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THE EFFECTS OF DRYING METHODS ON THE QUALITY OF TURKISH NOODLE WITH LEGUME FLOURS

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ABSTRACT
In this study, legume flours (lentil, faba bean, chickpea and common bean) replaced wheat flour (30%, w/w) in Turkish noodle formulation. The effects of the addition of legume flours to the formulation and the different drying conditions (room, hot oven and microwave) on the physicochemical, cooking and sensory properties of noodles were investigated. The use of legume flour in noodle formulation increased the ash, protein, fat, Ca, Fe, Mg, Cu, total phenolic content and antioxidant activity of noodle samples (P <0.05). In addition to shortening the drying time, microwave drying revealed higher total phenolic content and antioxidant activity values among other drying techniques. Legume flours, excluding faba bean, gave acceptable sensory analysis results in noodle samples. The results show that legume flour is an important source for improving the nutritional properties of noodles and microwave drying can be recommended to maintain the total phenolic content and antioxidant activity of the noodles.
Keywords: Noodle, legume, drying, microwave, oven

KURUTMA METOTLARININ BAKLAGİL UNLU TÜRK ERİŞTE KALİTESİ ÜZERİNE ETKİLERİ

ÖZ
Bu çalışmada, baklagil unları (mercimek, bakla, nohut ve fasülye), Türk eriştesi formülasyonunda buğday unu ile yer değiştirmiştir (30%, w/w). Formülasyona baklagil unları ilavesinin ve farklı kurutma koşullarının (oda, sıcak fırın ve mikrodalga) erişte örneklerinin fizikokimyasal, pişme ve duyusal özellikleri üzerine etkileri incelenmiştir. Baklagil ununun erişte formülasyonunda kullanılması, erişte numunelerinin kül, protein, yağ, Ca, Fe, Mg, Cu, toplam fenolik içerik ve antioksidan aktivitesini arttırmıştır (P <0.05). Kurutma süresini kısaltmaya ek olarak, mikrodalga kurutma diğer kurutma teknikleri arasında daha yüksek toplam fenolik içerik ve antioksidan aktivite değerleri açığa çıkarmıştır. Bakla unu hariç baklagil unları, erişte örneklerinde kabul edilebilir duyusal analiz sonuçları vermiştir. Sonuçlar, baklagil ununun erişte besinsel özelliklerini iyileştirmek için önemli bir kaynak olduğunu ve eriştenin toplam fenolik içerik ve antioksidan aktivitesini korumak için mikrodalga kurutmanın tavsiye edilebileceğini göstermiştir.
Anahtar kelimeler: Erişte, baklagil, kurutma, mikrodalga, fırın

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INTRODUCTION

Turkish noodle (erişte) is a traditional cereal product of Turkey. Wheat flour, egg, and salt are the main ingredients in the production of noodles. In some parts of Turkey, milk, whey or other additives can also be used in the formulation (Özkaya et al., 2004). Traditionally, erişte is usually dried in the sun, in room conditions, in hot air oven or in a hot pan (Özkaya et al., 2001). Raw material quality and drying methods are important parameters affecting the quality of the product (Özkaya et al., 2001; Bilgiçli, 2009).

Drying is one of the important processes in food production to increase storage time, facilitate transportation and produce value added products (Mujumdar and Law, 2010). Ideally, drying processes can be designed to reduce drying time and minimize energy costs while maintaining high product quality (Basman and Yalcin, 2011). Pasta is traditionally dried at low temperature, but the drying temperature has been increasing with the advancement of technology. High temperature and very high temperature drying methods, as well as an emerging ultra high temperature drying have been quickly adopted (Ogawa et al., 2017). In recent years, microwave drying is an alternative way to improve the quality of dried products (Maskan, 2001). Pasta products are difficult to dry, because moisture migrates slowly to the surface. Hot air itself is relatively effective in removing free water at or near the surface, whereas it takes time for internal moisture to move to the surface (Altan and Maskan, 2005). In conventional heating or drying methods, heat is transported 10-20 times more slower from surface to center compared to microwave heating (Berteli and Marsaioli, 2005). During microwave processing, heat is generated throughout the material, resulting in faster heating rates, shorter processing times, less operational costs, and a sharper pasteurization effect on the end product compared to conventional heating (Maurer et al., 1971; Gowen et al., 2006). Microwave drying is considered as a fast product rehydration method in noodle products, because volumetric heating can form porous structures in the food product (Pongpichaiudom and Songsermpong, 2018). Furthermore, the products to be dried may be heat sensitive and therefore require careful drying; conventionally drying in hot air can damage bioactive components. In addition, high temperature may cause adversities such as denaturation in the product, case hardening and discoloration (Altan and Maskan, 2005; Mujumdar and Law, 2010).

Legumes play an important role in human nutrition throughout the world. They are excellent sources of protein, dietary fibre, oligosaccharides, phytochemicals, vitamins and minerals which provide protective and therapeutic effects on chronic health problems such as obesity, cardiovascular diseases, diabetes and cancer (Geil and Anderson, 1994; Messina, 1999; Iqbal et al., 2006; Patterson et al., 2009). As well as being a rich source of protein, legumes provide high amounts of essential amino acid lysine which is lacking in cereal grains. Legumes are usually deficient in sulphur-containing amino acids, methionine and cystine. On the other hand, cereal-grain contains lower amounts of proteins which are deficient in lysine but have adequate amounts of sulphur-containing amino acids. Therefore, legume proteins may be a natural supplement to cereal proteins in producing an overall essential amino acid balance (Rockland and Radke, 1981; Singh and Singh, 1992). Globally, unhealthy diets and physical inactivity are the leading causes of major chronic diseases (Patterson et al., 2009). In addition, protein-calorie malnutrition is believed to be the primary nutritional problem, particularly affecting children in most developing countries (Singh and Singh, 1992; Iqbal et al., 2006). Due to its unique composition, legumes enhance the nutritional status of cereal-based foods and alleviate protein-calorie malnutrition problems.

Noodles generally lack nutrients such as protein, dietary fiber, vitamins and bioactive components that are lost during wheat milling or processing conditions. There are many studies on the use of different legume flours in noodle and noodle type products, but these studies have generally focused on the chemical composition of noodles, cooking quality, starch digestibility, texture etc. There are limited studies on the effect of drying conditions on total phenolic content and antioxidant activity of end product. Therefore, the aim of this study was to determine the effects of legume flours (lentil, faba bean, chickpea an common bean) on noodle quality and to compare the effects of different drying techniques (room, hot oven and microwave) on the cooking quality, physicochemical and sensory properties of noodles.

MATERIALS AND METHODS

Materials

The ingredients wheat flour with a 0.57% ash and 11.38% protein content (Hekimoğlu, Turkey), egg (Yumkar, Turkey), lentil, chickpea, common bean (Yayla, Turkey) and salt (Salina, Turkey) were purchased from local markets in Karaman, Turkey. Vital wheat gluten was obtained from Sinerji Food, Istanbul, Turkey. Sodium stearoyl 2-lactylate (SSL) was kindly provided by Teknaroma Agency Local&Foreign Trade, Istanbul, Turkey. Faba bean were obtained from local producers in Mersin, Turkey. In order to obtain legume flours, legumes were soaked in distilled water for 12 h at room temperature, cooked in water for 30 min at 90 ±2 °C, then dried in room conditions for 5 days and milled to flour with a hammer mill (Perten-3100, Perten Instruments, AB, Huddinge, Sweden) according to Demi et al. (2010).

Noodle preparation

Noodle samples were prepared according to Özkaya et al. (2001) with some modifications. Wheat flour (200 g), egg (40 g), salt (1 g) and water were mixed for 6 min in the Kitchen-aid mixer (Artisan Series, Greenville, OH, USA) and the dough was allowed to stand at room temperature for 30 min to prepare control Turkish noodles. Lentil, faba bean, chickpea and common bean flour replaced wheat flour at the level of 30% (w/w). The amount of water used in the noodle formulation varies between 75-90 ml according to the dough consistency. Vital wheat gluten was used due to the reduced gluten content of wheat flour substituted with legume flours. Vital wheat gluten (3%) and SSL (0.5%)(w/w) were added to the noodle formulation enriched with legume flours based on the wheat flour used. The dough pieces were thinned and allowed to rest for about 15 min and then were passed through cutting blades of noodle machine for obtaining noodle strips (Shule Pasta Machine, China). The noodle samples were dried to a moisture content of less than 10% by different drying methods: Room conditions at 25 ℃ for 5 days; Drying cabinet (Nüve FN-500, Turkey) at 50 °C for 18 h; microwave oven (Arçelik, 2450 MhZ) at 350W for 7 min. The samples were stored in polyethylene bags at 4 °C until use.

Chemical analysis

Moisture, ash, crude protein and fat contents of wheat flour, legume flours and noodle samples were analyzed by using standard methods (AACC, 2000). Noodle samples dried at room conditions were used for ash, protein, fat, phytic acid, phytate phosphorus, and mineral analysis but all noodle samples dried under different drying conditions were analyzed for total phenolic content and antioxidant activity. Phytic acid was measured by a colorimetric method according to the method given by Haug and Lantzsch (1983). Phytic acid in the sample was extracted with hydrochloric acid solution and precipitated with Fe III solution. The amount of iron remaining in the extract was determined by spectrophotometric method and the amount of phytic acid was calculated. For determining phytate phosphorus, the phytic acid value was divided by a factor of 3.546. Mineral contents were determined according to the method given by Biçer (2018) with some modifications. Ground sample (1 g) was precisely weighted and transferred into the burning cup and mixed with pure nitric acid (15 mL) and samples were kept at room temperature overnight. After addition of 4 mL of per chloric acid, samples were heated up to 130 °C for 5-6 hours using a hot plate. After cooling the samples at room temperature, 5 mL of hydrogen peroxide was added and samples were heated again until discoloration was observed. After filtration and dilution, the mineral contents of samples were determined by atomic absorption spectrometer (AAS) using Perkin Elmer PinAAcle 900.

Total phenolic content (TPC) was determined spectrophotometrically using Folin-Ciocalteu reagent. Two grams of each sample were extracted at room temperature (25 °C) with 10 mL solvent (methanol/HCl/water, 8:1:1, v/v/v) for 2 h. The mixture was then centrifuged at 3000 rpm for 10 min (Gao et al., 2002; Beta et al., 2005). Methanolic extracts (0.1 mL) were transferred into test tubes and mixed with 1.5 mL of saturated solution of sodium carbonate and 0.5 mL of diluted Folin-Ciocalteu reagent. It was filled with water up to 10 mL at room temperature. The mixture is allowed to stand at room temperature for 2 h then the absorbance was measured at 760 nm by using spectrophotometer (Shimadzu UV-1800, Kyoto, Japan). TPC was expressed as milligrams of gallic acid equivalents (GAE) per kg of dry weight.

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

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

Cooking properties

All noodle samples dried under different drying conditions were analyzed for cooking properties. For the determination of volume increase (VI), weight increase (WI) and cooking losses (CL), 10 g noodles were boiled in 300 mL of distilled water for 18 minutes. After draining and waiting for 2 min to remove residual water, the volumes of uncooked and cooked samples were determined by placing them in a graduated cylinder filled with a certain amount of water. Volume increase was calculated as shown in Equation 2. The weight increase was determined by the differences between uncooked and cooked noodle weights and calculated as shown in Equation 3. To determine the CL, the cooking water (~300 mL) was evaporated and dried to dryness in an oven at 105 °C for 12 h in pre-weighted erlenmeyer flask and calculated as shown in Equation 4 (Bilgiçli, 2013).

$$VI(\%) = (\text{Cooked noodle volume-uncooked noodle volume})*100/\text{uncooked noodle volume} \quad \text{(Eq. 2)}$$

$$WI(\%) = (\text{Cooked noodle weight-uncooked noodle weight})*100/\text{uncooked noodle weight} \quad \text{(Eq. 3)}$$

$$CL(\%) = \text{Weight of dry residue}*100 /\text{uncooked noodle weight} \quad \text{(Eq. 4)}$$

Physical properties of noodle samples

All noodle samples dried under different drying conditions were analyzed for color parameters. The color of noodle samples were evaluated by measuring the L*(100=white; 0=black), a* (+, red; -, green) and b*(+, yellow; -, blue) values using Minolta CR-400 (Minolta Camera, Osaka, Japan). Chroma (C*) describes the brightness or vividness of color. Hue angle indicates the hue or intensity of noodle samples (Gómez et al., 2008; Bilgiçli, 2013). Chroma and hue angle were calculated according to following equations (Francis, 1998). Color values were measured at five different points on samples. Values are the mean of five measurements.

$$\text{Chroma } (C^*)=[a^{*2} + b^{*2}]^{1/2} \quad \text{(Eq. 5)}$$

$$\text{Hue angle (hue)} = \arctan [b^*/a^*] \quad (\text{If } a > 0 \text{ and } b > 0) \quad \text{(Eq. 6)}$$

$$\text{Hue angle (hue)} = (\arctan [b^*/a^*] + 180°) \quad (\text{If } a < 0 \text{ and } b > 0) \quad \text{(Eq. 7)}$$

Textures of freshly cooked noodle samples were carried out with TAXT plus Texture Analyser (Stable Microsystems, Surrey, UK) equipped with a cutting device A/LKB-F. The maximum force required to determine the hardness (Fmax) was taken from the graph of the force-time diagram (Schoenlechner et al., 2010).

Sensory analysis
Sensory evaluation was performed in raw and cooked noodle samples. For cooked noodle preparation, 100 g noodle sample was boiled in 500 mL of unsalted water for 18 min and drained to remove excess water. Noodle samples were served to 14 panelists (male and female) to evaluate the surface smoothness, speck, crack and appearance of uncooked noodle and taste, odor, stickiness and chewiness of cooked noodle on a 1-9 scale where 1- dislike extremely, 9- like extremely. The samples were served in plastic dishes which were coded with letters, immediately after cooking. The sample presentation sequence was completely randomly selected to ensure that panelists are protected against any bias.

Statistical analysis
The data were analysed by using statistical software JMP 8.0 (SAS Institute, Cary, NC, USA) and expressed as the mean ± standard deviation. The means which were statistically different from each other were compared using Tukey's HSD comparison test at a 5% confidence interval.

RESULTS AND DISCUSSION

Raw material properties
The chemical properties, mineral contents and color values of the raw materials used in the production of noodle samples are given in Table 1. As expected, legume flours showed higher ash, protein, fat, phytic acid, total phenolic content and antioxidant activity values compared to wheat flour. The ash, protein and fat content of the raw materials of the noodle samples ranged from 0.57% to 3.51%, 11.38% to 24.80% and 0.72% to 4.80%, respectively. Ca, Fe, Mg and Cu contents of all legume flours were found richer than wheat flour. In general, similar results were reported for the chemical composition of wheat flour and legume flours by Patterson et al. (2009), Mlyneková et al. (2014) and Demi et al. (2010).

Table 1. Some chemical properties, mineral contents and color values of wheat flour and legume flours

	Wheat flour	Lentil flour	Faba bean flour	Chickpea flour	Common bean flour
Ash (%)	0.57±0.03^{e}	3.06±0.02^{c}	3.22±0.03^{b}	2.43±0.04^{d}	3.51±0.01^{a}
Protein (%)	11.38±0.20^{d}	23.15±0.16^{b}	24.80±0.21^{a}	21.45±0.14^{c}	22.73±0.11^{b}
Fat (%)	0.72±0.10^{d}	3.02±0.13^{c}	3.76±0.17^{b}	4.80±0.18^{a}	3.11±0.14^{c}
PA (mg/100g)	162.50±5.37^{e}	1080.60±6.70^{a}	710.40±9.19^{d}	820.50±6.51^{c}	951.78±7.31^{b}
PP (mg/100g)	45.83±2.79^{e}	304.74±2.81^{a}	200.34±2.40^{d}	231.39±0.83^{c}	268.41±1.23^{b}
TPC (mg GAE/kg)	438.52±6.25^{e}	1520.76±8.57^{b}	1813.08±6.19^{a}	966.92±7.81^{c}	836.15±7.03^{d}
AA (Inhibition%)	8.92±0.31e	54.25±0.52^{b}	56.42±0.34^{a}	38.74±0.61^{d}	41.34±0.42^{c}
Ca (mg/100g)	24.70±2.62^{e}	47.64±1.17^{d}	72.56±2.06^{c}	85.70±2.40^{b}	132.40±3.11^{a}
Fe (mg/100g)	2.15±0.10^{e}	4.77±0.04^{a}	2.80±0.03^{d}	3.62±0.07^{c}	3.96±0.06^{b}
Mg (mg/100g)	38.55±0.48^{e}	83.70±0.64^{c}	121.30±0.37^{a}	76.37±0.57^{d}	118.60±0.89^{b}
Cu (mg/100 g)	0.21±0.03^{d}	0.46±0.02^{b}	0.53±0.03^{ab}	0.34±0.04^{c}	0.58±0.01^{a}
L*	95.62±0.55^{a}	62.59±0.27^{e}	80.16±0.43^{d}	84.33±0.21^{c}	86.46±0.31^{b}
a*	-0.81±0.04^{d}	0.15±0.02^{b}	-0.07±0.05^{c}	-0.79±0.03^{d}	0.99±0.06^{a}
b*	8.41±0.13^{e}	20.61±0.10^{b}	14.67±0.14^{d}	29.51±0.23^{a}	15.31±0.25^{c}
C*	8.45±0.14^{e}	20.61±0.10^{b}	14.67±0.13^{d}	29.52±0.24^{a}	15.35±0.25^{c}
hue	95.50±0.17^{a}	89.59±0.13^{c}	90.26±0.25^{c}	91.53±0.21^{b}	86.29±0.20^{d}

The means with the different letter in row are significantly different (P <0.05); Results are dry-weight basis; PA: Pyhtic acid; PP: Pyhtate phosphorus; TPC: Total phenolic content ; AA: Antioxidant activity

Legume flours have lower lightness (L*) and hue, higher yellowness (b*) and chroma (C*) values than wheat flour. The highest redness (a*) value was obtained with common bean flour. Lentil flour showed the lowest L* whereas chickpea flour showed the highest b* values. Dry noodle quality largely depends on flour characteristics and conditions during noodle preparation (Oh et al., 1985a).

Chemical properties of noodle samples

Ash, protein, fat, phytic acid and phytate phosphorus values were significantly ($P < 0.05$) affected by the legume flour addition (Table 2). Ash and protein content of noodle samples ranged between 1.10-1.58%, 13.10-17.89%, respectively. The low ash content in flour is always an advantage for noodles since flour ash is traditionally viewed as causing noodle discoloration (Oh et al., 1985b). The highest protein content in noodle samples was obtained by the addition of faba bean flour. It has been reported that pulses contain relatively high amounts of protein and are an indispensable source of dietary protein (Tiwari and Singh, 2012).

Table 2. Some chemical properties of noodle samples prepared with legume flours

	Ratio (%)	Ash (%)	Protein (%)	Fat (%)	Phytic acid (mg/100g)	Phytate phosphorus (mg/100g)
Control	*0*	1.10±0.06^{d}	13.10±0.16^{c}	2.31±0.16^{c}	148.92±4.70^{e}	42.00±2.62^{d}
Lentil	30	1.38±0.04b^{c}	16.90±0.25^{b}	2.74±0.10^{bc}	418.70±6.53^{a}	118.08±3.79^{a}
Faba bean	30	1.50±0.03^{ab}	17.89±0.11^{a}	3.07±0.14^{ab}	306.12±6.11^{d}	86.33±2.44^{c}
Chickpea	30	1.24±0.05^{cd}	16.56±0.20^{b}	3.51±0.21^{a}	338.50±3.82^{c}	95.46±4.33^{bc}
Common bean	30	1.58±0.04^{a}	16.72±0.27^{b}	2.80±0.13^{bc}	368.20±4.95^{b}	103.84±2.88^{b}

The means with the different letter in column are significantly different ($P < 0.05$); Results are dry-weight basis.

The fat content of noodle samples increased from 2.31(control) to 3.51% by the addition of chickpea flour. Unlike other pulses and cereals, chickpeas are reported to have a relatively high fat content (Messina, 1999; Asif et al., 2013). The phytic acid and phytate phosphorus contents of control noodle samples increased from 148.92 to 418.70 mg/100g and from 42.00 to 118.08 mg/100g, respectively, with legume flour usage in accordance with Herken et al. (2007) who found that addition of cowpea flour (10, 15 and 20%) to the formulation increased the phytic acid content of macaroni samples. Similarly, Demi et al. (2010) reported that chickpea flour in noodle formulation at 0-50% levels increased the phytic acid content from 182.5 to 515.30 mg/100g. The highest phytic acid and phytate phosphorus values were obtained in noodle samples prepared with lentil flour.

Mineral contents of noodle samples are presented in Table 3. The Ca, Fe, Mg and Cu contents of noodle samples containing legume flours increased from 26.30 to 74.52 mg/100g, 2.27 to 4.92 mg/100g, 41.36 to 65.38 mg/100g and 0.28 to 0.51 mg/100g, respectively, compared to control. In noodle samples, the highest increases in mineral content by using legume flour were 2.8 times in Ca, 2.2 times in Fe, 1.6 times in Mg and 1.8 times in Cu. The rich mineral contents of legume flours (Table 1) are directly reflected in the mineral content of the final product. Tiwari and Singh (2012) reported that pulses are good source of phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg). Bilgiçli (2013) reported that chickpea and soy flour in gluten-free noodle formulation caused a significant increase in the mineral content of the end product.

Table 3. Mineral contents of noodle samples prepared with legume flours

	Ratio (%)	Ca (mg/100g)	Fe (mg/100g)	Mg (mg/100g)	Cu (mg/100g)
Control	*0*	26.30±1.27^{d}	2.27±0.04^{d}	41.36±0.34^{e}	0.28±0.04^{b}
Lentil	30	48.65±1.61^{c}	4.92±0.07^{a}	47.83±0.33^{c}	0.35±0.01^{b}
Faba bean	30	65.13±2.21^{b}	4.63±0.03^{b}	65.38±0.40^{a}	0.51±0.06^{a}
Chickpea	30	51.40±2.39^{c}	3.18±0.04^{c}	46.21±0.27^{d}	0.32±0.03^{b}
Common bean	30	74.52±1.95^{a}	3.21±0.06^{c}	62.75±0.38^{b}	0.41±0.04^{ab}

The means with the different letter in column are significantly different ($p<0.05$); Results are dry-weight basis.

All legume flours significantly increased total phenolic content and antioxidant activity values of noodle samples (P <0.05). Total phenolic contents and antioxidant activity values of noodle samples containing legume flours ranged from 767.83 to 1030.66 mg GAE/kg and 18.86 to 25.54%, respectively (Table 4). The total phenolic contents and antioxidant activity values of the control samples were 430.76 mg GAE/kg and 7.94%, respectively. High total phenolic content and antioxidant activity values of legume flours affected the results of the end product. Similarly, Levent (2019) reported that the use of legume hulls and flours in gluten-free tarhana formulation significantly increased total phenolic content and antioxidant activity of tarhana samples. Legumes contain varied amounts of polyphenols and possess a wide range of antioxidant activity (Bouchenak and Lamri-Senhadji, 2013).

Table 4. Cooking properties, total phenolic content and antioxidant activity values of noodle samples prepared with legume flour

	Volume increase (%)	Weight increase (%)	Cooking loss (%)	TPC (mg GAE/kg)	AA (%Inhibition)
Noodle types					
Control	225.85±2.60^{a}	178.35±2.60^{c}	7.43±0.12^{c}	430.76±25.37^{e}	7.94±0.42^{c}
Lentil	248.48±83.82^{a}	210.27±16.18^{ab}	9.12±1.06^{a}	918.16±39.78^{b}	23.82±3.16^{a}
Faba bean	249.52±23.82^{a}	203.20±31.73^{abc}	7.60±0.58^{bc}	1030.66±36.59^{a}	25.54±2.51^{a}
Chickpea	231.32±67.83^{a}	190.13±14.41^{bc}	8.93±0.66^{a}	872.03±33.01^{c}	20.28±2.93^{b}
Common bean	265.46±46.59^{a}	223.00±23.29^{a}	8.68±0.40^{ab}	767.83±46.89^{d}	18.86±2.55^{b}
Drying conditions					
Room	254.27±17.66^{a}	184.92±9.69^{b}	8.46±0.95^{a}	776.15±222.36^{b}	17.18±5.72^{c}
Oven	287.77±39.17^{a}	204.99±19.40^{a}	8.54±1.22^{a}	789.79±205.09^{b}	18.64±6.08^{b}
Microwave	190.35±36.91^{b}	213.06±31.51^{a}	8.07±0.50^{a}	845.72±221.46^{a}	22.05±7.77^{a}

The means with the different letter in column for noodle types and drying conditions are significantly different (p<0.05); TPC: Total phenolic content; AA:Antioxidant activity.

Among the noodle samples, the highest antioxidant activity values were obtained in noodles containing faba bean flour and lentil flour, followed by noodles containing chickpea and common bean flour. Amarowicz and Shahidi (2018) investigated the polyphenolic profiles and antioxidant properties of faba bean extract and faba bean was reported as a potentially valuable legume crop with high antioxidant potential.

The highest total phenolic content and antioxidant activity values were determined in microwave-dried samples. Değirmencioğlu et al. (2016) used oat flour (20-100%, w/w) in tarhana formulation and fermented dough samples were dried by different drying methods: (Sun dried, 5 days at 20 °C; Oven dried: 48 h at 55 °C; Microwave dried: 15 min at 900 W, 2450 MHz). It was reported that oven- and microwave- drying can be recommended to retain the highest for phenolic compounds as well as maximal antioxidant capacity in enriched tarhana samples.

Cooking properties of noodle samples

The cooking quality of noodle is one of the most important noodle properties for consumers. VI, WI and CL values for noodle samples are presented in Table 4. VI and WI values increased from 225.85% (control) to 265.46% and 178.35% (control) to 223.00% with the use of legume flour, respectively. However, these increases were not statistically significant in VI and in WI (except lentil and common bean) compared to control. On the other hand, it was reported that 30% or more of chickpea flour decreased the volume and weight increase values of noodles samples compared to control (Demi et al., 2010). In this study, the dilution of wheat gluten and starch by using legume flour was tried to be eliminated with vital wheat gluten. Therefore, the use of legume flour may not decrease the VI and WI values. The cooking loss values of noodle samples were higher than the control samples except for the noodle samples containing faba bean flour in accordance with Gallegos-Infante et al. (2012)

who found that the addition of 30% common bean flour to semolina increased the CL of spaghetti samples. In a study, the semolina used in the spaghetti formulation was replaced with 5-30% milled flours of green pea, yellow pea, chickpea and lentil. CL was reported to increase with the increase in legume flour content (Zhao et al., 2005). Due to the replacement of wheat protein with legume protein, cooking losses can be attributed to structural changes in the protein network (Torres et al., 2007).

Microwave-dried samples had the lowest VI in noodle samples. Oven and microwave drying improved WI values of samples. In this study, 50 °C was used for oven drying. In the study by Padalino et al. (2016), spaghetti samples were dried using different temperature profiles: 50 °C (very low temperature), 65 °C (low temperature), 75 °C (high temperature), 80 °C and 90 °C (very high temperature). Similarly, the sample dried at 50 °C and 65 °C was reported to exhibit a significant increase in water absorption compared to the sample dried at 90 °C. This was attributed to the fact that the higher drying temperature increases the hydrophobic properties of the gluten network and limits the water absorption behavior (Padalino et al., 2016).

Microwave drying yielded a low cooking loss value but this difference was not significantly different from room and oven-dried samples. Pongpichaiudom and Songsermpong (2018) reported that the higher drying rate of microwave drying compared to infrared drying and hot air drying results in less cooking loss. In another study, it was reported that microwave caused reduction in total organic matter (TOM) of pasta samples, which is the amount of organic matter released from the cooked pasta during exhaustive rinsing compared to conventional drying. Comparison of TOM mean values of samples dried by hot air and microwaves showed no significant difference (De Pilli et al., 2009).

Physical properties of noodle samples

Color values of noodle samples are presented in Table 5. Yellow color and bright appearance are preferred in Turkish noodles (Özkaya et al., 2001). The use of legume flours significantly reduced the lightness (L*) of noodle samples, except common bean flour ($P < 0.05$). Zhao et al. (2005) reported that the color of spaghetti samples became darker with the increase of legume flours in the formulation ($P < 0.05$). Negative correlation of protein content with L* was reported by Kaur et al. (2015). Oven-dried noodle samples showed the highest, while microwave-dried samples showed the lowest lightness values. Hayta et al. (2002) used different drying methods (home and industrial type microwave drying, tunnel drying and freeze drying) in tarhana production. Freeze-dried tarhana samples were reported to have the highest lightness and the home microwave-dried samples had the lowest lightness value (Hayta et al., 2002). Noodle samples containing chickpea flour had the highest yellowness (b*) and chroma (C*) values. The microwave-dried samples revealed the highest redness (a*) and yellowness (b*) values. Mohammed et al. (2012) reported that as the chickpea flour level increased in bread formulation, a* and b* values of bread crumb increased. A more red and yellow crumb was obtained by replacing chickpea flour. It has been reported that discoloration may be caused by non-enzymatic browning reactions between proteins and carbohydrates or by the destruction of naturally occurring pigments by heat treatment (Hayta et al., 2002).

The firmness is defined as the resistance that occurs during biting in cooked noodles (Schoenlechner et al., 2010). In general, the use of legume flour in noodle formulation increased the firmness value (Table 5). Similarly, Zhao et al. (2005) reported that firmness of the spaghetti samples prepared with legume flours (5% to 30%) increased with an increase in legume flour content. According to the drying conditions, it was found that the firmness values of noodle samples were not statistically different from each other. De Pilli et al. (2009) compared the effects of microwave and conventional drying (hot air) on the quality characteristics of cooked pasta and reported that pasta dried by microwaves had a higher firmness than samples dried by hot air.

Table 5. Some physical properties of noodle samples prepared with legume flours

	L*	a*	b*	C*	hue	Firmness (g)
Noodle types						
Control	85.63±2.72^{a}	1.57±1.28^{a}	18.38±3.34^{b}	16.64±0.71^{b}	85.54±2.89^{bc}	310.83±24.72^{bc}
Lentil	76.10±3.87^{d}	0.97±1.64^{b}	18.30±4.10^{b}	18.36±4.20^{b}	87.73±4.10^{a}	286.38±24.26^{c}
Faba bean	78.94±4.27^{c}	1.74±1.56^{a}	17.51±3.54^{b}	17.62±3.69^{b}	84.94±3.71^{c}	380.13±26.50^{a}
Chickpea	82.55±3.46^{b}	1.75±1.84^{a}	24.51±2.34^{a}	24.62±2.48^{a}	86.21±3.71^{b}	369.93±32.15^{a}
Common bean	84.48±3.46^{a}	1.52±1.39^{a}	18.24±2.88^{b}	18.32±3.01^{b}	85.70±3.34^{bc}	353.17±22.02^{ab}
Drying conditions						
Room	82.55±4.21^{b}	0.76±0.37^{b}	17.81±3.30^{b}	17.83±3.29^{b}	87.46±1.39^{b}	348.52±45.95^{a}
Oven	84.72±2.90^{a}	0.29±0.34^{c}	16.87±2.92^{b}	16.94±2.93^{b}	89.05±1.23^{a}	340.16±46.35^{a}
Microwave	77.35±4.22^{c}	3.48±0.40^{a}	23.48±2.13^{a}	22.58±3.57^{a}	81.57±0.73^{c}	331.59±41.85^{a}

The means with the different letter in column for noodle types and drying conditions are significantly different (P <0.05).

Sensory analysis

The use of faba bean flour in noodle formulation reduced all sensory attributes in raw samples (Table 6). Noodle samples dried at room conditions received higher scores in terms of surface smoothness and appearance compared to oven and microwave-dried samples. Drying conditions did not significantly affect the speck and crack scores of noodle samples. The control samples received the highest taste scores among the noodle samples; this was followed by noodle samples containing lentil, chickpea, common bean and faba bean flour. Zhao et al. (2005) used green pea, yellow pea, chickpea and lentil flours in spaghetti formulation (5 and 30%) and reported that spaghetti samples containing legume flour had beany off-flavor, which might be derived from the raw legume flour. In this study, legume flour was obtained after soaking, cooking, drying and milling of legumes. For that reason noodles containing legume flours had no beany off-flavor. Microwave-dried samples had higher taste scores than oven-dried samples. In the study by Pongpichaiudom and Songsermpong (2018), microwave-dried instant noodle had a higher score than fried samples in terms of odor, texture, and overall acceptability. Noodle samples containing legume flours had similar or lower taste, odor and chewiness scores compared to the control samples. Noodle types and drying conditions did not significantly affect the stickiness of noodles. Noodles containing faba bean flour had the lowest chewiness scores among the noodle samples. High flour protein causes a strong adhesion between starch and protein, thus resulting in a tight noodle structure (Oh et al., 1985b). In general, the sensory analysis scores of microwave-dried cooked noodles were found to be similar or higher than those dried in other drying conditions (Table 7).

Table 6. Sensory properties of raw (uncooked) noodle samples

	Surface smoothness	Speck	Crack	Appearance
Noodle types				
Control	8.57±0.45^{a}	7.83±0.46^{ab}	8.43±0.37^{ab}	8.73±0.37^{a}
Lentil	8.13±0.62^{ab}	7.43±0.43^{b}	7.90±0.62^{b}	8.03±0.73^{b}
Faba bean	6.77±0.76^{c}	5.23±0.71^{c}	6.73±0.33^{c}	6.90±0.50^{c}
Chickpea	7.73±0.61^{b}	8.40±0.25^{a}	8.63±0.16^{a}	8.63±0.16^{ab}
Common bean	8.0±0.67^{ab}	7.57±0.30^{b}	8.30±0.33^{ab}	8.57±0.38^{ab}
Drying conditions				
Room	8.38±0.57^{a}	7.58±0.94^{a}	8.18±0.81^{a}	8.56±0.63^{a}
Oven	7.54±0.94^{b}	7.18±1.17^{a}	7.92±0.70^{a}	7.90±0.80^{b}
Microwave	7.60±0.77^{b}	7.12±1.44^{a}	7.90±0.86^{a}	8.06±0.92^{b}

The means with the different letter in column for noodle types and drying conditions are significantly different (P <0.05).

Table 7. Sensory properties of cooked noodle samples

	Taste	Odor	Stickiness	Chewiness
Noodle types				
Control	8.23±0.41^{a}	8.37±0.34^{a}	8.57±0.29^{a}	7.77±0.34^{a}
Lentil	7.23±1.21^{b}	7.87±0.28^{ab}	8.47±0.22^{a}	7.17±0.45^{ab}
Faba bean	5.77±0.46^{c}	7.27±0.42^{c}	8.33±0.33^{a}	4.83±0.71^{c}
Chickpea	6.83±0.35^{b}	7.83±0.12^{abc}	8.50±0.21^{a}	6.83±0.38^{b}
Common bean	6.27±0.36^{bc}	7.40±0.46^{bc}	8.27±0.31^{a}	7.0±0.61^{ab}
Drying conditions				
Room	6.82±1.00^{ab}	7.80±0.33^{a}	8.46±0.26^{a}	6.54±1.19^{b}
Oven	6.50±0.96^{b}	7.62±0.68^{a}	8.36±0.29^{a}	6.56±1.31^{ab}
Microwave	7.28±1.13^{a}	7.82±0.49^{a}	8.46±0.31^{a}	7.06±0.84^{a}

The means with the different letter in column for noodle types and drying conditions are significantly different (P <0.05).

CONCLUSION

In this study, the effects of legume flours addition and different drying techniques on noodle quality were investigated. Legume flours significantly increased the ash, protein, fat, Ca, Fe, Mg, Cu, total phenolic contents and antioxidant activity of noodle samples (P <0.05). Phytic acid and phytate phosphorus content increased by using legume flour in noodle samples. Microwave and oven-dried samples gave the highest WI value in noodle samples. While drying conditions did not affect CL, microwave-dried samples gave the highest total phenolic content and antioxidant activity values. The lightness values of the legume flour added samples decreased except for common bean flour samples. Microwave drying decreased lightness and increased redness and yellowness values in noodle samples. The control and noodle samples containing lentil flour had a lower firmness values than the other samples. The use of faba bean flour in uncooked noodle samples decreased all sensory properties. As a result of this study, it was determined that legume flour is an important ingredient for nutritional enrichment of cereal products and microvawe drying can be recommended for drying of pasta products to keep bioactive components. In future studies, pasta-type products can be dried at different high temperature norms or by different drying techniques and results can be compared with microwave drying method.

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REFERENCES

AACC. (2000). *Approved methods of the American Association of Cereal Chemists* (8th ed.). St. Paul, MN: AACC International.

Altan, A., Maskan, M. (2005). Microwave assisted drying of short-cut (ditalini) macaroni: Drying characteristics and effect of drying processes on starch properties. *Food Res Int*, 38, 787-796, doi: 10.1016/j.foodres.2005.02.006.

Amarowicz, R., Shahidi, F. (2018). Antioxidant activity of faba bean extract and fractions thereof. *J Food Bioactives*, *2*, 112-118, doi: 10.31665/JFB.2018.2146.

Asif, M., Rooney, L.W., Ali, R., Riaz, M.N. (2013). Application and opportunities of pulses in food system: a review. *Crit Rev Food Sci Nutr*, 53, 1168-1179, doi: 10.1080/10408398.2011.574804.

Basman, A., Yalcin, S. (2011). Quick-boiling noodle production by using infrared drying. *J Food Eng*, 106, 245-252, doi: 10.1016/j.jfoodeng.2011.05.019.

Berteli, M.N., Marsaioli Jr, A. (2005). Evaluation of short cut pasta air dehydration assisted by microwaves as compared to the conventional drying process. *J Food Eng*, 68, 175-183, doi: 10.1016/j.jfoodeng.2004.04.043.

Beta, T., Nam, S., Dexter, J.E., Sapirstein, H.D. (2005). Phenolic content and antioxidant activity of pearled wheat and roller-milled fractions. *Cereal Chem,* 82, 390-393, doi: 10.1094/CC-82-0390.

Biçer, Ü.N.S. (2018). Determination of heavy metal contents in some varieties of molasses produced in Karaman with ICP-OES and AAS methods. Ms Thesis, Karamanoğlu Mehmetbey University, Karaman, Turkey, 152 p.

Bilgiçli, N. (2009). Effect of buckwheat flour on cooking quality and some chemical, antinutritional and sensory properties of erişte, Turkish noodle. *Int J Food Sci Nutr*, 60(sup4), 70-80, doi: 10.1080/09637480802446639.

Bilgiçli, N. (2013). Some chemical and sensory properties of gluten-free noodle prepared with different legume, pseudocereal and cereal flour blends. *J Food and Nutr Res*, 52, 251-255.

Bouchenak, M., Lamri-Senhadji, M. (2013). Nutritional quality of legumes, and their role in cardiometabolic risk prevention: a review. *J Med Food*, *16*, 185-198, doi: 10.1089/jmf.2011.0238.

De Pilli, T.D., Giuliani, R., Derossi, A., Severini, C. (2009). Study of cooking quality of spaghetti dried through microwaves and comparison with hot air dried pasta. *J Food Eng*, 95, 453–459, doi: 10.1016/j.jfoodeng.2009.06.005.

Değirmencioğlu, N., Gürbüz, O., Herken, E.N., Yıldız, A.Y. (2016). The impact of drying techniques on phenolic compound, total phenolic content and antioxidant capacity of oat flour tarhana. *Food Chem*, *194*, 587-594, doi: 10.1016/j.foodchem.2015.08.065.

Demi, B., Bilgiçli, N., Elgün, A., Demi, M.K. (2010). Effects of chickpea flours and whole egg on selected properties of erişte, Turkish noodle. *Food Sci Technol Res*, 16, 557–564, doi: 10.3136/fstr.16.557.

Francis, F.J., (1998). Colour analysis, In: *Food analysis,* Nielsen SS (Ed), An Aspen Publishers, Maryland, Gaithersnurg, USA, 599-612.

Gallegos-Infante, J.A., Rivas, M.G., Chang, S., Manthey, F., Yao, R.F., Reynoso-Camacho, R., ... Gonzalez-Laredo, R.F. (2012). Effect of the addition of common bean flour on the cooking quality and antioxidant characteristics of spaghetti. *J Microbiol Biotechno Food Sci*, 2, 730-744.

Gao, L.,Wang, S., Oomah, B.D. and Mazza, G., (2002). Wheat quality: antioxidant activity of wheat millstreams. In: Ng, P., Wrigley, C.W. (Eds.), *Wheat Quality Elucidation*. AACC International, St. Paul, MN, 219-233.

Geil, P.B., Anderson, J.W. (1994). Nutrition and health implications of dry beans: a review. *J Am Coll Nutr*, *13*, 549-558, doi: 10.1080/07315724.1994.10718446.

Gómez, M., Oliete, B., Rosell, C. M., Pando, V., Fernández, E. (2008). Studies on cake quality made of wheat–chickpea flour blends. *LWT-Food Sci Technol*, 41(9): 1701-1709, doi: 10.1016/j.lwt.2007.11.024.

Gowen, A., Abu-Ghannam, N., Frias, J., Oliveira, J. (2006). Optimisation of dehydration and rehydration properties of cooked chickpeas (Cicer arietinum L.) undergoing microwave–hot air combination drying. *Trends Food Sci Tech*, 17, 177-183, doi: 10.1016/j.tifs.2005.11.013.

Haug, W. and Lantzsch, H.J., 1983. Sensitive method for the rapid determination of phytate in cereals and cereal product. *Journal of the Science of Food and Agriculture*, 34: 1423-1426, doi: 10.1002/jsfa.2740341217.

Hayta, M., Alpaslan, M., Baysar, A. (2002). Effect of drying methods on functional properties of tarhana: A wheat flour-yogurt mixture. *J Food Sci*, 67, 740-744, doi: 10.1111/j.1365-2621.2002.tb10669.x.

Herken, E.N., İbanoğlu, Ş., Öner, M.D., Bilgiçli, N., Güzel, S. (2007). Effect of storage on the phytic acid content, total antioxidant capacity and organoleptic properties of macaroni enriched with cowpea flour. *J Food Eng*, 78, 366-372, doi: 10.1016/j.jfoodeng.2005.10.005.

Iqbal, A., Khalil, I. A., Ateeq, N., Khan, M.S. (2006). Nutritional quality of important food legumes. *Food Chem*, 97, 331-335, doi: 10.1016/j.foodchem.2005.05.011.

Kaur A., Singh N., Kaur S., Katyal M., Virdi A.S., Kaur D., Ahlawat A.K., Singh A.M. (2015) Relationship of various flour properties with noodle making characteristics amongst durum wheat varieties. *Food Chem*, 188, 517–526, doi: 10.1016/j.foodchem.2015.05.009.

Levent, H. (2019). Physical, chemical and sensory evaluation of gluten-free tarhana with legume hulls and flours. *Quality Assurance and Safety of Crops & Foods*, 1-10, doi: 10.3920/QAS2018.1538

Maskan, M. (2001). Drying, shrinkage and rehydration characteristics of kiwifruits during hot air and microwave drying. *J Food Eng*, 48, 177-182, doi: 10.1016/S0260-8774(00)00155-2.

Maurer, R.L., Tremblay, M.R., Chadwick, E.A. (1971). Microwave of pasta: improves product, reduces cost and production time, *Food Technol*, 25, 32–37.

Messina, M. J. (1999). Legumes and soybeans: Overview of their nutritional profiles and health effects. *Am J Clin Nutr*, 70:439S–450S, doi: 10.1093/ajcn/70.3.439s.

Mlyneková, Z., Chrenková, M., Formelová, Z. (2014). Cereals and Legumes in Nutrition of People with Celiac. *Int J Celiac Dis*, *2*, 105-109, doi: 10.12691/ijcd-2-3-3.

Mohammed, I., Ahmed, A. R., Senge, B. (2012). Dough rheology and bread quality of wheat–chickpea flour blends. *Ind Crop Prod*, 36, 196-202, doi: 10.1016/j.indcrop.2011.09.006.

Mujumdar, A.S., Law, C.L. (2010). Drying technology: Trends and applications in postharvest processing, *Food Bioprocess Tech*, *3*, 843-852, doi: 10.1007/s11947-010-0353-1.

Torres, A., Frias, J., Granito, M., Vidal-Valverde, C. (2007). Germinated Cajanus cajan seeds as ingredients in pasta products: Chemical, biological and sensory evaluation. *Food Chem*, 101, 202-211, doi: 10.1016/j.foodchem.2006.01.018.

Ogawa, T., Chuma, A., Aimoto, U., Adachi, S. (2017). Effects of drying temperature and relative humidity on spaghetti characteristics. *Drying Technology*, 35(10): 1214-1224, doi: 10.1080/07373937.2016.1236812

Oh, N.H., Seib, P.A., Chung, D.S. (1985a). Noodles III. Effects of processing variables on quality characteristics of dry noodles. *Cereal Chem*, 62, 437-440.

Oh, N.H., Seib, P.A., Ward, A.B., Deyoe, C.W. (1985b). Noodles IV. Influence of flour protein, extraction rate, particle size, and starch damage on the quality characteristics of dry noodles. *Cereal Chem*, 62, 441-446.

Özkaya, B., Özkaya, H., Buyukikiz, E. (2001). The cooking properties of Eriste (Turkish noodle) produced by traditional methods. *Getreide Mehl und Brot*, 55, 120–125.

Özkaya B, Özkaya H, Bayrak H, Gökpinar F. (20 04). The effect of drying process on the quality of erişte In: Proceedings of the Traditional Foods Symposium Van, Yüzüncü Yıl University, Turkey, 60–66.

Padalino, L., Caliandro, R., Chita, G., Conte, A.,Del Nobile, M.A. (2016). Study of drying process on starch structural properties and their effect on semolina pasta sensory quality. *Carbohydr Polym*, *153*, 229-235, doi: 10.1016/j.carbpol.2016.07.102

Patterson, C.A., Maskus, H., Dupasquier, C. (2009). Pulse crops for health. *Cereal Food World*, *54*(3), 108, doi: 10.1094/CFW-54-3-0108.

Pongpichaiudom, A., Songsermpong, S. (2018). Characterization of frying, microwave-drying, infrared-drying, and hot-air drying on protein-enriched, instant noodle microstructure, and qualities. *Journal of Food Processing and Preservation*, 42(3), e13560, doi: 10.1111/jfpp.13560

Rockland, L. B., Radke, T.M. (1981). Legume protein quality. *Food Technology (USA).*

Schoenlechner, R., Drausinger, J., Ottenschlaeger, V., Jurackova, K., & Berghofer, E. (2010). Functional properties of gluten-free pasta produced from amaranth, quinoa and buckwheat. *Plant Foods Hum Nutr*, 65(4): 339-34, doi: 10.1007/s11130-010-0194-0.

Singh, U., Singh, B. (1992). Tropical grain legumes as important human foods. *Economic Botany*, *46*(3), 310-321, doi: 10.1007/BF02866630.

Tiwari, B. K., Singh, N. (2012). *Pulse Chemistry and Technology*, Royal Society of Chemistry. United Kingdom: Royal Society of Chemistry Publishing.

Wronkowska, M., Zielińska, D., Szawara-Nowak, D.-Troszyńska, A. and Soral-Śmietana, M. (2010). Antioxidative and reducing capacity, macroelements content and sensorial properties of buckwheat enhanced gluten-free bread. *Int J Food Sci Tech,* 45, 1993–2000, doi: 10.1111/j.1365-2621.2010.02375.x.

Zhao, Y.H., Manthey, F.A., Chang, S.K., Hou, H.J., Yuan, S.H. (2005). Quality characteristics of spaghetti as affected by green and yellow pea, lentil, and chickpea flours. *J Food Sci*, *70*(6), 371-376, doi: 10.1111/j.1365-2621.2005.tb11458.x.