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PERFORMANCE OF EINKORN (*Triticum monococcum* L.) FLOUR IN THE MANUFACTURE OF TRADITIONAL TURKISH NOODLE

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ABSTRACT
Wheat flour used in traditional Turkish noodle formulation was replaced with einkorn wheat flour (EWF) at 0, 20, 40, 60, 80 and 100% levels. The effects of EWF on some properties of noodle samples were evaluated. The use of EWF resulted in significant increases in the ash, protein, total phenolic content and antioxidant activity of noodle ($P<0.05$). Volume and weight increase values increased as EWF ratio increased. The lowest cooking loss value (5.85%) was obtained in noodle containing 100 EWF%. Ca, Fe, Cu and Mg contents of noodle samples increased 1.41, 3.27, 1.45 and 2.66 times at 100% EWF compared to control sample. The use of 100% EWF decreased the taste and chewiness scores of cooked noodle. Considering the physicochemical, sensory properties and cooking quality of the samples, it can be concluded that the EWF can be used successfully up to 60% level in the Turkish noodle formulation.
Keywords: Turkish noodle, einkorn, antioxidant, total phenolic, mineral

GELENEKSEL TÜRK ERIŞTESI ÜRETIMINDE SIYEZ UNUNUN (*Triticum monococcum* L.) PERFORMANSI

ÖZ
Geleneksel Türk eriştesi formülasyonunda kullanılan buğday unu, % 0, 20, 40, 60, 80 ve 100 oranında einkorn buğday unu (EBU) ile yer değiştirmiştir. EBU'nun erişte örneklerinin bazı özellikleri üzerine etkileri değerlendirilmiştir. EBU kullanımı, eriştenin kül, protein, toplam fenolik madde içeriğinde ve antioksidan aktivitede önemli ($P<0.05$) artışlara neden olmuştur. EBU oranı arttıkça hacim ve ağırlık artışı değerleri de artış göstermiştir. En düşük pişirme kaybı değeri (%5.85), %100 EBU içeren eriştede elde edilmiştir. Erişte örneklerinin Ca, Fe, Cu ve Mg içeriği kontrol örneğine göre %100 EBU'da 1.41, 3.27, 1.45 ve 2.66 kat artmıştır. %100 EBU kullanımı, pişmiş eriştenin tat ve çiğneme puanlarını azaltmıştır. Örneklerin fizikokimyasal, duyusal özellikleri ve pişme kaliteleri dikkate alındığında, Türk eriştesi formülasyonunda EBU'nun %60 seviyesine kadar başarıyla kullanılabileceği sonucuna varılmıştır.
Anahtar kelimeler: Türk eriştesi, einkorn, antioksidan, toplam fenolik, mineral

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INTRODUCTION

Many types of noodles are produced in the world. In its simplest form, wheat noodles are a type of pasta prepared from dough containing flour, water and salt. Noodle raw materials, especially flour, have a great impact on the quality of the final product. Both protein content and protein quality of wheat flours affect the properties of noodle (Park and Baik, 2004). Color, cooking properties, texture and taste are quality parameters that influence consumer acceptance. Dry pasta must have an attractive appearance while cooked pasta must meet consumer criteria for good yellow color retention, smooth surface, pleasant flavor, firmness and stickiness with minimal cooking losses (Sisson et al., 2005; Brandolini et al., 2018).

Traditional Turkish noodles are produced mainly from wheat flour, egg and salt. Milk, whey powder and other additives can be added into noodle formulation in some regions of Turkey. The production stages of Turkish noodles include mixing, sheeting of dough, pre-drying, cutting and drying (Özkaya et al., 2001; Bilgiçli, 2009). Turkish noodles can be enriched with various protein sources, dietary fiber and micronutrients to improve their nutritional properties. In the literature, some cereal flours (Aydin and Gocmen, 2011), pseudo cereals (Bilgiçli, 2009; Bilgiçli, 2014), legume flours (Demir et al., 2010; Bilgiçli et al., 2011; Bilgiçli, 2013), cereal and legume brans (Ertaş, 2014; Yılmaz Tuncel et al., 2017; Kaya et al., 2018), wheat germ and β glucan (Aktaş et al., 2015), some fruit seed flour (Koca et al., 2018), chia flour (Levent, 2017), dairy by products (Aktaş and Türker, 2015), flaxseed (Yüksel et al., 2018), apple fiber (Yuksel and Gurbuz, 2019) have been used for enrichment of the Turkish noodles.

Einkorn (*Triticum monococcum* L.) is one of the ancient wheat cultivated in Turkey, Balkan countries, southern Italy, Germany, Switzerland, southern France, Spain and Morocco (Hidalgo and Brandolini, 2014). The hulled wheat einkorn was domesticated approximately 10000 years ago in the Karacadağ region of Turkey (Heun et al., 1997; Løje et al., 2003; Hidalgo and Brandolini, 2014). Einkorn kernels are rich source of proteins, lipids (generally unsaturated fatty acids), fructans, minerals especially zinc and iron compared to durum bread and bread wheat. It also contains carotenoids, tocols, conjugated phenolics, alkylresorcinols and phytosterols with high antioxidant content (Hidalgo and Brandolini, 2014; Fogarasi et al., 2015). Einkorn is generally more resistant to drought, diseases and suitable to be grown in environmentally friendly organic farming (Løje et al., 2003; Fogarasi et al., 2015). It is important for developing new or special foods such as bakery products, baby foods or enriched foods with high contents of protein, dietary fibre, carotenoids and tocols (Hidalgo and Brandolini, 2008; Hidalgo and Brandolini, 2014; Nakov et al., 2016). In general, it is believed that einkorn wheat is not suitable for bakery products due to its poor rheological properties and difficulties of dough handling (Corbellini et al., 1999). The high protein, carotenoid and tocol content has led to increased interest in einkorn wheat and its perfect flour composition plays a key role in the prevention of pathologies such as cancer, diabetes and chronic inflammatory diseases (Hidalgo et al., 2006; Nakov et al., 2016; Brandolini et al., 2018). Einkorn is reported to be not only a promising special food source, but also an ideal species for genetic research on wheat quality (Corbellini et al., 1999).

In the literature, einkorn wheat flour was used in some cereal products. In a study, the bread-making quality of einkorn wheats were evaluted by Borghi et al. (1996). Most of the einkorn flours were reported to produce sticky dough; but about one-third gave an acceptable dough and produced bright yellow colored breads with volumes similar to, or better than bread wheat.

Abdel-Aal et al. (1997), evaluated the einkorn in terms of kernel, milling and baking properties and reported that einkorn flour had low sedimentation values, weak Mixograph curves and low loaf volumes with no bromate response. In a study evaluating 24 einkorn lines, cookies made with einkorn flour had higher diameter and lower thickness than those made with soft wheat flour. In the same study, it was reported that all samples analyzed for breadmaking ability showed some stickiness, but it was possible to handle the dough at different bread making stages (Corbellini et al., 1999).

In another research, einkorn wheat flour was used in pasta production. They reported that dry einkorn pasta differs in most of the properties including dimensions, carotenoid content, color and image analysis parameters from durum wheat pasta. In general, einkorn pasta had similar technological properties but was reported to have a better nutritional value compared to durum wheat pasta (Brandolini et al., 2018).

Nakov et al. (2018) investigated the effect of enrichment on wheat cookies at 0, 30, 50, 70 and 100% levels with whole meal einkorn flour. Einkorn-enriched cookies were reported to have better physico-chemical properties than control cookies. In the same study, ash, protein, polyphenols, carotenoids, antioxidant activity and β-glucan content of biscuits were reported to be increased.

There is not much information about the use of einkorn flour in Turkish noodle production. For that reason, the aim of this study was to evaluate the possibility of using EWF in Turkish noodle production and its effect on physicochemical, sensory and cooking quality of end product.

MATERIALS AND METHODS

Materials

The ingredients refined wheat flour (0.56% ash, 13.8% moisture and 10.4% protein), egg, salt were purchased from local markets in Karaman, Turkey. EWF (1.67 ash%, 17.74% moisture and 11.12% protein) obtained by grinding the grain after separation of the grain husk was purchased from Sümerbank Gıda, Kastamonu, Turkey. Vital wheat gluten (Amygluten) was provided by Sinerji Food Chemical, Istanbul, Turkey. Transglutaminase enzyme (Probind TX, 90-125 U/g) was obtained from FMI Food and Chemical, İzmir, Turkey.

Methods

Noodle production

The formulations used in the preparation of noodles are given in Table 1. Refined wheat flour was replaced with EWF at levels of 0, 20, 40, 60, 80 and 100% in noodle formulation. Vital wheat gluten and transglutaminase enzyme were used to improve dough properties. Control samples were made only with refined wheat flour without any replacement. Noodle samples were prepared according to the method given by Özkaya et al. (2001) with some modification. Noodle ingredients were kneaded in the Kitchen-aid mixer (Artisan Series, Greenville, OH, USA) for 6 min and the dough was allowed to rest at room conditions for 30 min. The dough pieces were thinned and cut into a noodle strip with noodle machine (Shule Pasta Machine, China) and dried in drying cabinet (Nüve KD-200, Ankara, Turkey) at 50 ^{o}C for 18 h. After drying, the final moisture content of the product was maximum 10%.

Table 1. Experimental design of Turkish noodle prepared with Einkorn wheat flour (EWF)

	Ratio (%)					
	0	20	40	60	80	100
Refined wheat flour	100	80	60	40	20	0
EWF	0	20	40	60	80	100
Whole-egg	20	20	20	20	20	20
Salt	0.5	0.5	0.5	0.5	0.5	0.5
Vital wheat gluten	0	2	4	6	8	10
Transglutaminase	0	0.5	0.5	0.5	0.5	0.5

Chemical analysis

The AACC methods were used to determine ash (method 08-01), protein (method 46-12) and fat (method 30-25) (AACC, 1990). To determine the mineral content, the dried sample (0.3 g) was placed in the burning vessel and 5 mL HNO_3 + 5 mL H_2SO_4 added. The samples were incinerated in a microwave oven (MARS 5, CEM

Corporation, USA). The solution was diluted with distilled water to 100 mL. Mineral analysis (Ca, Fe, Cu and Mg) was determined with an inductively coupled plasma atomic emission spectrometer (ICP-AES, Varian Vista Model, Australia) (Bubert and Hagenah, 1987).

Total phenolic content (TPC) was determined spectrophotometrically using Folin-Ciocalteu reagent. Powdered samples (2 g) were extracted for 2 h with 10 mL solvent (methanol/HCl/water, 8:1:1, v/v/v) at room temperature (25 °C). After extraction, the samples were centrifuged for 10 min at 3000 rpm with a NF 800R Centrifuge (Nüve, Turkey). The methanolic extract (0.1 mL) was mixed in a test tube with 1.5 mL of saturated sodium carbonate solution and 0.5 mL of diluted Folin-Ciocalteu reagent and filled with water up to 10 mL. The mixture was allowed to stand at room temperature for 2 h and then the absorbance was measured at 760 nm by using spectrophotometer (Shimadzu UV-1800, Kyoto, Japan). Gallic acid was used as the reference standard and TPC was expressed in milligrams of gallic acid equivalent (GAE) per kg dry weight (Gao et al., 2002; Beta et al., 2005).

Antioxidant activity (AA) was determined according to the modified method of Wronkowska et al. (2010), using a 2,2 diphenyl-1-picrylhydrazyl (DPPH) as the free radical. Ground samples (1g) were extracted with 10 mL 80% aqueous methanol (10 mL) and centrifuged at 3000 rpm for 10 min. The DPPH solution was prepared freshly by mixing 10 mg of DPPH with 25 mL of 80% methanol. Exactly 100 μL of the supernatant was reacted with DPPH solution (250 μL) and 80% methanol (2 mL). After 20 minutes incubation of the mixture at room temperature in the dark, the absorbance was measured at 517 nm against the blank. The blank consisted of 80% methanol and the reagent solution without 80% methanolic extract added. AA was calculated as percentage of discoloration:

$$AA\% = [1 - (\text{Abs sample}_{t=20}/\text{Abs control}_{t=0})] * 100 \quad \text{(Eq.1)}$$

Cooking properties

Noodles were evaluated in terms of volume increase (VI), weight increase (WI) and cooking loss (CL) values. For determination of the changes in volume, weight and cooking losses, 10g of noodle was cooked for 18 min in 300 mL of distilled water. After draining and waiting for 2 min for the remaining water was removed, uncooked and cooked samples were put into a graduated cylinder with specific amount of water, the increase in volume was determined. VI was calculated as the percentage difference in uncooked and cooked noodles volume divided by the volume of uncooked noodles. The WI was determined as the percentage difference in weight of uncooked and cooked noodle divided by the weight of uncooked noodle. To determine the CL, cooking water was evaporated and dried to dryness in an oven at 105 °C for 12 h in pre-weighted erlenmeyer flask.

Color measurement

The color of noodle samples was assessed in terms of L* (brightness/darkness), a* (redness/greenness) and b*(yellowness/blueness) values by using chromometer (Model CR 400, Minolta Camera, Osaka, Japan). Chroma (C*) and hue angle (hue) values were calculated according to the following equations (Francis, 1998).

$$\text{Chroma } (C^*) = [a^{*2} + b^{*2}]^{1/2}. \quad \text{(Eq. 2)}$$

$$\text{Hue angle (hue)} = \arctan [b^*/a^*] \quad (\text{If } a > 0 \text{ and } b > 0) \quad \text{(Eq. 3)}$$

$$\text{Hue angle (hue)} = (\arctan [b^*/a^*] + 180°) \quad (\text{If } a < 0 \text{ and } b > 0) \quad \text{(Eq. 4)}$$

Sensory analysis

Sensory analyses were performed in raw and cooked noodles. For cooked noodle preparation, 100 g noodle samples were simmered in 500 ml unsalted water for 18 min and drained for removing excess water. Noodle samples were served to 14 panelists (male and female) at to evaluate the surface smoothness, speck, crack, appearance and overall acceptability of uncooked noodle and taste, odor stickiness, chewiness and overall acceptability of cooked noodle on fivepoint scale where 1-dislike extremely, 3-acceptable and 5-like extremely. The samples were coded with letters and served to the panelists at random to guard against any bias.

Statistical analysis

The data were reported as mean ±standard deviation and analysed by using statistical software JMP 8.0 (SAS Institute, Cary, NC, USA). Tukey's Honestly Significant Difference was used to differentiate between the mean values. Significant differences were based on a $P<0.05$.

RESULTS AND DISCUSSION

Chemical properties of noodle samples

Chemical compositions of noodle samples are given in Table 2. The use of EWF increased the ash and protein content of noodle samples from 1.15% to 1.69% and from 13.04% to 16.47%, respectively. The fat content of noodle samples varied between 2.34% and 2.72% but with the use of EWF, the increase in fat content of noodle samples was not significantly different from each other ($P>0.05$). Increased amount of EWF in the noodle formulation increased the total phenolic content values and antioxidant activity of noodle samples significantly ($P<0.05$). The higher ash and protein content of EWF than refined wheat flour affected the ash and protein content of end product. Similarly, the high ash and protein content of einkorn flour was reported by Abdel-Aal et al. (1995), Brandolini et al. (2008), Ertop and Atasoy (2019). The ash, protein and fat content of noodle samples were found to be 1.69%, 16.47% and 2.72% at 100% EWF, respectively.

Table 2. Chemical compositions of noodle samples prepared with EWF

EWF Ratio (%)	Ash (%)*	Protein (%)*	Fat (%)*	Total phenolic content (mg GAE/kg)*	Antioxidant activity (Inhibition %)*
0	1.15 ± 0.03^{d}	13.04 ± 0.14^{e}	2.34 ± 0.11^{a}	641.36 ± 4.58^{f}	18.39 ± 0.38^{f}
20	1.27 ± 0.01^{d}	13.88 ± 0.17^{d}	2.43 ± 0.17^{a}	764.45 ± 4.06^{e}	25.48 ± 0.17^{e}
40	1.41 ± 0.04^{c}	14.57 ± 0.10^{c}	2.54 ± 0.14^{a}	873.82 ± 3.48^{d}	30.84 ± 0.28^{d}
60	1.50 ± 0.01^{bc}	15.12 ± 0.18^{c}	2.60 ± 0.18^{a}	998.55 ± 4.12^{c}	38.62 ± 0.37^{c}
80	1.58 ± 0.04^{ab}	15.84 ± 0.13^{b}	2.68 ± 0.10^{a}	1108.93 ± 5.83^{b}	46.74 ± 0.45^{b}
100	1.69 ± 0.03^{a}	16.47 ± 0.11^{a}	2.72 ± 0.16^{a}	1209.72 ± 4.45^{a}	55.81 ± 0.16^{a}

*Results are dry-weight basis; Th

Nakov et al. (2018) reported that ash, protein, total polyphenols, antioxidant activity, total carotenoids and β-glucans increased when whole wheat einkorn flour was used in biscuit production. The total phenolic content and antioxidant activity of the noodle samples increased from 641.36 mg GAE/kg (control) to 1209.72 mg GAE/kg (100% EWF) and from 18.39% (control) to 55.81% (100% EWF), respectively. Brandolini and Hidalgo (2011) reported that einkorn kernels have higher protein and antioxidant (carotenoids and tocols) content than other wheats. Whole grain einkorn products are considered to be good sources of phenolic antioxidants (Abdel-Aal and Hucl, 2014). The antioxidant activity of einkorn wheat is due to the presence of antioxidants belonging to the group of hydrophilic and lipophilic compounds, such as polyphenols, carotenoids, phytosterols (Lachman et al., 2012; Nakov et al., 2016). Antioxidant activity values of noodle samples increased with the increasing EWF levels and showed the same tendency as total phenolic content. Similarly, the antioxidant activity of cereal products was reported to correlate with the content of phenols occurring in these cereals (Zieliński and Kozłowska, 2000; Lachman et al., 2012).

Mineral contents of noodle samples are given in Table 3. Ca, Fe and Mg contents of noodle samples increased significantly with the increasing level of EWF ($P<0.05$). The usage of 100% of EWF increased Ca, Fe and Mg contents of noodle samples from 31.57 mg/100g, 1.21 mg/100g and 51.92 mg/100g to 44.58 mg/100g, 3.96 mg/100g and 138.47 mg/100g, respectively. The higher mineral content of the EWF may have increased the mineral content of the noodle samples. Erba et al. (2011) studied the trace elements and minerals of whole meal flours of einkorn and bread wheats and reported that einkorn varieties exhibited higher Zn (7.18 mg/100g), Fe (5.23 mg/100g), Mn (4.65 mg/100g), Cu (0.90 mg/100g), Mg (151.2 mg/100g) and P (541.1 mg/100g) concentration than bread wheat. Megyeri et al. (2014), reported that the most of the einkorn genotypes examined have significantly higher trace element and antioxidant contents than the control wheat variety. Also einkorn has more than three times more β-carotene than wheat variety.

Table 3. Mineral contents (mg/100g) of noodle samples prepared with EWF*

EWF Ratio (%)	Ca	Fe	Cu	Mg
0	31.57±0.58[f]	1.21±0.04[f]	0.35±0.06[a]	51.92±0.38[f]
20	34.12±0.40[e]	1.80±0.13[e]	0.37±0.07[a]	68.84±0.89[e]
40	36.24±0.65[d]	2.35±0.09[d]	0.41±0.03[a]	88.67±0.41[d]
60	39.05±0.54[c]	2.77±0.03[c]	0.44±0.04[a]	105.71±0.71[c]
80	41.94±0.48[b]	3.41±0.04[b]	0.48±0.10[a]	119.35±0.42[b]
100	44.58±0.37[a]	3.96±0.07[a]	0.51±0.07[a]	138.47±0.54[a]

*Results are dry-weight basis; The means with the different letter in column are significantly different (*P* <0.05); EWF: Einkorn wheat flour

Cooking properties of noodle samples

The cooking properties of the dried pasta depend on both the raw material properties and the processing conditions (De Noni and Pagani, 2010). The amount and quality of protein is the most important factor influencing the characteristics of cooked pasta (Brandolini et al., 2018).

Cooking properties of noodles as VI, WI and CL are given in Table 4. Increased EWF levels caused a significant increase in VI values (*P*<0.05) and the highest value (282.2%) was obtained at 100% EWF. WI values also increased with the use of EWF in the noodle formulation and ranged between 154.2% and 191.2%. In a study, einkorn flours were used by Brandolini et al. (2018) in short-cut pasta production and it was reported that all samples recorded a sharp weight increase after 10 min of cooking, indicating intense water uptake in the early stages of cooking. In the same study, dimensional changes of pasta during cooking were observed by image analysis and it was determined that all parameters showed significant increases over time.

Table 4. Cooking properties of noodle samples prepared with EWF

EWF Ratio %	VI (%)	WI (%)	CL (%)
0	175.4±2.33[f]	154.2±1.56[d]	9.04±0.24[a]
20	200.7±2.21[e]	176.1±1.10[c]	8.71 ±0.35[a]
40	222.1±1.36[d]	179.2±2.47[c]	7.36±0.40[b]
60	250.3±1.78[c]	182.9±1.78[bc]	7.19±0.16[b]
80	271.4±2.16[b]	187.5±2.16[ab]	6.42±0.24[bc]
100	282.2±1.56[a]	191.2±1.64[a]	5.85±0.20[c]

The means with the different letter in column are significantly different (*P* <0.05); EWF: Einkorn wheat flour; VI: Volume increase; WI: Weight increase; CL: Cooking loss

The CL values ranged from 5.85% to 9.04%, while the 100% EWF revealed the lowest value compared to the control. Noodles should maintain its integrity during cooking, with a minimum loss of solid into the cooking water during boiling (Wu and Corke, 2005). The starch granules and protein behave in a completely different way during cooking of pasta. The starch granules swell rapidly and tend to disperse and become partially soluble. On the contrary, proteins become completely insoluble and coagulate, forming a net-like structure. The starch components will remain trapped in the protein network. If the netlike structure is not strong or its formation delayed the starch granules are not trapped and will swell up easily. In this case, a portion of the gelatinized and soluble material will pass into cooking water. As a result, the product is considered sticky (Pagani et al., 2007). In this study, decreasing tendency of cooking loss values with increasing EWF level may be due to a higher degree of cross-linking of protein which is capable of holding starch components in the noodle structure with the combined effect of transglutaminase and vital gluten. An optimally cross-linked protein network encapsulates starch particles in the network, limiting starch swelling and subsequent leaching (Delcour et al., 2012). Brandolini et al. (2018) reported that pasta samples prepared with einkorn wheat exhibited lower cooking losses than control due to their high protein content, that which leads to the formation of a well-structured and compact protein network which prevent solid losses into cooking water.

Color values of noodle samples

Noodle color is the most important feature affecting consumer perception. The color values of the noodle samples are given in Table 5. Compared to control noodle, the use of EWF in the noodle formulation decreased the brightness (L*) values of noodle samples. In general, the redness values of the samples containing EWF were higher than the control. The use of EWF increased b * and C * except for noodles containing 20% EWF compared to the control. In the study of Nakov et. al. (2018), einkorn flour was used in cookie production at 0%, 30%, 50%, 70% and 100% levels and L* values were reduced by increasing the amount of einkorn flour in the cookie formulation. In the same study, it was reported that einkorn addition led to reddish and yellow tinges in cookie samples. Similarly, Brandolini et al. (2018) used einkorn flours in pasta formulations and observed significant differences ($P<0.05$) for the parameters L* and a*: the einkorn spaghetti was less bright (50.9 ± 1.79) and with a higher red index (8.5 ± 0.16) than samples prepared with the durum wheat semolina.

Table 5. Color values of noodle samples prepared with EWF

EWF Ratio %	L*	a*	b*	C*	hue
0	83.52±0.56[a]	1.13±0.11[b]	18.88±0.22[d]	18.91±0.21[d]	86.56±0.36[a]
20	79.98±0.42[b]	1.85±0.19[a]	19.17±0.16[cd]	19.26±0.14[cd]	84.47±0.60[b]
40	78.27±0.28[b]	1.75±0.15[a]	21.48±0.28[a]	21.55±0.26[a]	85.35±0.46[ab]
60	77.94±0.46[bc]	1.66±0.10[a]	20.59±0.31[ab]	20.66±0.32[ab]	85.38±0.22[ab]
80	76.14±0.57[cd]	1.92±0.14[a]	20.60±0.19[ab]	20.69±0.21[ab]	84.69±0.33[b]
100	75.32±0.73[d]	1.65±0.07[ab]	20.05±0.26[bc]	20.12±0.26[bc]	85.30±0.25[ab]

The means with the different letter in column are significantly different ($P<0.05$); EWF: Einkorn wheat flour

Sensory analysis

Sensory analyses results of raw and cooked noodle samples are presented in Figure 1 and Figure 2. Raw (uncooked) noodle samples containing 20%, 40% and 60% EWF had similar sensory scores in terms of surface smoothness, speck, crack and appearance with the control sample. In comparison with control, surface smoothness, speck, appearance and overall acceptability scores decreased in 80% and 100% EWF samples. Taste, odor, stickiness, chewiness and overall acceptability scores of cooked noodles up to 100% EWF level were not statistically different from each other ($P>0.05$, Figure 2). Noodle samples containing 100% EWF had the lowest taste and chewiness scores among cooked noodle samples. The taste and chewiness score may have decreased due to the use of EWF in whole flour form. Emeksizoglu (2016) used different EWF in noodle production and reported that the samples had low scores in terms of taste and aroma.

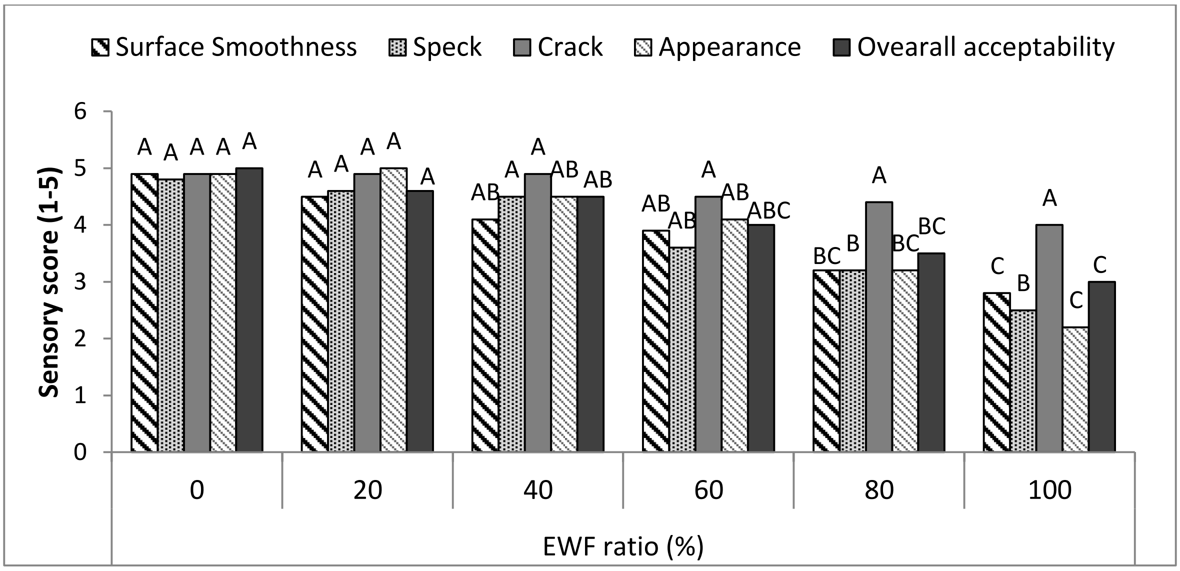

Figure 1. Sensory properties of raw (uncooked) noodle samples (EWF:Einkorn wheat flour)

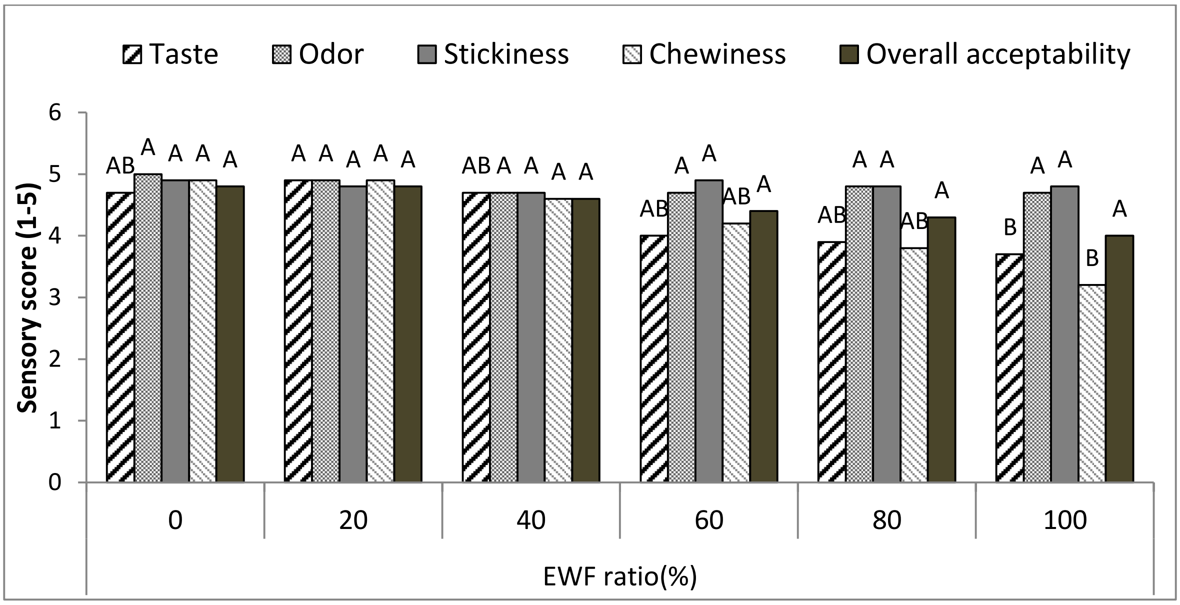

Figure 2. Sensory properties of cooked noodle samples (EWF:Einkorn wheat flour)

CONCLUSIONS

In the present study, physicochemical, sensory properties and cooking quality of Turkish noodle prepared with different levels of EWF were investigated. EWF usage improved the ash, protein, total phenolic content and antioxidant activity of noodle samples prepared with refined wheat flour. VI, WI values increased and CL values decreased with the usage of EWF in Turkish noodle formulation. The highest increase in the mineral content of noodle was determined in the Fe and Mg compared to control. The addition of EWF (100%) decreased the brightness and increased yellowness and chroma values of noodle samples. The use of EWF in noodle formulation did not cause any negative effect on cooked noodles up to 100%, but the use of EWF in raw noodles after 60% reduced surface smoothness, speck, appearance and overall acceptability scores. From the results of this study, it can be concluded that 60% EWF can be used without any negative effect on sensory quality in Turkish noodle formulation with the aid of vital wheat gluten and transglutaminase enzyme.

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