



Effects of different flour blends with varying protein content and quality on dough and crust properties of “etliekmek”, a pizza-like traditional food of Turkey

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Abstract Etliekmek, which somewhat resembles pizza in terms of crust and toppings, is a widely consumed traditional food in Turkey. It consists of a sheeted dough topped with a mixture of minced meat and some vegetables. In this study, the effects on dough processing and crust properties of etliekmek of five flour blends with varying protein content and quality were investigated. The blends (Blend-1 through Blend-5) consisted respectively of hard-endosperm Bezostaja and soft-endosperm Gerek-79 wheat flours at the ratios of 100:0, 75:25, 50:50, 25:75 and 0:100. In addition to physicochemical properties of wheats and their flour blends, dough processing and etliekmek crust properties were measured through the instrumental and sensory approaches. It was determined that protein contents and qualities of the blends decreased from Blend-1 through Blend-5. The dough from Blend-1 was judged to be extremely elastic, which resisted to sheeting due to elastic recovery, whereas the dough from Blend-5 was scored to be somewhat weak and easily extensible. The most suitable dough for the processing of etliekmek crust, i.e., optimally elastic and properly extensible dough with appropriate sheetability, seemed to be 50:50 blend of Bezostaja and Gerek-79 flours (Blend-3). Blend-1 yielded etliekmek crust with thick, moist and excessively chewy

texture, as opposed to the thinner, drier and rather crunchy crust texture from Blend-5. Based on the dimensional measurements and sensory evaluations, Blend-3 yielded the best etliekmek crust. The results demonstrate that an optimum balance of dough viscosity and elasticity, which are mostly governed by flour protein content and quality, is of vital importance to the production of high-quality etliekmek crust.

Keywords Etliekmek · Flour · Protein · Dough · Crust · Quality

Introduction

Bakery products that are produced using wheat flour are globally essential foods (Zhou and Therdthai 2007). Along with the commonly consumed bread types, the crust or shell parts of such foods as pizza, lahmacun and etliekmek are also produced from wheat-flour doughs. Of those crust containing bakery foods, etliekmek, which somewhat resembles pizza in terms of crust and toppings (Lehmann 1979), is a widely consumed traditional food in Turkey. It consists of a sheeted dough topped with a mixture of minced meat and some vegetables (Anonymous 2018). Like many traditional foods, there is no standardized method of production nor enough academic studies on etliekmek, leading to rather large fluctuations in such crucial etliekmek properties as dimension, texture, color and flavor. According to a recent survey (Büyük et al. 2018), most of the consumers preferred the etliekmek crust with a balanced chewiness and crispiness.

Having a Geographical Identification Label specific to Konya region of Turkey (Anonymous 2018), the recipe of etliekmek dough consists of flour, salt (1.0–2.5%), small

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amount of compressed yeast (0.2–0.5%) and adequate level of water (55–60%). A medium-strength bread flour seems suitable in the preparation of etliekmek dough. Once the dough is kneaded to optimum consistency, it is rested at room temperature for about 30 min. The rested dough is cut (150–200 g) and rounded prior to a proof time of 2–3 h at room temperature. The dough is then gradually extended in biaxial directions by hand to form a dough sheet with 75–125 cm in length, 7–20 cm in width and 3–4 mm in thickness. Finally, the topping mixture (150–200 g) containing about equal ratio of ground meat (about 20–25% fat) and minced vegetables (usually tomatoes, onion and green pepper) is spread atop and then baked in traditional stone ovens for 4–6 min at 300–400 °C. Upon baking, etliekmek is sliced and serviced for consumption usually together with the traditionally fermented dairy drink of ayran or buttermilk (Anonymous 2018).

The aforementioned process of etliekmek production clearly indicates that flour properties and dough rheology are of importance in etliekmek processing and crust quality. It is a well-known fact that protein content and quality together with starch damage and pentosans are central to dough rheology (Bushuk 1998; Singh and Singh 2013; Ortolan and Steel 2017). Glutenin proteins are mainly responsible for dough elasticity and strength, whereas gliadin proteins are accounted for dough viscosity and extensibility (Shewry et al. 2001; MacRitchie 2016). Furthermore, viscoelastic and cohesive properties of wheat flours, i.e., protein quality, are affected by protein content, proportion of gluten to nongluten proteins, ratio of glutenin to gliadin proteins and specific combinations of high-molecular and low-molecular weight glutenin subunits (Lasztity and Abonyi 2009; Singh and Singh 2013; MacRitchie 2016).

Based on the personal communications with etliekmek makers and the fundamental knowledge on gluten viscoelasticity (Shewry et al. 2001; Singh and MacRitchie 2001), we hypothesized that etliekmek dough should be strong (elastic) enough to carry the topping, yet extensible (weak) enough to get satisfactorily sheeted. When protein content and/or quality of the flour is excessively high, the resulting dough is likely to be too elastic (Barak et al. 2014; MacRitchie 2016), which will in turn resist to sheeting and give a thicker and chewier etliekmek crust. In contrast, whenever protein quantity and/or quality of the flour is exceptionally low, a rather extensible and sticky dough will be obtained (Barak et al. 2014; MacRitchie 2016). Such a weak dough will either become excessively thin or will tear apart during sheeting, which will cause failure in proper carrying of the topping or lead to a disproportionately crunchy etliekmek crust. Therefore, selection and utilization of a proper flour that produces a dough with optimally balanced viscosity and elasticity seems a prerequisite for

high-quality etliekmek production, which constituted the main goal of this research.

Numerous studies on the physical and chemical properties of wheat flour and their functions in common wheat products have been carried out and extensively reviewed, including breads (Bushuk 1998; Dowell et al. 2008; Lasztity and Abonyi 2009; MacRitchie 2016), pasta products (Troccoli et al. 2000; Sicignano et al. 2015) and cookies (Pareyt and Delcour 2008; Mamat and Hill 2018). To the best of our knowledge, however, there is no academic work on the role of wheat flour properties pertaining to dough processing and eating quality of etliekmek crust. The purpose of this study was therefore to investigate the effects of flour blends with varying protein content and quality on dough processing and crust properties of etliekmek.

Materials and methods

Materials

Bezostaja and Gerek-79 wheats, which were milled into flour for etliekmek production, were supplied by Sosyete Flour Mill (Karaman, Turkey). Other materials used for etliekmek production (table salt, compressed baker's yeast, ground beef with about 20% fat content, tomatoes, onion and green pepper) were purchased from a local market in Karaman, Turkey.

Wheat kernel analysis

Wheat kernel hardness was measured by standard method 39-70A of the American Association Cereal Chemists International (AACCI 2000) using Inframatic 8600-Ash near infrared spectroscopy (Perten Instruments, Hagersten, Sweden). Thousand-kernel weight was determined using Numigral-I automated seed counter (Chopin Technologies, Villeneuve-la-Garenne, France). Hectoliter weight was measured on GAC Plus device (Dickey-John, Auburn, IL, USA) by standard method 55-10 of the AACCI (AACCI 2000). Kernel size distribution was determined using a grain sortimat device fitted with 2.8-, 2.5- and 2.2-mm screens (Pfeuffer GmbH, Kitzingen, Germany). Moisture, protein and ash contents of wheats were determined using Inframatic 9500 system (Perten Instruments, Hagersten, Sweden). Kernel color was assessed through ColorFlex EZ colorimeter (HunterLab, Reston, VA, USA).

Milling of wheats and preparation of flour blends

Bezostaja and Gerek-79 wheats were milled into straight-grade flours with respectively 82.0 and 80.0% extraction

rates in a commercial flour mill (Sosyete Flour Mill, Karaman, Turkey). Prior to milling, hard-endosperm Bezostaja wheat was tempered at 16% moisture content for 48 h, while soft-endosperm Gerek-79 wheat at 15% moisture content for 24 h. Bezostaja and Gerek-79 straight-grade flours were blended respectively at the ratios of 100:0 (Blend-1), 75:25 (Blend-2), 50:50 (Blend-3), 25:75 (Blend-4) and 0:100 (Blend-5) and used in etlikiemek production upon 30 days of storage at room temperature for flour maturation.

Flour analysis

Moisture, protein and ash contents of flours were determined using Inframatic 8600-Ash near infrared spectroscopy (Perten Instruments, Hagersten, Sweden). Dough-mixing properties of flours and rheological features of the doughs were measured using farinograph, extensograph and mixolab devices. Farinograms and extensograms of flours were respectively obtained using farinograph (Hauvelt Laborgerate GmbH, Berlin, Germany) by standard method 54-21 of the AACCI and extensograph (Hauvelt Laborgerate GmbH, Berlin, Germany) by the standard method 54-10 of the AACCI (AACCI 2000). Mixolab (Chopin Technologies, Villeneuve-la-Garenne, France) was used to measure the mixing and thermorheological properties of flours following “Chopin + protocol” as described by the standard method 173 of the International Association for Cereal Science and Technology (ICC 2011). Damaged starch content was measured on SDmatic device (Chopin Technologies, Villeneuve-la-Garenne, France) by the ICC standard method of 172 (ICC 2011). Alpha-amylase activity was determined through Falling Number 1500 system (Perten Instruments, Hagersten, Sweden) by the AACCI standard method of 56-81B (AACCI 2000). Zeleny sedimentation volume was assayed by the AACCI standard method of 56-60 and 56-61A (AACCI 2000).

Etlikiemek production and quality evaluation

Since there is no standardized laboratory-scale method of etlikiemek production, etlikiemek samples were produced in a small commercial bakery (Efor Etlikiemek, Karaman, Turkey) under strictly controlled conditions. Throughout the etlikiemek production process, temperatures of the dough, bakery room and oven surface and the durations for dough mixing, resting and baking were recorded.

Etlikiemek doughs were prepared using 10 kg of flour blends. The dough recipe consisted of salt (2.3%, flour basis), compressed yeast (0.5%, flour basis) and required level of water based on the judgements of dough masters, ranging from 55 through 71% for Blend-5 through Blend-1,

respectively. The ingredients were then kneaded to an optimum dough for durations varying from 9.4 through 12.1 min, based again on the judgements of dough masters, for Blend-5 through Blend-1, respectively. The bulk of dough was first rested at 18 °C for 30 min and then cut (160 g), rounded and subjected to fermentation at 18 °C for 120 min. In the etlikiemek production, a slightly fermented dough is preferred to obtain a crust with balanced elasticity and crunchiness, which is somewhat achieved through the use of restricted level (0.5%) of yeast at lower temperatures (15–25 °C) during fermentation. The fermented dough was manually sheeted to a length of 110 cm, topped with the mixture (150 g) of minced meat and vegetables (1:1 ratio of meat:vegetables like tomatoes, onions and green peppers) and baked in a wood-fired stone-surfaced oven for 5 min at a stone surface temperature of 350 ± 15 °C.

Prior to baking, the fermented dough was evaluated for elasticity, extensibility, stickiness and sheeting characteristics by semi-trained panelists (6 etlikiemek dough makers) according to the score sheet shown in Table 1. Upon baking, the weight, length, width and thickness of 10 etlikiemek subsamples were measured. Etlikiemek crusts (20 subsamples) were also subjected to sensory evaluation for shape and symmetry, texture, flavor and color by semi-trained panelists (16 persons consisting of food science faculty and graduate students) using the score sheet described in Table 1.

Experimental design and statistical analysis

All physicochemical analyses were carried out in duplicate. Etlikiemek production (30 subsamples for each flour blend) was accomplished in the completely randomized design with two replications. The collected data were then subjected to the analysis of variance and the means were compared by Duncan’s multiple comparison test (Sayaslan and Şahin 2018).

Results and discussion

Properties of wheats and flour blends

Selected physical and chemical properties of wheats that were milled into straight-grade flours for the preparation of etlikiemek dough are listed in Table 2. Hectoliter weights of wheats were comparable; however, Bezostaja wheat had larger kernels (53.9 g/TKW) with more homogeneous size distribution, as opposed to the smaller kernels of Gerek-79 wheat (45.2 g/TKW) with a slightly less homogenous size distribution. As seen in Table 2, hardness and color (L^* , a^* and b^*) values of wheats were quite in agreement with their genetic backgrounds (Anonymous 2019), i.e., Bezostaja is

Table 1 Score sheet and descriptors used for sensory evaluation of etliemkek dough and crust

	Extremely weak dough	Weak dough	Optimum dough	Strong dough	Extremely strong dough			
Etliemkek dough	*Extremely extensible *Extremely sticky *Excessively tears apart during sheeting	*Somewhat extensible *Slightly sticky *Tears apart to some extend during sheeting	*Easily sheeted without tearing apart *Optimally elastic and extensible	*Somewhat elastic *Noticeably resistant to extension *Recovers slightly during sheeting	*Extremely elastic *Extremely resistant to extension *Strongly recovers during sheeting (hard-to-sheet problem)			
Score	1	2	3	4	5			
Etliemkek crust	Color	Creamy	Yellowish	Light yellow	Yellow–brown (optimum)	Brown	Dark brown	Black
	Flavor	Dough	Slight dough	Slight bread	Bread (Optimum)	Slightly bitter	Bitter	Burnt
	Texture	Extremely hard and crunchy	Hard and crunchy	Somewhat crunchy	Elastic and crunchy (optimum)	Slightly elastic	Elastic and chewy	Extremely elastic and chewy
	Shape and symmetry	Extremely extended in width and length, thinnest and torn apart	Extended in width and length, thin and torn apart	Slightly extended in width and length, thin	Balanced shape and symmetry (optimum)	Slightly recovered in length and width, thick	Noticeably recovered in length and width, thicker	Extremely recovered in length and width, thickest
Score		1	2	3	4	5	6	7

Comments:

a hard red wheat and Gerek-79 is a softer white wheat (Ercan 1989). In terms of chemical compositions (Table 2), the wheats demonstrated significant ($P < 0.05$) differences in most of the analyzed parameters. Bezostaja had higher protein and ash contents than Gerek-79 wheat. Similarly, wet gluten, gluten index and sedimentation volume of Bezostaja were significantly higher than those of Gerek-79, indicating the superior gluten quality (MacRitchie 1984; Pena et al. 2002) of Bezostaja hard wheat. As opposed to Gerek-79 wheat, Bezostaja wheat with higher hardness and larger kernels coupled with the elevated protein quantity and quality seemed more appropriate for breadmaking as reported previously by Ercan (1989).

As listed in Table 2, protein contents and qualities of the flour blends, which were respectively prepared from Bezostaja and Gerek-79 flours, decreased significantly ($P < 0.05$) from Blend-1 through Blend-5. These results confirmed that the flour blends prepared from two wheats with varying protein contents and qualities would likely help elucidate the dough rheology and crust properties of etliemkek.

Doughs properties by flour blends

The behavior of a dough under stress conditions, such as mixing, sheeting, extension, expansion etc., is defined as dough rheology and governed mainly by the viscous, elastic and cohesive nature of gluten proteins (Singh and MacRitchie 2001). The rheological properties of the doughs prepared from the flour blends were measured using farinograph, extensograph and mixolab devices and through sensory approaches. Farinograph results of the flour blends are shown in Fig. 1. From Blend-1 through Blend-5, optimum water absorption, mixing time and stability values of the blends decreased significantly ($P < 0.05$) as opposed to the increase in the degree of softening. Mixolab data of the flour blends also showed a similar trend (Table 3). Blend-1 had the highest optimum water absorption (56.8%) and stability (4.28 min) as opposed the lowest water absorption (53.1%) and stability (3.65 min) for Blend-5. Mixolab C2 torque, which indicate gluten weakening upon further mixing along with heating (Sayaslan and Şahin 2018), did not differ significantly ($P > 0.05$) among the flour blends. However, mixolab C3, C4 and C5 torques, which mainly reveal starch

Table 2 Properties of wheats and their flour blends used in production of etliekmek

Property	Wheat kernels ¹		Flour blends of Bezostaja/Gerek-79 wheats ²				
	Bezostaja	Gerek-79	100/0 (Blend-1)	75/25 (Blend-2)	50/50 (Blend-3)	25/75 (Blend-4)	0/100 (Blend-5)
Hectoliter weight (kg/hl)	80.6 a	79.3 a	– ³	–	–	–	–
Thousand-kernel weight (g)	53.9 a	45.2 b	–	–	–	–	–
Kernel size distribution (%)							
> 2.8 mm	62.9 a	30.2 b	–	–	–	–	–
> 2.5 mm	23.5 b	42.4 a	–	–	–	–	–
> 2.2 mm	8.8 b	19.0 a	–	–	–	–	–
< 2.2 mm	4.8 b	8.4 a	–	–	–	–	–
> 2.5 mm + > 2.8 mm	86.4 a	72.6 b	–	–	–	–	–
> 2.2 mm + > 2.5 mm	32.3 b	61.4 a	–	–	–	–	–
Kernel color							
L*	48.7 b	58.9 a	–	–	–	–	–
a*	8.5 a	7.2 b	–	–	–	–	–
b*	22.2 b	26.6 a	–	–	–	–	–
Kernel hardness (%)	52.5 a	40.5 b	–	–	–	–	–
Moisture content (%)	10.0 a	10.2 a	12.9 b	13.0 ab	13.1 ab	13.1 ab	13.2 a
Protein content (%; Nx5.7, db)	14.2 a	13.0 b	13.4 a	13.0 b	12.8 c	12.5 d	12.1 e
Ash content (%; db)	1.78 a	1.69 b	1.09 a	0.90 b	0.84 c	0.82 c	0.76 d
Lightness (L*)	–	–	87.1 e	87.5 d	87.9 c	88.3 b	88.8 a
Wet gluten (%)	30.6 a	28.4 b	30.7 a	30.3 ab	29.8 ab	29.6 ab	28.9 b
Gluten index (%)	89.5 a	77.5 b	92.0 a	88.0 b	87.0 b	85.0 c	81.0 d
Sedimentation volume (ml, %14 mb)	34.5 a	28.0 b	34.0 a	32.0 b	30.0 bc	30.0 bc	28.0 c
Modified sedim. volume (ml, %14 mb)	43.0 a	36.0 b	41.0 a	39.0 b	36.5 c	35.0 d	33.0 d
Falling number (s, %14 mb)	457.0 a	364.5 b	453 a	435 b	399 c	379 d	357 e
Damaged starch content (%; %14 mb)	–	–	5.7 a	5.4 b	5.2 bc	4.9 c	4.6 d

¹Different letters in the same line of wheat kernels indicate significant difference ($P < 0.05$)

²Different letters in the same line of flour blends indicate significant difference ($P < 0.05$)

³Not applicable

gelatinization, degradation and retrogradation properties of flours, respectively, during simultaneous mixing and heating/cooling conditions (Sayaslan and Şahin 2018), showed significant differences ($P < 0.05$) among the flour blends. Blend-1, exhibiting the highest protein content and quality, had the lowest C3, C4 and C5 mixolab torques, whereas Blend-5, consisting of the lowest protein content and quality, produced the highest C3, C4 and C5 torque values. As the protein and starch contents of flours are inversely related (Hoseney 1994; Pylar 1988), Blend-1 with the highest protein probably had the lowest starch, leading to lower C3, C4 and C5 torque values. This is because C3, C4 and C5 torques disclose respectively viscosity of starch during gelatinization, shear-thinning of starch due to further mixing and retrogradation of starch upon cooling, all

of which are mainly governed by the content and properties of starch in the flour (Sayaslan and Şahin 2018). Furthermore, extensograms of the blends (Fig. 1) yielded dough strength values comparable to the farinograph and mixolab data. In this respect, from Blend-1 with the highest protein quantity and quality through Blend-5 with the lowest protein quantity and quality, the dough-mixing energy requirement and resistance to extension decreased, as opposed the increase in dough extensibility. It has been well established that water absorption and mixing properties of flours are governed by their protein contents and qualities along with damaged starch and hemicellulose contents (Hoseney 1994; Bushuk 1998). The results of this study indicated that the blends containing higher ratio of Bezostaja flour were of strong dough properties, while that

Fig. 1 Farinograph (a) and extensograph (b) properties of flour blends used in etliemkek production

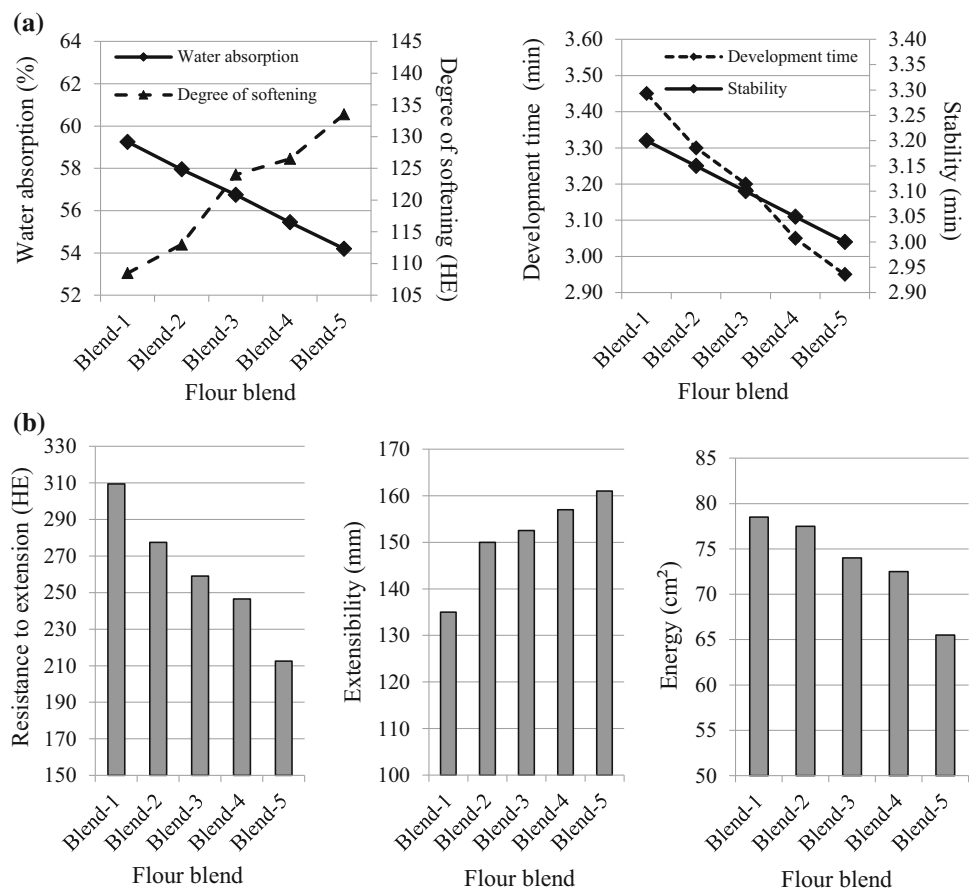


Table 3 Mixolab properties of flour blends used in etliemkek production

Flour blend	Optimum water absorption (% 14% mb)	Optimum mixing time (min)	Stability (min)	C2 torque (Nm)	C3 torque (Nm)	C4 torque (Nm)	C5 torque (Nm)
Blend-1	56.8 a	3.69 c	4.28 a	0.45 a	1.84 c	1.92 c	2.78 d
Blend-2	56.1 b	3.83 b	3.92 b	0.44 a	1.88 bc	1.96 bc	2.80 d
Blend-3	55.1 c	4.04 a	3.96 b	0.45 a	1.92 bc	2.01 b	2.85 c
Blend-4	54.4 d	3.67 c	3.81 bc	0.44 a	2.00 b	2.02 b	2.93 b
Blend-5	53.1 e	3.67 c	3.65 c	0.46 a	2.16 a	2.11 a	3.16 a

Different letters in the same column indicate significant difference ($P < 0.05$)

of Gerek-79 were weaker. It is generally accepted that an optimum balance of viscosity and elasticity is a prerequisite for a given type of bakery product (Pylar 1988; Anderssen et al. 2004; Marchetti et al. 2012; Barak et al. 2014). The instrumentally measured dough properties in this study were of importance in determining the optimum attributes of dough viscoelasticity required for high-quality etliemkek processing.

In addition to the instrumental measurements, rheological properties of the doughs, prepared from the blends of Bezostaja and Gerek-79 flours, were sensorially evaluated

(Table 4) by the score sheet given in Table 1. The dough made from Bezostaja parent flour (Blend-1) was judged to be extremely elastic, which resisted to sheeting due to elastic recovery in the processing of etliemkek crust. In contrast, the dough made from Gerek-79 parent flour (Blend-5) was scored to be somewhat weak and easily extensible. The most suitable dough for the processing of etliemkek crust, i.e., optimally elastic and extensible dough with proper sheetability, seemed to be 50:50 blend of Bezostaja and Gerek-79 flours (Blend-3).

Table 4 Sensory evaluation results for etliemek doughs and crusts produced from different flour blends

Property	Blend-1	Blend-2	Blend-3	Blend-4	Blend-5
Etliekmek dough					
Dough processing and sheeting quality ^{1,2}	4.25 a	3.95 b	2.90 c	2.75 d	2.45 e
Rheological property	Extremely strong and recovering dough Strong dough Optimum dough Somewhat weak and easily extensible dough				
Etliekmek crust					
Color ^{1,3}	3.53 a	3.44 a	3.47 a	3.56 a	3.51 a
Shape and symmetry ^{1,3}	4.19 b	4.13 b	4.06 ab	3.75 a	3.97 a
Flavor ^{1,3}	3.56 c	3.34 b	3.63 d	3.13 a	3.44 bc
Texture ^{1,3}	4.59 c	4.22 b	4.22 b	4.25 b	3.91 a
Overall quality ^{1,3}	4.78 b	4.91 b	4.44 a	4.84 b	4.41 a

¹Different letters in the same line indicate significant difference ($P < 0.05$)

²Values ranged from 1 to 5, in which 1 indicated extremely weak dough, 3 indicated optimum viscoelastic dough, and 5 indicated extremely strong dough

³Values ranged from 1 to 7, in which 1 indicated extremely bad-quality etliemek crust produced from the weakest dough, 4 indicated optimum-quality etliemek crust, and 7 indicated extremely bad-quality etliemek crust produced from the strongest dough

Properties of etliemek crusts by flour blends

It has been well accepted that the best test for the quality assessment of a bakery product is the baking test. In the overall judgment of bakery products; baking loss, product volume, shape, crust and crumb texture, color and flavor are taken into consideration (Pylar 1988; Hosene 1994). Likewise, dough processability, crust shape and symmetry, texture, color and flavor were deemed as the important quality parameters for the etliemek crust (Büyük et al. 2018).

Baking losses of etliemek samples produced from the flour blends are given in Table 5. The losses differed significantly ($P < 0.05$) by the blend and ranged from 23.0 to 36.8%. Etliekmek samples produced from strong flour of Bezostaja wheat (Blend-1) gave the lowest baking loss while Gerek-79 (Blend-5) flour had the highest baking loss. Other blends generated baking losses in-between the Blend-1 and Blend-5. As a partial result of this variation in baking losses, the crust texture of etliemek samples produced from the Blend-1 was somewhat elastic and chewy (tougher), whereas etliemek samples from the Blend-5

had an extremely dry and crunchy texture. Büyük et al. (2018) reported that the great majority of consumers preferred etliemek crust with a balanced level of chewiness and crunchiness. In other words, etliemek crust should not be neither extremely chewy nor too crunchy.

As presented in Table 5, the dimensional properties of etliemek samples exhibited significant differences ($P < 0.05$). In general, the length and width of the etliemek samples from the strong flour (Blend-1) were lower than those of the weaker flour (Blend-5). On the other hand, etliemek samples exhibited an opposite trend in thickness and volume. This is mostly because the dough of the stronger flour recovered much more during sheeting and early stages of baking, leading to a shorter and thicker crust with high moisture content and chewier structure. Instead, the doughs from the weaker blends were probably subjected to viscous flow during the initial phase of baking, resulting in a longer and thinner crust with drier and crunchier texture.

The sensory properties of the etliemek samples by the flour blends are listed in Table 4, which were scored by the guidelines given in Table 1. Sensory scores ranged from 1

Table 5 Baking loss and dimensional properties of etliemek crusts produced from different flour blends

Flour blend	Baking loss (%)	Length (cm)	Width (cm)	Thickness (mm)	Volume (cm ³)
Blend-1	23.0 a	97.0 a	9.00 a	7.0 d	611.1 d
Blend-2	28.5 b	96.5 a	9.00 a	6.5 c	564.5 c
Blend-3	30.2 b	96.0 a	9.25 a	5.5 b	488.4 b
Blend-4	36.0 c	102.5 b	9.75 b	4.5 ab	449.6 ab
Blend-5	36.8 c	104.5 b	10.00 b	4.0 a	418.0 a

Different letters in the same column indicate significant difference ($P < 0.05$)

to 7, in which 1 indicated extremely bad-quality etliekmek crust produced from the weakest dough, 4 indicated optimum-quality etliekmek crust, and 7 indicated extremely bad-quality etliekmek crust produced from the strongest dough. The etliekmek crusts exhibited important differences ($P < 0.05$) in shape, texture and flavor but not in color among the different flour blends. In general, some sensory scores concentrated around 4, which corresponded to the ideal sensory properties expected of etliekmek. Furthermore, the rheological properties of the doughs, made of the flour blends with varying protein content and quality (Table 3, Fig. 1), were quite well agreed with the textural properties of the corresponding etliekmek crusts (Table 4). Based on the overall sensory quality scores, it was evident that the best etliekmek crust was achieved when 50:50 flour blend (Blend-3) of strong Bezostaja and weak Gerek-79 wheats was utilized. To sum up, the findings of this study on the dough rheology and crust properties of etliekmek as affected by flour protein content and quality indicated that a medium-strength flour is required for high-quality etliekmek processing.

Conclusion

In this study, physical, chemical, rheological and etliekmek processing properties of five flour blends, which were prepared from two wheats (Bezostaja and Gerek-79) with varying protein content and quality, were investigated to elucidate the possible effects on dough processing and crust properties of etliekmek. The straight-grade flour of hard red Bezostaja wheat had higher protein content and quality than those of the softer wheat Gerek-79. The blends of those wheats at different levels had protein contents and qualities in-between the parent flours. A corresponding trend was observed in terms of dough mixing and rheological properties, evidenced by the farinograph, extensograph and mixolab data. These results were further confirmed by the sensory evaluation of etliekmek doughs prepared from the flour blends. The sheeting and processing qualities of the doughs made solely of the parent flours were inappropriate; however, the sheeting and processing qualities were improved through the utilization of flour blends. In fact, the strong Bezostaja flour alone produced a dough with severe elastic recovery, resulting in sheeting problems and excessively chewy etliekmek crust. The weaker Gerek-79 flour alone, however, gave a weak dough with high extensibility, leading to tearing problems in sheeting coupled with extremely crunchy crust texture. On the other hand, the flour blends, especially the 50:50 blend of a strong and a weak wheat, were shown to alleviate the problems encountered during dough processing and crust formation. Based on the dimensional measurements and

sensory evaluations, again 50:50 blend of the flours produced the best etliekmek crust. These results demonstrated that an optimum balance of dough viscosity and elasticity, which are mostly governed by flour protein content and quality, is of vital importance for the production of high-quality etliekmek.

Compliance with ethical standards

Informed consent All authors of this manuscript, namely Fatih Büyük, Abdulvahit Sayaslan, Süleyman Gökmen, Nazlı Şahin and Hasan Yetim, have been involved in the execution of this research and/or in the preparation of the manuscript. All authors have informed consents that this manuscript has been submitted to the Journal of Food Science and Technology for publication.

References

- AACCI (2000) Approved methods of American Association of Cereal Chemists International (AACCI), 10th edn. AACCI, St. Paul
- Anderssen RS, Bekes F, Gras PW, Nikolov A, Wood JT (2004) Wheat-flour dough extensibility as a discriminator for wheat varieties. *J Cereal Sci* 39:195–203
- Anonymous (2018) Konya etliekmek: geographical identification label (No. 214). Turkish Patent Institute, Ankara. [<https://www.turkpatent.gov.tr/TURKPATENT/resources/temp/A36D8E4B-6863-437D-83E6-47C2EADF1517.pdf?jsessionid=9AC26528FCA901585FF67089CFB74330>]. Retrieved on 20 Feb 2019
- Anonymous (2019) Registered wheat varieties. Transitional Zone Agricultural Research Institute, Turkish Ministry of Agriculture and Forestry, Eskişehir. <https://arastirma.tarimorman.gov.tr/gktaem/Menu/12/Tescilli-Cesitlerimiz>. Retrieved on 15 Feb 2019
- Barak S, Mudgil D, Khatkar BS (2014) Influence of gliadin and glutenin fractions on rheological, pasting, and textural properties of dough. *Int J Food Prop* 17:1428–1438
- Bushuk W (1998) Wheat breeding for end-product use. *Euphytica* 100:137–145
- Büyük F, Sayaslan A, Gökmen S, Yetim H (2018) Determination of some qualitative characteristics of “bread with meat” (etliekmek) as a traditional food specific to Konya region. In: The VIth international KOP regional development symposium, 26–28 October 2018, Konya, Turkey, pp 56–62
- Dowell FE, Maghirang EB, Pierce RO, Lookhart GL, Bean SR, Xie F, Caley MS, Wilson JD, Seabourn BW, Ram MS, Park SH, Chung OK (2008) Relationship of bread quality to kernel, flour, and dough properties. *Cereal Chem* 85:82–91
- Ercan R (1989) Bazı ekmeklik buğday çeşitlerinin kalitesi [Quality of certain bread wheat varieties]. *Gıda* 14:219–228
- Hoseney RC (1994) Principles of cereal science and technology, 2nd edn. American Association of Cereal Chemists, St. Paul
- ICC (2011) Standard methods of International Association for Cereal Science and Technology (ICC). ICC, Vienna
- Lasztity R, Abonyi T (2009) Prediction of wheat quality—past, present, future. A review. *Food Rev Int* 25:126–141
- Lehmann T (1979) Guide to pizza crust production. AIB technical bulletin, vol 1, issue 11. American Institute of Baking, Manhattan
- MacRitchie F (1984) Baking quality of wheat flours. In: Chichester CO, Mraek EM, Schweigert BS (eds) *Advances in food research*, vol 29. Academic Press, New York, pp 201–277

- MacRitchie F (2016) Seventy years of research into breadmaking quality. *J Cereal Sci* 70:123–131
- Mamat H, Hill SE (2018) Structural and functional properties of major ingredients of biscuit. *Int Food Res J* 25:462–471
- Marchetti L, Cardos M, Campana L, Ferrero C (2012) Effect of glutes of different quality on dough characteristics and breadmaking performance. *LWT Food Sci Technol* 46:224–231
- Ortolan F, Steel CJ (2017) Protein characteristics that affect the quality of vital wheat gluten to be used in baking. A review. *Compr Rev Food Sci Food Saf* 16:369–381
- Pareyt B, Delcour JA (2008) The role of wheat flour constituents, sugar, and fat in low moisture cereal based products: a review on sugar-snap cookies. *Crit Rev Food Sci Nutr* 48:824–839
- Pena RJ, Trethowan R, Pfeiffer WH, Van Ginkel M (2002) Quality (end-use) improvement in wheat. *J Crop Prod* 5:1–37
- Pyler EJ (1988) *Baking science and technology*, vol I and II, 3rd edn. Sosland Publishing, Kansas City
- Sayaslan A, Şahin N (2018) Effects of fermented-chickpea liquor (chickpea yeast) on whole-grain wheat flour bread properties. *Qual Assur Saf Crops Foods* 10:183–192
- Shewry PR, Popineau Y, Lafiandra D, Belton P (2001) Wheat glutenin subunits and dough elasticity: findings of EuroWheat project. *Trends Food Sci Technol* 11:433–441
- Sicignano A, Di Monaco R, Masi P (2015) From raw material to dish: pasta quality step by step. *J Sci Food Agric* 95:2579–2587
- Singh H, MacRitchie F (2001) Application of polymer science to properties of gluten. *J Cereal Sci* 33:231–243
- Singh S, Singh N (2013) Relationship of polymeric proteins and empirical dough rheology with dynamic rheology of dough and gluten from different wheat varieties. *Food Hydrocoll* 33:342–348
- Troccoli A, Borrelli GM, De Vita P, Fares C, Di Fonzo N (2000) Durum wheat quality: a multidisciplinary concept. *J Cereal Sci* 32:99–113
- Zhou W, Therdthai N (2007) Manufacturing of bread and bakery products. In: Hui YH (ed) *Handbook of food products manufacturing*. Wiley, Hoboken, pp 260–278

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