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Effects of wheat maturation stage and cooking method on physical and chemical properties of firiks

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Abstract

In this study, samples of two durum wheat cultivars at different maturation stages (13, 16, 19, 22, 25 days post anthesis) were processed into firik using two different cooking processes: roasting (scorching) on flames and boiling at atmospheric pressure. In both cultivars hectolitre weights and 1000 kernel weights of the firiks produced by boiling and roasting increased steadily and significantly ($p < 0.05$) with maturation. The percent of small kernels decreased and the percent of large kernels increased uniformly in the firiks produced by boiling and roasting from both cultivars during ripening. The ash contents of the firiks of both cultivars decreased significantly ($p < 0.05$) with maturation. Fe, Cu, Zn, Mn Na, K and Mg contents of the firiks of both cultivars produced by both methods showed a downward trend within the period of maturation. However, Ca contents of the firiks, first showed a significant ($p < 0.05$) upward trend and then a downward trend during maturation. Significant ($p < 0.05$) reductions in thiamin and riboflavin contents occurred in both cooking methods and both cultivars with maturation. The first two stages of kernel development (13 and 16 days after anthesis) resulted in the highest sensory scores, for the firiks produced by both methods.

1. Introduction

Firik (or frekeh) is a traditional food which is consumed in several countries of the Middle East and North Africa (Williams & El-Haremein, 1985; Dick & Matsuo, 1988; Qarooni, 1995). Immature bread wheats and, preferentially, durum wheats are used in the production of firik. Today, there is no large-scale industrial firik production. It is generally homemade for domestic consumption or commercially produced by small-scale manufacturers (Özkaya, Özkaya, & Köksel, 1998).

Firik is usually produced from immature wheat by two different processes: roasting (scorching) the immature spikes on flames to burn off the awns and leafy material or boiling them at atmospheric pressure. Then the cooked spikes are dried in the sun, threshed and the kernels separated from hulls. The parching or charring gives the firik a characteristic flavour (Dick & Matsuo, 1988). The consumption of firik resembles that of bulgur. It is mainly used as a substitute for rice and bulgur in pilav. Firik-pilav is a traditional dish in Anatolia, consisting of firik, meat, tomatoes, salt, fat and/or butter cooked together. It is generally accepted that firiks processed from wheat harvested in late-milk-ripe to mid-dough-ripe stages are more delicious than the ones processed at the full ripe stage, probably due to higher contents of free simple sugars. Durum wheat is the most suitable raw material since the best firik is made from the largest, hard kernels (Dick & Matsuo, 1988; Özkaya et al., 1998).

Physical properties and chemical composition of wheat vary during the maturation period. In a study including hard red spring and durum wheats, decreases in moisture and ash contents and increases in test weight, 1000 kernel weight and kernel size were observed as the maturation proceeded (Skarsaune, Youngs, & Gilles, 1970). Preston, Kilborn, Morgan, and Babb (1991) reported that kernel hardness, kernel weight, test weight, ash content and milling quality were affected more than protein content. In another study, it was indicated that protein content of the kernel did not change significantly. However, changes were observed

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in the amino acid composition of proteins; some of the amino acids increased while others decreased as the grain matured (Pomeranz, Finney, & Hoseney, 1966). It was also reported that zinc and phytic acid contents increased while the total P content had a tendency to decrease as the kernels matured (Abernethy, Paulsen, & Ellis, 1973).

To the best of our knowledge there are no published research studies on firik. The changes in kernel composition during maturation will certainly affect the properties and composition of firiks produced from wheats at different maturation stages. The objective of this study was to examine the effects of different wheat maturation stages and cooking methods on the properties and composition of firiks.

2. Materials and methods

2.1. Material

Two durum wheat samples (cvs. Duraking, and Ege 88) used in this study were from the Experimental Research Farm of Harran University, Sanliurfa, Turkey. The materials were sampled at five different maturation stages, taken 13, 16, 19, 22, 25 days after anthesis.

2.2. Preparation of firiks

Wheat heads were randomly cut from the field at various maturation stages to obtain approximately 6 kg of grain. They were cut at the stem approximately 30 cm below spikes. For each maturation stage, the cut spikes were bunched into two groups and firiks were produced by two different cooking processes: by roasting (scorching) the spikes on flames and by boiling the spikes at atmospheric pressure in an open pan. For each cultivar these cooking methods were performed in duplicate. During scorching on flames, each bunch of spikes was exposed to fire by holding from the stems. The hulls covering the grain and the awns got burnt almost completely, but care was taken to avoid excessive parching of the kernels. Threshing was performed by rubbing the heads on metal sieves and hulls, and chaff were removed by ventilation. Then the firik samples were dried in the sun. For cooking at atmospheric pressure, wheat spikes were cooked in boiling water for 20 min. The cooked material was dried under the sun. Threshing was performed using an experimental thresher. In both processing methods, the cooked material was dried to a moisture content of about 10%.

2.3. Tests on grain and firik samples

All of the tests on the firik samples were performed in triplicate and the average values reported. The hectolitre weight was determined by using an Ohaus test weight apparatus and reported on an "as is" moisture basis. The weight per thousand kernels was determined by counting the number of seeds in 20 grams of grain and reported on a dry basis.

Protein, ash, thiamin and riboflavin contents, and mineral element composition were determined in parallel on each duplicate sample and the average values reported on a dry basis. Samples of raw wheats and firiks were ground in a laboratory mill (Falling Number, Type-KT 30). Moisture, protein (Nx5.7), and ash contents were determined according to AACC Approved Methods 44-15A, 46-12, 08-01, respectively (Anonymous, 1995). Thiamin and riboflavin contents were determined according to AACC Approved Methods 86-80 and 86-70, respectively (Anonymous, 1995). Samples for mineral element measurements were prepared according to the methods by Czerniejewski, Shank, Bechtel, and Bradley (1964). Following this preparation, an atomic absorption spectrophotometer (Perkin–Elmer 1100 b) was used for the determination of Fe, Cu, Zn, Mn, Ca and Mg contents (Garcia, Blessin, & Inglett, 1972). Na and K contents were quantified by a flame photometer as described by Czerniejewski et al. (1964).

2.4. Sensory analysis

For sensory analysis, the dry firik samples (150 g) were cooked in 300 ml water on a hot plate for 20 min. The samples were then rested for 5 min. A minimum amount of water was used to avoid leaching of soluble nutrients which is the most common practice for the preparation of firiks for consumption. The cooking time and the optimum amount of water required for cooking were determined in preliminary studies. For each sample, the cooking was performed in duplicate.

After cooking, the firik samples were served in disposable dishes labelled randomly with two digit numbers. Eight panellists were chosen who were familiar with firik. Ages ranged from 25 to 45. Three of them were male. All panellists were non-smokers. Instructions were given in full to panellists beforehand. Final judgment was obtained by averaging the scores given by all panellists.

Roasted firik samples were scored from 5 to 1 for four quality parameters; taste and aroma, mouthfeel, colour, odour. A ballot sheet was prepared (Table 1) by adapting the parameters and scoring of pasta products and noodles to firik (D'Egidio et al., 1982; Köksel, Çelik, & Tuncer, 1996). Sensory analysis of firiks produced by boiling was carried out similarly to the scoring of firiks produced by roasting, except the odour value. The firiks produced by boiling did not show a notable variation in terms of odour. Therefore they were not evaluated for their odour values.

Table 1
Ballot sheet

Taste and aroma
(5) Characteristic firik taste and aroma; no undesirable taste and aftertaste
(4) Characteristic firik taste and aroma; slightly undesirable taste and aftertaste
(3) Perceptible deviation from firik taste and aroma; slightly undesirable taste and aftertaste
(2) Definite undesirable taste and aftertaste
(1) Unacceptable taste and aroma

Mouthfeel
(5) Very pleasant, aldante, nonsticky
(4) Pleasant, al dente, nonsticky
(3) Slightly sticky when chewing
(2) Sticky when chewing
(1) Very sticky and doughy when chewing

Colour
(5) Yellowish green colour with a low level of dark spots
(4) Slight deviations from yellowish green colour with a low level of dark spots
(3) Slightly grayish yellow colour with no perceptible greenness with a moderate level of dark spots
(2) Gray colour with a high level of dark spots
(1) Dark gray colour with a very high level of dark spots

Odor
(5) Characteristic roasted firik odour; no undesirable odour due to processing
(4) Characteristic firik odour; slight undesirable odour due to processing
(3) Perceptible deviation from characteristic firik odour; slight undesirable odour due to processing
(2) Definite undesirable odour due to processing
(1) Unacceptable odour due to processing

2.5. Statistical analysis

The data were statistically evaluated by the one-way analysis of variance procedure (factor: maturation time) using a MSTAT-C statistical analysis program (Anonymous, 1988). The least significant difference test was applied to compare the mean values.

3. Results and discussion

Hectolitre weight, 1000 kernel weight, kernel size distribution and, ash and protein contents of the firik samples produced using two different processing methods from the two durum wheat samples at different maturation stages are presented in Table 2. In both cultivars hectoliter weights and 1000 kernel weights of the firiks produced by boiling and roasting, increased steadily and significantly ($p < 0.05$) with maturation. The kernel weights of the firiks produced from the wheats harvested 25 days after anthesis were approximately three times larger than the ones produced from samples harvested 13 days after anthesis. The hectolitre weights of the firiks of the same cultivar at the same maturation stage produced by roasting were lower than the ones produced by boiling (probably due to shrivelling). The percent of small kernels decreased uniformly in firiks produced by boiling and roasting from both cultivars during ripening. The percent of large kernels increased until full maturity was attained. The ash contents of the firiks decreased significantly ($p < 0.05$) with maturation. The ash content of the firiks of cv. Duraking dropped from initial values of around 2.20% to less than 1.60% in the samples produced 25 days after anthesis. A similar decrease also occurred in the ripening of other cultivar (Ege). It was shown, in a study investigating the effects of maturation stage on corn bulgur, that ash contents of pilav bulgur and fine bulgur decreased substantially as corn matured (Elgün, Ertugay, & Certel, 1990). Skarsaune et al. (1970) also reported that ash content of whole wheat decreased linearly during maturation. In the present study, the ash contents of the firiks of the same cultivar and same maturation stage produced by roasting were higher than the ones produced by boiling. This might be due to dissolution of minerals during boiling. Similar changes in kernel weight, hectolitre weight and ash content during wheat maturation were also reported by Preston et al. (1991). In the present study, although the protein contents of the firiks produced by two different methods decreased slightly for both cultivars during maturation, the decreases were not significant. Pomeranz et al. (1966) also reported that protein content of wheat remained relatively uniform during maturation.

Mineral contents (Fe, Cu, Zn, Mn, Na, K, Ca, Mg) of the firik samples produced using two different processing methods from the durum wheat samples at different maturation stages are presented in Tables 3 and 4. Fe, Cu, Zn and Mn contents of the firiks showed a downward trend within the period of maturation (13–25 days post anthesis) used in firik production. Cu, Zn and Mn contents of the firiks produced by boiling were lower than the ones produced by roasting for both cultivars. However, Fe contents of the firiks produced by the two methods did not show such a tendency. Na, K and Mg contents of the firiks also showed a downward trend within the period of maturation (13–25 days post anthesis) used in firik production. Ca contents of the firiks first showed a significant ($p < 0.05$) upward trend and then a downward trend during maturation with the exception of firiks produced by boiling from cv. Ege. Abernethy et al. (1973) reported that Zn content increased steadily through maturity. Their results were presented as (mole Zn per kernel. However, their Zn content values would show a tendency to decrease if they were converted into Zn content per unit weight of

Table 2
Physical properties of firiks produced from two Durum wheats at different maturation stages by boiling and roasting[a,b]

Variety	Days after anthesis	1000 Kernel weight (g)		Hectolitre weight (kg/hl)		Kernel size distribution (%)								Ash[b] (%)		Protein[b] (%, N×5.7)	
						B[c]				R[d]							
		B[c]	R[d]	B[c]	R[d]	>2.8	>2.5	>2.2	<2.2	>2.8	>2.5	>2.2	<2.2	B[c]	R[d]	B[c]	R[d]
Duraking	13	15.1d	14.9d	62.8c	46.6d	0.0	1.4	4.8	93.8	6.6	5.1	9.8	78.6	2.18a	2.21a	13.5	13.3
	16	16.6d	17.4d	65.8c	53.0c	0.0	0.5	8.0	91.5	5.5	5.2	9.8	79.5	2.15a	2.19a	12.7	12.4
	19	22.0c	23.8c	73.4b	54.6c	0.0	3.4	29.4	67.2	10.9	8.1	35.7	45.2	1.86b	1.92b	12.8	12.9
	22	27.9b	30.3b	78.6a	59.7b	4.3	27.8	46.5	21.4	18.3	18.2	41.1	22.4	1.74b	1.76b	12.6	12.7
	25	48.0a	36.8a	82.5a	71.3a	16.3	47.8	28.9	7.0	28.0	45.0	19.5	7.5	1.57c	1.59c	12.4	12.5
	ripe	48.0		82.0				83.2	13.1	1.2	2.5			1.57		12.8	
	LSD ($p < 0.05$)	2.59	2.71	4.54	3.55									0.152	0.164		
Ege	13	18.0e	18.6e	66.2c	53.6d	0.0	0.7	10.5	88.8	4.1	5.8	17.9	72.2	2.27a	2.61a	14.5	14.5
	16	22.6d	23.5d	69.2c	55.4cd	0.0	2.1	26.8	71.1	10.9	10.7	42.9	35.5	2.26a	2.34b	13.7	14.0
	19	30.4c	31.0c	78.2b	58.6c	3.5	25.6	48.4	22.5	15.6	32.0	35.5	16.9	2.04b	2.11c	13.2	13.1
	22	38.6b	38.1b	81.2ab	63.1b	29.7	45.1	20.7	4.5	43.6	35.5	15.2	5.7	1.78c	2.01.c	13.4	13.3
	25	47.8a	44.3a	82.8a	71.4a	69.1	23.4	6.2	1.3	58.8	27.3	9.3	4.6	1.70c	1.81d	13.4	13.2
	ripe	50.1		82.6				77.6	18.8	3.6	0.0			1.72		13.9	
	LSD ($p < 0.05$)	2.56	2.50	4.06	3.94									0.196	0.186		

[a] For each cultivar, means with the same letter within a column are not significantly different ($p < 0.05$) by least significant difference analysis.
[b] Dry basis.
[c] B = Firiks produced by boiling.
[d] R = Firiks produced by roasting.

Table 3
Fe, Cu, Zn and Mn contents of firiks produced from two durum wheats at different maturation stages by boiling and roasting[a,b]

Variety	Days after anthesis	Fe (ppm)		Cu (ppm)		Zn (ppm)		Mn (ppm)	
		B[c]	R[d]	B[c]	R[d]	B[c]	R[d]	B[c]	R[d]
Duraking	13	55.9a	56.7a	10.0a	10.7a	31.6a	33.9a	38.3a	41.3a
	16	54.4a	53.4ab	9.4a	10.0ab	29.1b	31.8ab	35.6ab	42.4a
	19	54.2a	50.1b	6.0b	9.4b	27.2bc	30.4b	32.9b	37.7b
	22	43.5b	44.1c	5.3b	5.4c	25.5c	27.5c	30.0c	34.1c
	25	40.1b	42.2c	5.0b	5.4c	26.0c	26.1c	28.9c	29.3d
	ripe	40.2		6.2		29.6		29.8	
	LSD ($p < 0.05$)	4.11	4.04	1.03	0.95	2.30	2.48	2.82	2.96
Ege	13	50.1a	48.3a	11.2a	11.8a	37.9a	37.1a	35.2a	35.3a
	16	50.2a	42.2b	9.4b	10.4b	27.4b	27.5b	30.2b	31.4b
	19	44.7b	42.9b	9.1b	9.7bc	27.0b	28.0b	29.7b	31.1b
	22	43.4b	43.8b	6.0c	8.9cd	25.5b	27.2b	26.7c	29.8b
	25	43.9b	42.2b	6.4c	8.0d	25.9b	28.0b	24.9c	26.0c
	ripe	43.4		6.8		30.4		28.4	
	LSD ($p < 0.05$)	3.95	3.92	1.11	1.22	2.14	2.31	2.52	2.60

[a] For each cultivar, means with the same letter within a column are not significantly different ($p < 0.05$) by least significant difference analysis.
[b] Dry basis.
[c] B = Firiks produced by boiling.
[d] R = Firiks produced by roasting.

the sample considering the several fold increase in the kernel weights.

As shown in Table 5, at the early stages of kernel development, there were relatively high concentrations of thiamin and riboflavin in the firiks produced by both methods. Significant ($p < 0.05$) reductions in thiamin and riboflavin contents occurred in both cooking methods and both cultivars with maturation. Thiamin and riboflavin contents of the firiks produced by boiling were lower than the ones produced by roasting except for the thiamin contents of the firik samples produced from cv. Ege 13 and 25 days after anthesis. However, the difference of the firiks produced by roasting and boiling in terms of riboflavin content was much greater as compared to their difference in thiamin content. The larger loss of riboflavin may be attributed to sun-drying (Pence, Ferrel, & Robertson, 1964; Özkaya, Özkaya, & Köksel, 1996). Although the firiks produced by both

Table 4
Na, K, Ca and Mg contents of Firiks produced from two durum wheats at different maturation stages by boiling and roasting[a,b]

Variety	Days after anthesis	Na (mg/100g)		K (mg/100g)		Ca (mg/100g)		Mg (mg/100g)	
		B[c]	R[d]	B[c]	R[d]	B[c]	R[d]	B[c]	R[d]
Duraking	13	10.4a	9.0a	435a	430a	37.3c	32.1c	200a	195a
	16	8.9b	8.2a	387b	418a	52.0a	52.0a	189b	199a
	19	7.2c	6.6b	384b	387b	46.8b	39.4b	173c	183b
	22	7.6c	6.8b	377bc	375bc	36.3c	41.5b	170c	182b
	25	5.4d	5.0c	369c	371c	33.1d	32.1c	169c	179b
	ripe	5.4		370		35.6		166	
	LSD ($p < 0.05$)	0.92	0.89	13.2	12.6	3.11	2.98	10.4	9.7
Ege	13	12.6a	12.5a	430a	428a	47.8a	41.0a	201a	202a
	16	9.5b	10.7b	423a	400b	45.7a	42.6a	195a	202a
	19	9.0b	11.0b	394b	390bc	40.5b	41.5a	190ab	190b
	22	7.8c	8.2c	389bc	392bc	39.7b	41.5a	181bc	183b
	25	7.6c	7.2c	378c	383c	38.1b	34.2b	175c	184b
	ripe	7.8		458		44.2		178	
	LSD ($p < 0.05$)	0.98	1.02	14.0	14.3	2.77	2.63	11.5	11.1

[a] For each cultivar, means with the same letter within a column are not significantly different ($p < 0.05$) by least significant difference analysis.
[b] Dry basis.
[c] B = Firiks produced by boiling.
[d] R = Firiks produced by roasting.

Table 5
Thiamin and riboflavin contents of firiks produced from two durum wheats at different maturation stages by boiling and roasting[a,b]

Variety	Days after anthesis	Thiamin[a] (μg/g)		Riboflavin[a] (μg/g)	
		B[c]	R[d]	B[c]	R[d]
Duraking	13	2.70a	2.75a	1.93a	2.80a
	16	2.38b	2.50b	1.98a	2.36b
	19	2.15bc	2.28bc	1.40b	2.32b
	22	2.10c	2.30bc	1.25b	1.95c
	25	2.10c	2.23c	1.20b	1.55d
	ripe	3.68		1.85	
	LSD ($p < 0.05$)	0.277	0.240	0.215	0.248
Ege-88	13	2.70a	2.65a	2.00a	2.76a
	16	2.56ab	2.62a	1.95a	2.68a
	19	2.56ab	2.62a	1.83a	2.52ab
	22	2.48b	2.50a	1.40b	2.31b
	25	2.30c	2.25b	1.35b	1.95c
	ripe	4.22		1.89	
	LSD ($p < 0.05$)	0.176	0.206	0.263	0.240

[a] For each cultivar, means with the same letter within a column are not significantly different ($p < 0.05$) by least significant difference analysis.
[b] Dry basis.
[c] B = Firiks produced by boiling.
[d] R = Firiks produced by roasting.

methods were sun-dried, the firiks produced by boiling required a much longer drying period (after boiling) than the ones produced by roasting, since the moisture contents of the firiks after the roasting were quite low.

Sensory scores of firik samples produced by boiling and roasting are presented in Table 6. As shown in the Table, the first two stages of kernel development (13 and 16 days after anthesis) resulted in the highest sensory scores, for the firiks produced by both methods. However, there were no significant differences in the sensory properties at the first three maturation stages except for the colour value of the Duraking sample produced by boiling. Significant ($p < 0.05$) reductions in sensory scores occurred in both cooking methods and both cultivars at the last two stages of maturation (22 and 25 days after anthesis).

The results described in the present study indicate that mineral and vitamin contents of firiks produced at early stages of wheat maturation were higher than the ones produced at later stages. Significant reductions in sensory scores have also occurred in both cooking methods and both cultivars at the last two stages of maturation. Therefore, it can be concluded that immature wheat grains at the first two stages of maturation (13 and 16 days after anthesis) appeared to be a more suitable material for firik production in terms of the nutritional value and sensory properties than those at later stages of maturation.

The consumer demands for healthy foods have been exploding in recent years. Health professionals recommend that cereal products, as well as fruits and vegetables, should make up the bulk of the diet. In order to increase the annual per capita consumption of cereal-based foods, more innovative and appealing products are required in the market. Ethnic cereal foods have a potential to provide healthier diets to the people around the world. Hence, research on ethnic foods such as firik, bulgur, couscous etc. might create an opportunity to fill the gap between recommended and actual consumption of cereal-based products and broaden the base of cereal products in the international market.

Table 6
Sensory properties of firiks produced from two durum wheats at different maturation stages by boiling and roasting [a,b]

Variety	Days after anthesis	Taste and aroma		Mouthfeel		Colour		Odour
		B[c]	R[d]	B[c]	R[d]	B[c]	R[d]	R[d]
Duraking	13	4.31 a	4.75 a	4.56 a	4.44 a	4.69 a	4.63 a	4.50 a
	16	4.38 a	4.31 a	4.38 a	4.25 a	4.56 a	4.06 a	4.38 ab
	19	3.88 a	4.13 a	3.88 ab	4.00 ab	3.44 b	4.13 a	4.25 ab
	22	3.13 b	3.38 b	3.25 bc	3.50bc	2.38 c	3.19 b	3.75 bc
	25	3.00 b	3.31 b	3.13 c	3.25c	2.25 c	2.63 b	3.38 c
	LSD($p < 0.05$)	0.682	0.69 5	0.704	0.647	0.812	0.677	0.649
Ege	13	4.56 a	4.56 a	4.63 a	4.56 a	4.50 a	4.63 a	4.50 a
	16	4.63 a	4.50 a	4.44 a	4.31 a	4.75 a	4.75 a	4.25 a
	19	4.13 a	4.25 a	4.19 a	4.25 a	4.13 a	4.25 a	4.00 a
	22	3.13 b	3.25 b	3.13 b	3.38 b	2.50 b	3.31 b	3.25 b
	25	3.13 b	3.25 b	3.13 b	3.13 b	2.25 b	2.63 c	3.00 b
	LSD($p < 0.05$)	0.557	0.704	0.600	0.579	0.747	0.621	0.580

[a] For each cultivar, means with the same letter within a column are not significantly different ($p < 0.05$) by least significant difference analysis.
[b] Dry basis.
[c] B = Firiks produced by boiling.
[d] R = Firiks produced by roasting.

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