64
Fiber[b]	4.36	5.27	5.51
Protein[b] (N × 6.25)	15.11	11.34	10.57
Fat[b]	3.30	2.41	2.64

[a]Milky = Milklike endosperm; yellow = waxlike endosperm; ripe = dry endosperm.
[b]Dry basis.

Milling Studies

Data from the milling experiments are given in Table II. The coarse fractions over 1.5 mm showed higher values than the other fractions. Also, milky stage bulgur gave the highest bran and dust fractions due to its high fiber content (Table V and Fig. 2).

The statistically significant change of energy requirement in the grinding of the whole bulgur as an index of hardness of the endosperm resulting from the cooking and drying procedures is shown in Table II and illustrated in Figure 1. As seen, the bulgur made of shelled, milky corn needed very low energy in milling because its high moisture content and the high soluble dry matter loss during cooking resulted in more shrunken kernels. While milky stage corn bulgur had a more convenient physical state for the milling, it was not functional as bulgur. Yellow stage corn bulgur had the highest energy requirement in both cooking forms (Fig. 1) as a result of the vitreous and tough endosperm structure. This structure is essential for better storage stability and the appearance of bulgur products (Neufeld et al 1957). The bulgur samples cooked in the shelled form required lower energy than those cooked on the cob for all the maturation stages.

As shown in Table IV and Figure 1, as corn matured both the pilav (>1.5-mm screen) and total (>0.5-mm screen) bulgur yields increased.

Characteristics of Corn Bulgur Products

The results of the color measurement and chemical analysis of the corn bulgur products are given in Table V. In general, as the fractions of the ground bulgur became finer in particle size, the ash, fiber, protein, and fat contents increased. The trend was similar for color intensity except for milky stage corn cooked

TABLE II
Bulgur-Making Data of Corn Harvested in Different Maturation Stages and Cooked On the Cob or Shelled [a]

	Milky[b]		Yellow[b]		Ripe[b]	
Parameters	On the Cob	Shelled	On the Cob	Shelled	On the Cob	Shelled
Cooking wastewater						
Dry matter (%, grain db)	2.22	4.4	1.57	2.66	0.75	1.29
Total color intensity (Lovibond)	0.55	0.95	0.30	0.55	0.45	0.65
Energy requirement in milling (Whr/100 g whole bulgur)	34.8	22.4	36.3	34.8	30.9	30.2
Granulation of bulgur (%)						
> 2.5 mm	12.7	24.5	21.9	26.0	18.4	17.0
1.5–2.5 mm	32.9	32.4	24.9	28.0	31.7	32.6
0.5–1.5 mm	11.6	11.3	21.0	12.7	19.6	19.4
< 0.5 mm	21.1	10.4	21.9	20.8	18.3	18.3
Bran and dust	21.6	21.4	10.3	12.5	12.0	12.7
Bulgur yield (%)						
Pilav (>1.5 mm)	14.0	17.4	17.3	19.0	42.7	42.3
Total (>0.5 mm)	20.9	20.9	25.0	24.6	59.4	58.8

[a]Each reading is the mean of two replications.
[b]Milky = milklike endosperm, yellow = waxlike endosperm, ripe = dry endosperm.

TABLE III
F Values and Their Significances
(Obtained by Analysis of Variance of the Data)
Relating to Parameters of Corn Bulgur Production

Source of Variation[a]	df	Cooking Wastewater: Dry Matter	Cooking Wastewater: Total Color Intensity	Milling Energy Requirement	Bulgur Yield[b]: Pilav	Bulgur Yield[b]: Total
MS	2	7.46	12.9**[c]	1.22	215.66**	367.44**
CF	1	6.89	28.9**	1.68	2.61	0.38
MS × CF	2	13.12**	1.3	47.94**	6.37**	6.17*
Error	6					

[a]MS = Maturation stage, CF = cooking form.
[b]Pilav = over 1.5 mm, total = over 0.5-mm screen.
[c]** = $P<0.01$ and * = $P<0.05$.

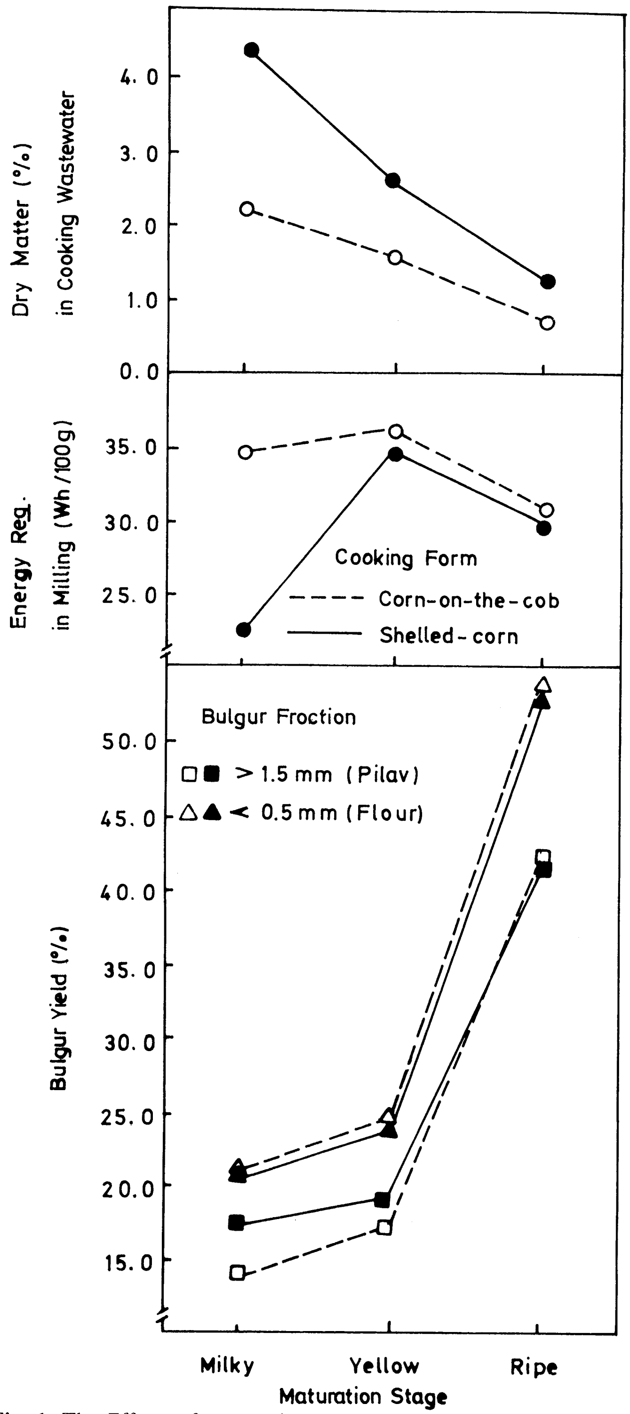

Fig. 1. The Effects of maturation stage and cooking form of the corn on some parameters obtained in the bulgur-making process.

on the cob. The finest fraction (corn bulgur flour) has the highest nutrient content. Similar findings confirming our results for ash and fat contents of ground raw corn samples on the Stenvert hardness tester were described by Pomeranz and Czuchajowska (1985) and Pomeranz et al (1986).

The results of the statistical analysis of the data are summarized in Tables VI, VII, and VIII, and in Figures 2 and 3.

Whole Bulgur

As illustrated in Figure 2, there was a relative decrease in the

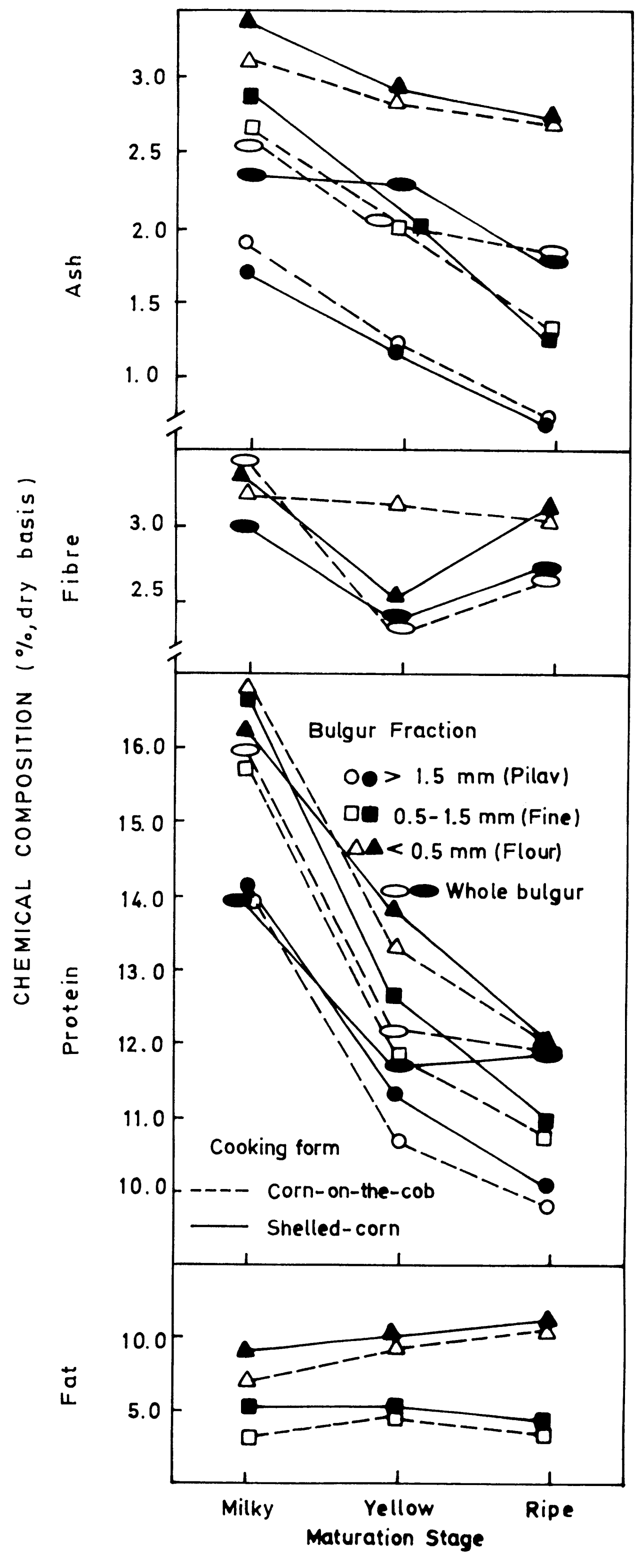

Fig. 2. The effects of maturation stage and cooking form of the corn on some chemical components of bulgur products.

ash content of whole bulgur during maturation, corresponding to the properties of the raw material used (Table I). Also, it was determined that whole bulgur cooked as shelled corn from the milky stage and ripe kernels had lower ash contents than those cooked on the cob. The findings presented in Table II and Figure 1 show some ash loss in milky stage, shelled corn during cooking from diffusion into wastewater and during milling from the high amounts of bran and dust removed from the whole kernel. A little ash loss in ripe shelled corn possibly results from the greater tendency of the shelled kernels to burst. In relation to nutritional loss, the yellow stage corn bulgur retained more minerals during bulgur making when the corn was shelled before cooking.

TABLE IV
Effects of Maturation Stage and Cooking Form on the Color Intensity of Cooking Wastewater and Yield of Corn Bulgur Based on Duncan's Multiple Range Test[a]

Variable (n)	Color Intensity of Cooking Wastewater[b]	Bulgur Yield[c](%) Pilav	Total
Maturation stage			
Milky (4)	0.75 a	15.7 c	19.2 c
Yellow (4)	0.43 b	18.6 b	24.8 b
Ripe (4)	0.55 b	42.5 a	59.1 a
Cooking form			
Corn on the cob (6)	0.43 b	...	...
Shelled corn (6)	0.71 a	...	...

[a]Means with the same letter are not significantly different ($P < 0.05$).
[b]Measured on a Lovibond Tintometer.
[c]Pilav = over 1.5 mm, total = over 0.5-mm screen.

Figure 2 also shows the statistically significant changes in fiber content of whole bulgur, especially for milky stage corn samples; the whole bulgur from corn cooked on the cob showed higher fiber content than that from shelled corn due to the same causes described for the loss of ash content.

The protein content of whole bulgur was affected by the same interaction (Table VI). As seen in Figure 2, the proportional protein content of whole bulgur decreased with maturation. Especially, whole bulgur from the milky stage had a higher protein content for the bulgur from corn cooked on the cob than from shelled corn. The difference in protein content between the two cooking forms was the largest for milky stage corn bulgur due to greater soluble loss during the cooking (Fig. 1), and became lowest with the ripe corn. The protein contents of the yellow stage and ripe corn bulgur were almost same. The detrimental effect of shelling on protein content of the whole bulgur was small for the yellow stage and disappeared by ripening. If it is not important to obtain high bulgur yield, the whole bulgur from milky stage corn cooked on the cob has the highest protein content (Fig. 2) in addition to its nutritive value described by Reyna et al (1984) for milky corn and by Abdel-Rahman (1984) for cooking process.

As seen in Table VII, during maturation the fat content of the whole bulgur increased from the milky to yellow stage; a slight increase occurred in the ripe stage.

Pilav Bulgur

Pilav bulgur is the main product of the bulgur-making process. Consumers in Turkey prefer a vitreous structure and amberlike yellowness; the nutritive value of corn bulgur is of secondary interest. For this reason, the yellow and total color intensities

TABLE V
Characteristics of Bulgur Products[a] from Corn Harvested at Different Maturation Stages and Cooked On the Cob or as Shelled Corn[b]

	Corn Maturation Stage[c]					
	Milky		Yellow		Ripe	
Parameters	On the Cob	Shelled	On the Cob	Shelled	On the Cob	Shelled
Color intensity on Lovibond Tintometer						
Pilav bulgur	5.9	7.5	9.1	9.1	7.6	7.5
Yellow color						
Fine bulgur	8.3	6.5	7.6	8.8	6.1	6.4
Bulgur flour	6.3	5.1	6.2	5.5	3.4	3.1
Pilav bulgur	7.7	9.8	11.3	11.7	9.6	9.8
Total color						
Fine bulgur	10.3	8.3	9.5	11.0	7.9	8.3
Bulgur flour	7.7	6.7	8.4	7.2	4.7	4.4
Chemical composition (%, db)						
Ash						
Whole bulgur	2.54	2.35	2.02	2.27	1.81	1.79
Pilav bulgur	1.89	1.71	1.20	1.21	0.70	0.68
Fine Bulgur	2.67	2.87	2.00	2.02	1.31	1.24
Bulgur Flour	3.13	3.51	2.86	2.95	2.70	2.71
Fiber						
Whole bulgur	3.57	3.03	2.30	2.40	2.64	2.66
Pilav bulgur	1.25	1.10	1.06	1.10	0.85	0.86
Fine bulgur	1.96	1.40	1.37	1.43	1.39	1.44
Bulgur flour	3.41	3.73	3.33	2.50	3.15	3.20
Protein[d]						
Whole bulgur	15.9	13.9	12.1	11.7	11.9	11.9
Pilav bulgur	14.2	14.2	10.7	11.3	9.8	10.1
Fine bulgur	15.8	16.7	11.8	12.7	10.8	11.1
Bulgur flour	16.8	16.3	13.3	13.8	12.1	12.1
Fat						
Whole bulgur	4.02	4.51	5.27	5.16	5.42	5.52
Pilav bulgur	1.58	1.72	1.62	1.63	1.73	1.74
Fine bulgur	3.70	5.39	4.98	5.14	4.13	4.28
Bulgur flour	6.93	9.53	9.31	10.29	10.54	10.95

[a]Pilav bulgur = over 1.5 mm, fine bulgur = between 0.5 and 1.5 mm, bulgur flour = through 0.5-mm screen. Whole bulgur = sound bulgur grain with bran.
[b]Each reading is the mean of two replications.
[c]Milky = milklike endosperm, yellow = waxlike endosperm, ripe = dry endosperm.
[d]Protein = N × 6.25.

of pilav bulgur were measured on a Lovibond Tintometer and are given in Table V, and the results of statistical analysis of the data are given in Table VIII. Diagramatic representation of the statistically significant maturation stage × cooking form interactions in the color intensities are presented in Figure 3. As seen, the pilav bulgur of corn harvested in the yellow stage gave the most desirable and intensive yellow and total color. In general, cooking shelled corn provided more intensive total color than cooking corn on the cob, but not for yellow color. In the milky stage pilav bulgur, both total and yellow color intensities showed lower values for corn cooked on the cob; these were much different from those of the more mature stages. The difference in yellow color between the cooking forms was not important for the yellow and ripe maturation stages. Consequently, shelled corn of the yellow stage was seen as the most useful combination for bulgur making, having the preferred yellow color and economy of cooking process, saving energy and space. The reasons for the satisfying bright and amberlike yellowness of the pilav bulgur obtained for shelled corn of yellow stage are, presumably, easy swelling, good gelatinization, colorant transfer from the outer layers into the endosperm during the cooking, the more vitreous endosperm after drying, and ultimately, large granulization over 1.5mm in milling (Table II). Possibly, the richer pigment and large granulization are the most probable causes of the intensive color of yellow stage corn bulgur.

The results of statistical analysis of ash data (Table VI) show that, generally, there was a gradual decrease in ash content in the pilav bulgur with maturation. Among all the bulgur products, pilav bulgur is the largest fraction and has the lowest ash content (Fig. 2). This finding shows that the source of the pilav bulgur is predominantly the central endosperm of the kernel, confirmed for ground raw corn by Pomeranz and Czuchajowska (1985).

The fiber content of pilav bulgur was affected only by variation in maturation stage (Table VI). As seen in Table VII, the fiber

TABLE VI
***F* Values and Their Significance (Obtained by Analysis of Variance) of Chemical Composition Data of Whole Bulgur and Its Fractions[a] (df of error = 6)**

Component/ Source of Variation[b]	df	Whole Bulgur	Pilav Bulgur	Fine Bulgur	Bulgur Flour
Ash					
MS	1	8.46	118.23**[c]	118.32*	3.32
CF	1	0.01	1.15	00.40	2.90
MS × CF	2	28.96**	11.17**	20.25**	21.97**
Fiber					
MS	1	7.43	27.33**	3.67	1.22
CF	1	0.48	0.53	2.51	0.20
MS × CF	2	22.22**	1.67	4.68	19.46**
Protein					
MS	1	11.28	210.79**	260.56**	69.04
CF	1	1.83	2.27	12.54	0.09
MS × CF	2	240.36**	81.61**	15.58**	28.81**
Fat					
MS	1	52.54**	0.75	0.94	5.01
CF	1	2.50	0.44	1.70	4.13
MS × CF	2	3.02	0.32	102.00**	16.24**

[a]Pilav bulgur = over 1.5 mm, fine bulgur = between 0.5 and 1.5 mm, bulgur flour = through 0.5-mm screens.
[b]MS = Maturation stage, CF = cooking form.
[c]* = $P < 0.05$, ** = $P < 0.01$.

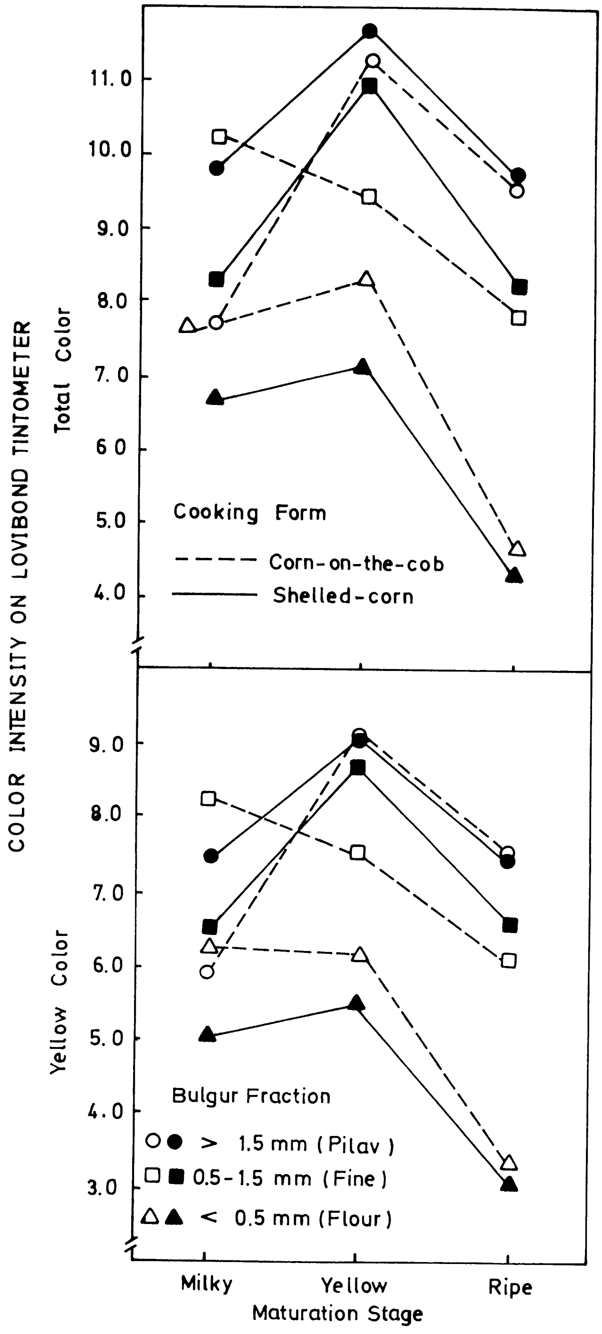

Fig. 3. The effects of maturation stage and cooking form of the corn on the color intensity of bulgur products.

TABLE VII
The Effects of Maturation Stage on the Chemical Composition[a] of Whole Bulgur and its Fractions Based on Duncan's Multiple Range Test[b] for Significant Factors

Maturation Stage (n)	Whole Bulgur Fat (%)	Pilav Bulgur[c] Ash (%)	Pilav Bulgur[c] Fiber (%)	Pilav Bulgur[c] Protein[d] (%)	Fine Bulgur[c] Ash (%)	Fine Bulgur[c] Protein[d] (%)
Milky (4)	4.27 b	1.80 a	1.18 a	14.21 a	2.77 a	16.25 a
Yellow (4)	5.22 a	1.21 b	1.08 b	10.98 b	2.01 b	12.27 b
Ripe (4)	5.47 a	0.69 c	0.86 c	9.95 c	1.28 c	10.95 c

[a]Dry basis.
[b]Means with the same letter are not significantly different ($P < 0.05$).
[c]Pilav bulgur = over 1.5 mm, fine bulgur = 0.5 and 1.5 mm screens.
[d]Protein = N × 6.25.

TABLE VIII
F Values and Their Significance (Obtained by Analysis of Variance) for Color Intensities of Corn Bulgur Fractions Measured on a Lovibond Tintometer

Source of Variation[b]	df	Pilav Bulgur[a] Yellow	Pilav Bulgur[a] Total Color	Fine Bulgur[a] Yellow	Fine Bulgur[a] Total Color	Bulgur Flour[a] Yellow	Bulgur Flour[a] Total Color
MS	2	6.27	7.73	1.46	1.41	79.36	61.21
CF	1	0.75	2.23	0.03	0.00	11.37	10.00
MS × CF	2	225.80**[c]	218.00**	500.66**	967.65**	15.87**	48.20**
Error	6						

[a]Pilav bulgur = over 1.5 mm, fine bulgur = between 0.5 and 1.5 mm screens, bulgur flour = through 0.5-mm screens.
[b]MS = Maturation stage, CF = cooking form.
[c]** = $P<0.01$.

content of the pilav bulgur decreased during maturation, possibly due to the low bran and dust content of the ripe kernel (Table I) and correspondingly low bran contamination of the pilav bulgur.

There was a sharp decrease in the pilav bulgur protein content correlated with maturation, especially from the milky to the yellow stages (Tables VI and VII, Fig. 2). Corn cooked after shelling had higher protein content than corn cooked on the cob, the difference being largest in yellow stage pilav bulgur. But for whole bulgur, this finding was contrary (Fig. 2). These results suggest that during the cooking process, while some soluble nitrogenous substances are removed from the outer layers of the kernel some are transferred through the central endosperm.

The fat content of pilav bulgur was the lowest among all the corn products (Table V) as a result of distribution of fat in the outer layers and germ of the kernel.

Fine Bulgur

Fine bulgur is the second most important bulgur product and is used in some meat dishes in Turkey. As seen in Figure 3, the yellow stage corn gave the highest intensity in both total and yellow color of fine bulgur, and with further maturation color intensity decreased. In addition, shelling corn before cooking resulted in higher color intensity. In contrast, the fine bulgur of milky stage corn had a higher color intensity for corn cooked on the cob. Although the trend was similar to those of the pilav bulgur for the yellow and ripe stages, it was reversed for the milk stage.

The ash content of the fine bulgur decreased with grain maturation (Table V and Fig. 2), especially from the milky to yellow stage, similar to that of the pilav bulgur. Also, cooking cob had a lower ash content than the cooked shelled corn. Also the variation in fiber content was not parallel to the ash content of the fine bulgur (Table V).

The fine bulgur protein content showed a sharp decrease during maturation (Table V and Fig. 2), especially from the milky to yellow stage, similar to that of the pilav bulgur. Also, cooking of shelled corn gave a higher protein content than cooking corn on the cob, resembling that of the pilav bulgur (Fig. 2).

The changes in fat content of the fine bulgur are shown in Figure 2. Apart from the fine bulgur of the milky stage corn on the cob, the other samples showed a higher and almost equivalent fat level during maturation.

Bulgur Flour

As a by-product of the bulgur-making process, bulgur flour is used commonly in homemade soups and *helva*, a sweet meal made of flour or semolina, butter, sugar, and water or milk. The total and yellow color intensities of bulgur flour were significantly affected by the maturation stage × cooking form interaction (Table VI). As seen in Figure 3, in contrast to the coarser fine and pilav bulgurs, the bulgur flour from corn cooked on the cob recorded higher color intensities at all the maturation stages.

As seen in Table V and Figure 2, the ash content of bulgur flour was the highest among all the bulgur products. In general, the ash content decreased steadily with maturation, the bulgur flour of shelled corn being the highest, especially for the milky and yellow stages. As with other fractions, there was a decrease in protein content of the bulgur flour with maturation. However, the fat content of the bulgur increased with maturation. The higher fat content of bulgur flour is a desirable property for soup and *helva* making, allowing less butter and oil to be used and providing better flavor to the meal.

CONCLUSIONS

The results described in this paper indicate that, in every case, the yellow stage corn bulgur was the best for functionality but not for bulgur yield. The loss of the soluble dry matter during cooking was observed in all maturation stages and cooking forms, being the highest for the milky stage. To solve this problem, corn needs to be cooked without wastewater or by one of the steam-cooking methods. The bulgur flours of all the corn maturation stages were very rich in ash, protein, and fat contents, with the milky stage flour being the most nutritious. These parboiled and nutrient-rich bulgur flours might be considered valuable for soup and baby foods.

The most delicious milky and yellow stage sweet corn bulgur could be an alternative to canned corn products after boiling in water, or ideally in milk, for 15 min.

The ripe stage corn produced the highest bulgur yield but tended to burst during cooking and could not be obtained with entirely gelatinized endosperm. Further research is necessary to solve these problems. In addition, the nutritive value and organoleptic properties of corn bulgur products ought to be the subject for further studies.

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