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Nutritional, chemical and cooking properties of noodles enriched with terebinth (*Pistacia Terebinthus*) fruits roasted at different temperatures

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Abstract

This study aims to investigate the possible usages of terebinth as a functional additive in noodle formulation. For this purpose, raw terebinth and roasted terebinth in different temperatures (100 °C, 125 °C, 150 °C, 175 °C and 200 °C) were added to the formulation at rates of 0%, 10%, 20% and 30% to produce noodles. According to the results of this study, the use of terebinth in the noodle formulation decreased the amount of phytic acid in the noodles while it significantly increased the amount of ash, protein, fat, total dietary fiber, total phenolic content and antioxidant ($p < 0.05$). In the sensory analysis, the highest score in the context of general acceptances was obtained from the sample B1 which 10% terebinth roasted at 100 °C while the lowest score belonged to the sample F3 which 30% terebinth roasted at 200 °C was added.

Keywords: noodles; noodle quality; terebinth (*Pistacia terebinthus*); functional food.

Practical Application: Terebinth is recently reported to be a plant rich in antioxidant, phenolic, and tocopherol content. In this study, unroasted terebinth and roasted terebinth in different temperatures were added to the formulation at different rates to produce noodles, and terebinth's effects on nutritional, chemical and cooking properties of noodle were evaluated. It has been concluded that the use of terebinth in noodle formulation increases especially nutritional properties (total dietary fiber, total phenolic content and antioxidant activity) and that terebinth can be a suitable component in noodle enrichment.

1 Introduction

Pistacia terebinthus L. is one of the 20 Pistacia species commonly found in Mediterranean and Asian countries and it is also a slow growing tree. Pistacia species, which are a member of the *Anacardiaceae* family, specifically contain flavonoids and other phenolic compounds. It has attracted the attention of researchers due to its antioxidant, anti-inflammatory, antipyretic and antiseptic properties and the fat content in its seeds (Göğüş et al., 2011). The fruit of *Pistacia terebinthus* L. tree, locally known as the terebinth, is a highly aromatic, fatty seed with unique taste and odor which is collected from trees and shrubs found in the Mediterranean region in August-December, and sold in spice stores, herbalists and public markets throughout the year. Terebinth tree is not cultivated in the cultural sense, and its fruits are traditionally processed and consumed in both raw and roasted form and it has various uses from beverages to pastes (Karakaş & Certel, 2004). The paste obtained by grinding the terebinth after being roasted is consumed as coffee under the name "menengic coffee" in Gaziantep region, Turkey (Baytop, 1999). In rural areas, the terebinth is mixed with dried figs and walnuts. Also, the ground and roasted terebinth is used in special flat bread making. In some regions it is blended with some flavors and spices to produce a mixture called "*zahter*" to be consumed at breakfasts. In addition, the oils obtained from the terebinth have usages in cooking (Tanker & Tanker, 1990).

There are many studies on the volatile components of *Pistacia terebinthus* L. obtained from its fruits, flowers or leaves and branches. Dried fruit extracts of *P. terebinthus* L. have been shown to have some hypolipidemic effects on rabbits without toxic effects (Bakirel et al., 2003). *P. terebinthus* L. fruits have been found to improve lipid profile and leads to atherosclerosis decrease (Edwards et al., 1999). It was found out in a study that the compounds in citlembik (terebinth) essential oil played an active role in prevention of many illnesses such as cancer, alzheimer, and so on. It is also stated that these substances bind to the reactive oxygen by easily entering the tissues with their lipophilic effect and thus, have antioxidant properties (Grassmann et al., 2002). The coffee produced from terebinth (menengic coffee) locally used against sunstroke, abdominal pains, stomach discomfort, rheumatism, cough, foot sweating, wound and burn along with its diuretic, antipyretic properties were proven to have medical values in many scientific studies (Özcan et al., 2009).

Due to the increase in consumers' expectance in life quality, the development of healthy eating awareness, and the increase in obesity and cardiovascular diseases in recent years, the consumers now expect nutritional and various other benefits. Thus, the functional food production and consumption has increased. The main purpose of enrichment studies for functional food production is to replace nutrients lost from foods for various reasons and to add more nutrients to them to prevent problems related to nutritional deficiency (Koyuncu et al., 2011). Due to its simple preparation process, low cost, fast and easy cooking, sensory properties, long shelf life, diversity and nutritiousness, the popularity of noodles is constantly increasing. For this reason, noodles are considered to be a suitable food for enrichment.

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Therefore, this study aims to determine to what extent terebinth as a functional component can be added to the noodle formulation, and also to investigate the effects terebinth addition on the nutritional and some quality characteristics of noodles.

2 Materials and methods

2.1 Materials

The wheat flour and salt were used in the production of noodles were obtained from a local market. The terebinth fruit was used as an additive in the study was bought from Şekeroğlu Baharatçılık Co. Ltd. operating in Kilis, Turkey.

Noodles were produced by adding the paste which is sticky consistency not powder obtained from raw and roasted terebinth fruits into noodle dough flour. A noodle sample with no terebinth addition was used as control group. Terebinth fruits were separated into six groups after being sorted out from foreign matter and defective fruits, and each group was roasted for 20 minutes in preheated drying-oven at the temperatures given below:

- Group 1 unroasted
- Group 2 roasted at 100 °C
- Group 3 roasted at 125 °C
- Group 4 roasted at 150 °C
- Group 5 roasted at 175 °C
- Group 6 roasted at 200 °C

Terebinth pastes were obtained by grinding the terebinth in a laboratory type crushing mill.

2.2 Methods

Noodle production

The terebinth pastes were added to the noodle formulation were replaced with the same amount of wheat flour at rates of 0%-control, 10%, 20% and 30%. Yalçın & Başman's (2008) noodle production method was modified and utilized in this study. 200 g flour, 4 g salt and 90 mL water were used in the production of control noodles. 2% salt in proportion to wheat flour-terebinth paste mixture was added to noodle formulations prepared by mixing with terebinth paste in different ratios. The amount of water and kneading time was determined by considering the dough characteristics. The sample names in the text are abbreviated with codes. According to this, (A) is the code given to unroasted terebinth, (B) for roasted at 100 °C, (C) for roasted at 125 °C, (D) for roasted at 150 °C, (E) for roasted at 175 °C, and (F) for roasted at 200 °C. The terebinth addition rates 10%, 20% and 30% were expressed as 1, 2, and 3 respectively.

Chemical analysis

AACC methods were used to determine the ash (method 08-01), protein (method 46-12) and fat (method 30-25) contents of wheat flour, terebinth paste and noodle samples (American Association of Cereal Chemists, 2010).

Noodle cooking tests

The optimum cooking time of the noodles was determined based on the AACC method (method 66-50) (American Association of Cereal Chemists, 2010). The optimum cooking time was defined as the time required for disappearance of the opaque central core of the noodle strand when squeezed between two glass plates. Weight increase (WI), volume increase (VI) and cooking loss (CL) values were determined according to Aktaş et al. (2015). 10 g noodles samples were cooked in 300 mL distilled water for 18 minutes. Noodles were weighed before and after cooking and weight increase was calculated by using Equation 1. For VI, raw and cooked noodle samples were placed in a graduated cylinder with a certain amount of distilled water and the increase in water level was measured. VI was calculated using Equation 2. For cooking loss (CL), the cooking water was evaporated to constant weight at 100 °C and expressed as the % total amount of substance passing into water.

$$\text{WI (\%)} = 100 \times \left[\left(\begin{matrix} \text{cooked noodles weight} - \\ \text{raw noodles weight} \end{matrix} \right) / \text{ weight of raw noodles} \right] \quad (1)$$

$$\text{VI (\%)} = 100 \times \left[\left(\begin{matrix} \text{cooked noodles volume} - \\ \text{raw noodles volume} \end{matrix} \right) / \text{ raw noodles volume} \right] \quad (2)$$

Total organic matter (TOM): TOM value of noodles was determined according to the method reported by D'Egidio et al. (1982). The method is based on the washing noodles samples are with a little water after cooking which leads the organic matter on sample surface pass into the water and the amount of organic matter in the washing water is determined with chemical methods.

Nutritional features

Total Dietary Fiber (TDF)

The analysis was made on flour, terebinth paste and dry noodle samples. The total dietary fiber was determined with a fiber test kit (Megazyme International Ireland Ltd., Bray Business Park, Bray, Co. Wicklow, IRELAND) by using the modified method proposed by Lee et al. (1992).

Phytic acid

The phytic acid content was determined by using Haug & Lantzsch's (1983) calorimetric method.

Total Phenolic Content (TPC)

Gutfinger's (1981) method was used to determine TPC in flour, terebinth paste and dried noodles. TPC values were calculated with the equation obtained from the absorbance/concentration standard curve previously formed with gallic acid and the results were expressed as the mg amount of gallic acid equivalent (GAE) for 100 grams sample.

Antioxidant activity

The modified version of Yu et al.'s (2002) method was used to analyze flour, terebinth paste and dry noodles. This method is based on the spectrophotometric measurement of the decrease in color resulting from the destruction of DPPH (2,2-diphenyl-1-

picrylhdrazyl) radical, a pink colored stable compound. Results were calculated by using Equation 3 as the rate of inhibition percentage of DPPH radical.

$$\text{DPPH inhibition } (\%) = \left[\left(A_{Blank} - A_{Sample}\right) / A_{Blank}\right] \text{ x } 100 \quad (3)$$

where: A_{Blank} = Absorbance of blank; A_{Sample} = Absorbance of sample.

Protein digestibility

The analysis was made on cooked noodle samples according to the method reported by Akıllıoğlu & Yalçın (2010).

Color analysis

Color measurements of flour, terebinth paste and dry noodle samples were made with Hunterlab MiniScan EZ (Reston, Virginia, USA) model color measurement device and values were again expressed according to the CIELAB measurement system in the same device. In HunterLab color scale, L * = 0 (black), L * = 100 (white); -a * (green), +a * (red); -b * (blue), +b* (yellow) values were recorded as (D65/10°) in daylight.

Sensory properties

Sensory analysis was carried out by modifying the method by Inglett et al. (2005). While preparing the noodle samples for analysis, 100 g sample was cooked in 500 mL water for 10 minutes and the excess water was filtered for 20 seconds. Sensory analysis was performed by 10 semi-trained panelists, who are between the ages of 30 and 55. The panelists were asked to do a sensory analysis between a scale of 1-5 (1-very bad, 2-bad, 3-medium, 4-good and 5-very good) in terms of appearance (color and brightness), textural properties (hardness and stickiness), taste-aroma characteristics and general acceptability.

Statistical analysis

The results of the study, which was conducted with two replicates, were evaluated statistically by using JMP (JMP 11 for Windows) software. The differences between groups was determined with LSD test at $p < 0.05$ level by applying the One-way statistical model.

3 Results and discussion

3.1 Raw material properties

Table 1 shows the composition of wheat flour and terebinth paste used in the study. The ash, protein, fat and phytic acid contents of wheat flour were 0.55%, 10.47%, 1.03% and 1.74 mg/g respectively. In the literature, ash, protein, fat and phytic acid contents of wheat flour used in noodle production were reported to be 0.50%, 10.50%, 0.62% and 2.40 mg/g, respectively (Aktaş & Türker, 2015). As it can be seen from the table, the wet gluten value of wheat flour was determined as 29.10%, dry gluten value as 11.50%, gluten index value as 96.48% and Zeleny sedimentation value as 37.00 mL. TDF, TPC and antioxidant activity values of wheat flour used in noodle production were found as 1.97%, 1012.16 mgGAE/100 g and 12.92%, respectively. These results were similar to those reported by Bilgiçli & İbanoğlu (2007). In our study, the ash content of unroasted terebinth fruit was determined as 3.07%, protein content was 10.55% and fat content was 41.37% (Table 1).

In a study conducted by Özcan (2004), ash, protein and fat contents of the terebinth fruits were found to be 3.1%, 9.67% and 38.74% respectively. While the nutritional fiber values of the roasted terebinth at different temperatures were determined as 4.28%, 7.15%, 13.67%, 16.92%, 19.34% and 22.60% respectively, while the phenolic matter contents were 607.82 mgGAE/100 g, 556.91 mgGAE/100 g, 738.95 mgGAE/100 g, 756.45 mgGAE/100 g, 770.55 mgGAE/100 g, 800.55 mgGAE/100 g and antioxidant values were found as 90.39%, 91.91%, 93.57%, 95.08%, 96.29% and 98.18%. According to these values, different roasting temperatures resulted in a significant increase in the chemical properties of the terebinth ($p < 0.05$).

When Table 1 is examined, L*, a* and b* values of wheat flour were determined as 96.56, -0.53, 7.51 respectively. The color values of unroasted terebinth (sample A) were determined as L* = 16.04, a* = 3.82 and b* = 12.26.When the color values of the unroasted terebinth were examined, it was observed that

Table 1. Chemical, physicochemical, functional and color properties of wheat flour and terebinth used in noodle production†.

Properties	Wheat Flour	Terebinth					
		A	B	C	D	E	F
Ash (%)	0.55	3.07 ± 0.04^{a}	3.12 ± 0.12^{a}	3.18 ± 0.44^{a}	3.27 ± 0.27^{a}	3.34 ± 0.09^{a}	3.46 ± 0.24^{a}
Protein (%)	10.47	10.55 ± 0.06^{c}	10.68 ± 0.22^{bc}	10.94 ± 0.25^{bc}	11.04 ± 0.18^{bc}	11.24 ± 0.47^{b}	11.97 ± 0.22^{a}
Fat (%)	1.03	41.37 ± 0.87^{d}	44.74 ± 0.84^{c}	45.22 ± 0.84^{c}	48.03 ± 0.90^{b}	49.33 ± 0.45^{ab}	51.11 ± 0.21^{a}
TDF (%)	1.97	4.28 ± 1.57^{d}	7.15 ± 0.07^{d}	13.67 ± 0.42^{c}	16.92 ± 0.32^{bc}	19.34 ± 2.35^{ab}	22.60 ± 3.05^{a}
TPC (mgGAE/100 g)	102.16	607.82 ± 51.75^{b}	656.91 ± 58.82^{b}	738.95 ± 2.57^{a}	756.45 ± 26.03^{a}	770.55 ± 7.39^{a}	800.55 ± 11.89^{a}
Antioxidant activity (%)	12.92	90.39 ± 0.32^{f}	91.91 ± 0.32^{e}	93.57 ± 0.32^{d}	95.08 ± 0.11^{c}	96.29 ± 0.11^{b}	98.18 ± 0.00^{a}
Phytic acid (mg/g)	1.74	4.48 ± 0.58^{a}	2.51 ± 1.19^{b}	1.50 ± 0.50^{bc}	0.91 ± 0.55^{c}	0.82 ± 0.20^{c}	0.74 ± 0.35^{c}
L*	96.56	16.04 ± 0.29^{a}	15.66 ± 0.07^{a}	14.34 ± 0.31^{b}	12.47 ± 0.51^{c}	9.72 ± 0.19^{d}	7.16 ± 0.76^{e}
a*	-0.53	3.82 ± 0.18^{d}	6.22 ± 0.61^{c}	7.59 ± 0.22^{b}	7.98 ± 0.06^{ab}	8.43 ± 0.80^{ab}	8.86 ± 0.08^{a}
b*	7.51	12.26 ± 0.54^{b}	13.60 ± 1.46^{ab}	13.77 ± 0.62^{ab}	13.99 ± 0.04^{a}	14.04 ± 0.06^{a}	14.11 ± 0.14^{a}

†Mean values with same letters in the same line are not statistically different ($p > 0.05$).

they were more yellow, red and darker than wheat flour. It was found out that the color values decreased and the color density increased as the roasting temperature of the terebinth samples were increased. In addition, color values found for wheat flour were found to be compatible with the literature (Aktaş et al., 2015; Demi et al., 2010).

3.2 Chemical properties

Table 2 shows the chemical properties of the noodle samples. Ash content values of the noodle samples significantly increased based on the increase in both roasting temperature and terebinth paste addition ratio. Ash content of the noodles varied between 0.81% and 2.00%. The highest ash value belonged to sample F3 with 2.00% while A1 had the lowest value with 0.81%.

It was observed that the use of terebinth in the noodle formulation significantly increased the amount of protein ($p < 0.05$). While the amount of protein was determined as 11.36% in the control noodles, it ranged from 11.46% to 14.16% in the noodles with terebinth addition. Table 2 shows that the protein values of the noodles with terebinth addition were higher than the control sample. Protein values in the samples increased depending on both the increase of the roasting temperature and the increase in the ratio of terebinth addition. While the highest protein value was 14.16% in sample F3, the control sample had the lowest protein value with 11.36%. The increase in protein values was due to the high protein content of the terebinth fruit. Since the fat content in the terebinth is higher than the fat content in wheat flour, the fat content in the noodles increased significantly as the addition rate increased ($p < 0.05$) (Table 2). The fat values of the samples also increased due to the increase in roasting temperature. While the amount of fat in the control noodle was 1.08%, the highest fat content in the noodles with terebinth was found in the sample F3 with a value of 13.94%. The results of this study are consistent with the results reported by Aktaş et al. (2015), Bilgiçli & İbanoğlu (2015).

3.3 Color

Color is one of the most important characteristics affecting the acceptability of food products by consumers. In particular, brightness is an indispensable criterion for noodles to be perceived as high quality (Koca et al., 2017). The effect of different amounts of terebinth addition on the color properties of uncooked noodle samples is shown in Table 3. Terebinth addition ratio and different roasting temperatures significantly affected all color values ($p < 0.05$). It was observed that the L* values of the noodle samples ranged from 43.44 to 90.90 and the values decreased depending on the roasting temperature and the increase in terebinth addition ratio. The lowest L* value in the noodles with terebinth addition belonged to sample F3. As can be seen from Table 3, the a* and b* values of the noodles with terebinth addition increased due to both the increase in the addition rate and the increase in the roasting temperature. The highest a* value was 9.21 in sample F3 while the lowest a* value was 2.06 in control sample. Noodles with terebinth addition were found to be more yellow and red in color than the control sample. These color changes in the noodle samples are closely related to the color properties of the terebinth added to the noodle formulation.

In many studies that investigated the color properties of noodles, as the addition ratio increased, the color values of end product changed depending on the color characteristics of the raw material used for enrichment. Corn cob fiber (Aukkanit et al., 2017), chickpea flour (Demi et al., 2010), buckwheat flour (Bilgiçli, 2009), lupine flour (Bilgiçli & İbanoğlu, 2015) and rosehip flour (Koca et al., 2017) decreased the L* values of the noodles but increased a* and b* values. The color values determined in our study were found to be compatible with the values obtained in these studies.

Table 2. Chemical properties of terebinth added noodle samples*.

Samples	Ash (%)	Protein (%)	Fat (%)
Control	0.92 ± 0.03^{h}	11.36 ± 0.11^{k}	1.08 ± 0.09^{m}
A1	0.81 ± 0.00^{h}	11.46 ± 0.25^{jk}	4.42 ± 0.09^{l}
A2	0.95 ± 0.03^{gh}	11.54 ± 0.44^{jk}	7.26 ± 0.21^{ij}
A3	1.09 ± 0.03^{gh}	11.58 ± 0.04^{ijk}	10.33 ± 0.15^{efgh}
B1	1.16 ± 0.06^{fgh}	11.58 ± 0.37^{ijk}	4.71 ± 0.03^{l}
B2	1.28 ± 0.04^{defg}	11.71 ± 0.01^{hijk}	$8.78 \pm 1{,}64^{hi}$
B3	1.50 ± 0.09^{cdef}	11.98 ± 0.32^{fghi}	11.02 ± 0.62^{cdef}
C1	1.28 ± 0.10^{efg}	11.78 ± 0.21^{ghij}	5.18 ± 0.11^{kl}
C2	1.54 ± 0.08^{bcde}	12.03 ± 0.04^{fgh}	$8.94 \pm 0{,}95^{ghi}$
C3	1.63 ± 0.34^{bcd}	12.27 ± 0.14^{ef}	11.92 ± 0.08^{bcde}
D1	1.50 ± 0.32^{cdef}	12.17 ± 0.34^{fg}	6.08 ± 0.01^{jkl}
D2	1.61 ± 0.30^{bcde}	12.64 ± 0.05^{de}	9.77 ± 0.08^{fgh}
D3	1.76 ± 0.31^{abc}	12.81 ± 0.31^{d}	12.65 ± 2.96^{abc}
E1	1.53 ± 0.01^{cde}	12.96 ± 0.23^{cd}	6.89 ± 0.70^{jk}
E2	1.73 ± 0.05^{abc}	13.02 ± 0.17^{cd}	10.58 ± 0.21^{defg}
E3	1.89 ± 0.12^{ab}	13.30 ± 0.02^{bc}	13.07 ± 0.13^{ab}
F1	1.60 ± 0.46^{bcde}	13.47 ± 0.42^{b}	7.66 ± 1.95^{ij}
F2	1.77 ± 0.06^{abc}	14.02 ± 0.08^{a}	12.18 ± 0.35^{abcd}
F3	2.00 ± 0.11^{a}	14.16 ± 0.12^{a}	13.94 ± 0.04^{a}

*Mean values with same letters in the same column are not statistically different ($p > 0.05$).

Table 3. Color properties of uncooked noodle samples†.

Samples	L*	a*	b*
Control	90.90 ± 0.28^{a}	2.06 ± 0.08^{l}	14.60 ± 0.05^{mn}
A1	77.72 ± 0.02^{b}	2.73 ± 0.02^{k}	14.33 ± 0.25^{n}
A2	69.32 ± 0.04^{e}	3.76 ± 0.02^{j}	16.39 ± 0.40^{l}
A3	59.90 ± 0.05^{i}	4.81 ± 0.01^{h}	18.33 ± 0.12^{h}
B1	76.18 ± 0.11^{c}	2.90 ± 0.02^{k}	14.73 ± 0.04^{m}
B2	70.19 ± 0.29^{e}	4.24 ± 0.08^{i}	17.79 ± 0.20^{i}
B3	60.86 ± 0.06^{i}	5.67 ± 0.02^{fg}	19.61 ± 0.03^{g}
C1	74.44 ± 0.50^{d}	4.00 ± 0.02^{ij}	16.81 ± 0.01^{k}
C2	67.63 ± 0.02^{f}	5.46 ± 0.03^{g}	19.86 ± 0.06^{fg}
C3	54.18 ± 0.10^{k}	7.27 ± 0.07^{e}	20.37 ± 0.33^{e}
D1	69.63 ± 1.51^{e}	4.75 ± 0.01^{h}	17.33 ± 0.09^{j}
D2	56.13 ± 1.21^{j}	7.64 ± 0.57^{de}	20.20 ± 0.13^{ef}
D3	50.83 ± 1.64^{m}	7.93 ± 0.01^{cd}	20.97 ± 0.01^{cd}
E1	65.15 ± 0.04^{g}	5.49 ± 0.09^{g}	17.40 ± 0.04^{j}
E2	52.03 ± 0.04^{l}	7.92 ± 0.03^{d}	20.92 ± 0.01^{d}
E3	48.11 ± 0.02^{n}	8.72 ± 0.04^{b}	21.42 ± 0.65^{b}
F1	63.56 ± 0.22^{h}	6.09 ± 0.09^{f}	17.67 ± 0.25^{ij}
F2	49.86 ± 1.32^{m}	8.37 ± 0.68^{bc}	21.30 ± 0.04^{bc}
F3	43.44 ± 0.73^{o}	9.21 ± 0.64^{a}	22.27 ± 0.13^{a}

†Mean values with same letters in the same column are not statistically different ($p > 0.05$).

3.4 Cooking properties

The data of the cooking properties of control group and noodles with terebinth addition are given in Table 4. The results show that the cooking time of the noodles decreased with the increase in terebinth addition ratio and the roasting temperature. It is believed that this is probably due to the different cellulosic structure of the terebinth fruit. These decreases in cooking time were found to be statistically significant ($p < 0.05$). The cooking times of the noodles with terebinth addition were lower than the control noodles. While the cooking time of the control noodles was determined as 10.50 minutes, the highest and lowest cooking times of noodles with terebinth addition were determined as 8.75 min in sample A1 and 6.00 min. in sample F3 respectively. The results were consistent with the data presented in the literature. Choy et al.'s (2013) study revealed that buckwheat flour addition led to a decrease in the cooking time of noodles.

The addition of roasted terebinth at different temperatures significantly influenced the weight increase, volume increase and the cooking loss ($p < 0.05$) (Table 4). The weight increase values of the noodles ranged from 122.99% to 154.21%, the volume increase values ranged between 6.49% to 9.49% and cooking loss ratio ranged from 6.35% to 11.95%. Increasing the terebinth addition along with roasting temperature reduced the weight increase and volume increase values of noodles.

While the highest weight increase ratio was observed in control noodles with 154.21%, the lowest weight increase ratio was in sample F3 with 122.99%. These results were found to be in agreement with other studies in the literature (Bilgiçli & İbanoğlu, 2015; Demi et al., 2010; Bilgiçli, 2009). It is desirable to have a high weight increase during noodle cooking. As a result of low weight increase, noodles are reported to have a hard texture after cooking (Bhattacharya et al., 1999). As can be seen in the Table 4, the highest volume increase belonged to control noodles. The least amount of volume increase was seen in sample F3 sample. These results were found to be in line with the results reported by Demi et al. (2010). It is desirable to have a high volume increase during noodle cooking. Since the low volume increase indicates that noodles absorb less water which in turn causes a harder texture after cooking (Bhattacharya et al., 1999).

The cooking loss is an important quality criterion in the evaluation of pasta and other similar products. Structural integrity after cooking, maintaining its texture and not deforming of a good quality pasta is depended on low cooking loss (Köksel et al., 2000). High cooking loss indicates that the starch is highly dissolved and its cooking tolerance is low (Bhattacharya et al., 1999). Table 4 shows that cooking loss values of the noodle samples increased depending on the increase of terebinth ratio and the roasting temperature. Cooking loss values of terebinth added noodles were found to be higher than control noodles. According to the results of the previous studies, the decrease in wheat flour ratio in noodle formulation led to a decrease in cooking loss (Aukkanit et al., 2017; Koca et al., 2017; Choy et al., 2013). Cooking loss is due to poor protein-starch matrix or protein starch matrix degradation. It is considered that the noodles with terebinth addition were affected in the same way, and cooking loss values of the noodles might have increased due to proportional decrease of gluten in noodles possibly after terebinth addition.

Total organic matter (TOM) analysis is based on the determination of starch and other organic compounds on the surface of cooked pasta. Too much material on the pasta surface increases the TOM value. A quality pasta should not be deformed during cooking. If deformed, too much starch passes into the cooking water and increases its stickiness, causing it to

Table 4. Cooking properties of terebinth added noodle samples*.

Samples	Cooking time (min)	Weight increase (%)	Volume increase (%)	Cooking loss (%)	TOM (%)
Control	10.50 ± 0.71^{a}	154.21 ± 5.27^{a}	9.49 ± 0.00^{a}	6.35 ± 0.10^{i}	1.07 ± 0.00^{m}
A1	8.75 ± 0.35^{b}	146.56 ± 5.15^{ab}	8.86 ± 0.00^{b}	6.78 ± 0.18^{hi}	1.11 ± 0.00^{lm}
A2	8.25 ± 0.35^{bc}	143.91 ± 0.59^{abc}	8.54 ± 0.45^{bc}	7.43 ± 0.43^{fghi}	1.18 ± 0.00^{jkl}
A3	7.75 ± 0.35^{cd}	139.72 ± 15.10^{bcde}	7.91 ± 0.45^{def}	8.09 ± 0.10^{efg}	1.21 ± 0.05^{hijk}
B1	7.75 ± 0.35^{cd}	142.57 ± 2.92^{bc}	8.23 ± 0.00^{cd}	6.97 ± 0.59^{ghi}	1.14 ± 0.05^{klm}
B2	7.50 ± 0.71^{de}	140.46 ± 1.52^{bcd}	8.07 ± 0.22^{cde}	7.51 ± 0.67^{fghi}	1.20 ± 0.14^{ijk}
B3	7.50 ± 0.00^{de}	136.25 ± 1.42^{bcdefg}	7.75 ± 0.22^{defg}	9.02 ± 0.09^{cde}	1.23 ± 0.01^{ghij}
C1	7.00 ± 0.00^{ef}	139.46 ± 0.32^{bcde}	8.07 ± 0.22^{cde}	7.08 ± 0.29^{ghi}	1.21 ± 0.05^{hijk}
C2	7.00 ± 0.00^{ef}	137.26 ± 1.92^{bcdefg}	7.91 ± 0.45^{def}	7.86 ± 0.02^{efgh}	1.27 ± 0.00^{fghi}
C3	6.75 ± 0.35^{fg}	133.43 ± 6.18^{cdefgh}	7.59 ± 0.00^{efgh}	9.64 ± 0.86^{cd}	1.29 ± 0.03^{efg}
D1	7.00 ± 0.00^{ef}	138.37 ± 4.75^{bcdef}	7.91 ± 0.45^{def}	7.16 ± 0.08^{ghi}	1.25 ± 0.00^{fghij}
D2	6.50 ± 0.71^{fgh}	133.62 ± 0.40^{cdefgh}	7.59 ± 0.00^{efgh}	8.14 ± 1.10^{efg}	1.27 ± 0.02^{fghi}
D3	6.25 ± 0.35^{gh}	130.32 ± 3.36^{defgh}	7.28 ± 0.45^{ghi}	10.02 ± 0.04^{bc}	1.32 ± 0.02^{def}
E1	6.75 ± 0.35^{fg}	133.24 ± 0.31^{cdefgh}	7.44 ± 0.22^{fghi}	7.50 ± 0.28^{fghi}	1.36 ± 0.03^{cde}
E2	6.50 ± 0.00^{fgh}	131.54 ± 2.72^{defgh}	7.12 ± 0.22^{hij}	8.68 ± 0.09^{def}	1.39 ± 0.01^{bcd}
E3	6.25 ± 0.35^{gh}	128.64 ± 0.19^{fgh}	6.96 ± 0.00^{ijk}	10.94 ± 0.91^{ab}	1.45 ± 0.00^{ab}
F1	6.50 ± 0.00^{fgh}	129.58 ± 9.74^{efgh}	7.12 ± 0.22^{hij}	8.15 ± 1.32^{efg}	1.44 ± 0.06^{bc}
F2	6.50 ± 0.00^{fgh}	127.52 ± 0.38^{gh}	6.65 ± 0.45^{jk}	9.75 ± 1.00^{bcd}	1.47 ± 0.02^{ab}
F3	6.00 ± 0.00^{h}	122.99 ± 9.46^{h}	6.49 ± 0.67^{k}	11.95 ± 1.28^{a}	1.52 ± 0.01^{a}

*Mean values with same letters in the same column are not statistically different ($p > 0.05$).

clump together and thus, high TOM values are obtained. This is an undesirable situation (Köksel et al., 2000). TOM value less than %1.4 indicates that the pasta is of very good quality. This classification is for pasta made from durum wheat semolina (D'Egidio et al., 1982; Köksel et al., 2000). TOM analysis was applied to noodle samples in this study. TOM values changed between 1.07% and 1.52% and the amount of TOM in the noodles with terebinth addition was found to be higher than the control group. There was an increase in the TOM values depending on the increase in terebinth addition ratio and the roasting temperature. The highest TOM value among noodles produced with terebinth was observed in sample F3 with 1.52%, while the lowest TOM value was observed in the control noodle with 1.07%. In the study conducted by Güvendi (2011), it was found out that TOM values of the samples increased as the triticale addition ratio increased in triticale added noodle samples. In the same study, it was observed that barley and oats addition led to a decrease in TOM values.

3.5 Nutritional properties

Total dietary fiber (TDF), total phenolic content (TPC) and antioxidant activity (inhibition percentage of the DPHH radical) values of noodle samples are shown in Table 5. There was a significant increase in TDF values of noodles with terebinth addition with the increase of both additive ratio and the roasting temperature ($p < 0.05$). TDF values of all noodles with terebinth additive were higher than TDF values of control noodles. TDF value of control noodles was determined as 4.49%. In their study, Yokoyama et al. (1997) found that TDF amount of the control noodles made from durum was 4.1%.

The highest TDF value (9.46%) among all noodles produced in our study was found in sample F3. The results were close to the results reported in previous studies (Aktaş & Türker, 2015; Güvendi, 2011). In a study conducted by Yılmaz Tuncel et al. (2017), rice bran enriched noodles were produced. In the study, they found that TDF content increased in noodle samples due to the increase of rice bran addition ratio.

The amount of TPC in noodles with terebinth addition was found to be higher than that of control noodles. The amount of TPC in all noodles with terebinth addition increased significantly with the increase in the addition ratio ($p < 0.05$) (Table 5). The increase in roasting temperature also increased the amount of TPC. The lowest amount of TPC was observed in control noodles with 147.36 mgGAE/100 g while the highest was observed in sample F3 with 610.77 mgGAE/100 g. These values were in compliance with the results reported by Koca et al. (2017) and Güvendi (2011). The antioxidant activity detected in control noodles and raw noodles with terebinth addition was expressed as inhibition percentage of the DPHH radical (%) and the results are given in Table 5. According to this, the antioxidant activity values of noodles with terebinth addition were found to be higher than control noodles.

The antioxidant activity of the noodles with terebinth addition increased significantly with the increase of the addition ratio and the roasting temperature ($p < 0.05$). The results were in parallel with the results in literature (Koca et al., 2017; Choy et al., 2013). Choo & Aziz (2010) identified the total phenolic matter and antioxidant activity of noodle samples containing 30% banana flour. They reported that the total phenolic matter and antioxidant activity in the noodles were higher than the control group.

When the phytic acid content of the noodle samples were examined, it was seen that the phytic acid values decreased in the samples depending both on the increase of addition ratio and roasting temperature. The highest amount of phytic acid

Table 5. Nutritional properties of terebinth added noodle samples*.

Samples	TDF (%)	TPC (mgGAE/100 g)	Antioxidant activity (%)	Phytic acid (mg/g)	Protein digestibility (%)
Control	4.49 ± 0.02^{g}	147.36 ± 2.25^{l}	21.41 ± 0.32^{l}	1.57 ± 0.00^{abc}	79.11 ± 3.29^{fghı}
A1	4.54 ± 0.33^{g}	265.32 ± 40.50^{k}	32.38 ± 1.49^{k}	1.72 ± 0.05^{a}	74.39 ± 0.00^{ı}
A2	4.65 ± 0.04^{g}	380.32 ± 3.86^{h}	37.22 ± 1.07^{ıj}	1.63 ± 0.08^{abc}	76.46 ± 0.00^{hı}
A3	4.72 ± 0.48^{g}	518.95 ± 38.57^{cd}	40.85 ± 0.21^{fg}	1.58 ± 0.02^{abc}	83.96 ± 0.00^{defg}
B1	4.70 ± 0.06^{g}	306.91 ± 36.32^{jk}	32.98 ± 0.21^{k}	1.68 ± 0.01^{ab}	78.15 ± 0.00^{ghı}
B2	5.82 ± 0.72^{fg}	395.32 ± 77.78^{gh}	37.90 ± 1.39^{hı}	1.55 ± 0.03^{abcde}	81.90 ± 3.40^{efgh}
B3	6.90 ± 0.33^{f}	541.45 ± 9.96^{bc}	42.89 ± 0.33^{de}	1.53 ± 0.04^{abcde}	84.11 ± 3.71^{defg}
C1	5.76 ± 1.28^{fg}	323.95 ± 5.14^{ıj}	33.21 ± 0.11^{k}	1.56 ± 0.01^{abcd}	80.71 ± 3.80^{efghı}
C2	8.94 ± 2.66^{e}	426.23 ± 4.50^{fg}	39.11 ± 0.54^{ghı}	1.42 ± 0.01^{cdef}	82.48 ± 3.07^{efgh}
C3	10.79 ± 0.14^{de}	572.14 ± 1.29^{ab}	44.48 ± 2.14^{cd}	1.34 ± 0.07^{defg}	84.87 ± 3.33^{def}
D1	9.29 ± 0.93^{e}	362.36 ± 8.68^{hı}	35.85 ± 1.28^{j}	1.51 ± 0.02^{abcde}	81.39 ± 3.20^{efgh}
D2	12.55 ± 1.73^{d}	465.09 ± 4.18^{ef}	40.39 ± 0.43^{fg}	1.33 ± 0.28^{efgh}	83.62 ± 3.48^{defg}
D3	16.34 ± 0.16^{bc}	589.41 ± 19.29^{a}	45.54 ± 1.07^{c}	1.26 ± 0.08^{fgh}	85.16 ± 3.01^{cdef}
E1	12.06 ± 1.48^{d}	398.73 ± 17.68^{gh}	37.82 ± 1.71^{hı}	1.48 ± 0.10^{bcdef}	84.62 ± 6.47^{def}
E2	16.84 ± 0.33^{b}	473.95 ± 0.64^{de}	42.21 ± 3.42^{ef}	1.28 ± 0.01^{fgh}	86.28 ± 3.59^{bcde}
E3	19.13 ± 0.55^{a}	604.64 ± 0.32^{a}	49.47 ± 1.07^{b}	1.16 ± 0.01^{gh}	91.71 ± 3.61^{ab}
F1	14.62 ± 2.86^{c}	446.00 ± 32.46^{ef}	39.56 ± 0.33^{gh}	1.43 ± 0.20^{cdef}	89.38 ± 3.51^{bcd}
F2	17.22 ± 0.45^{b}	512.14 ± 3.22^{cd}	44.18 ± 0.22^{cd}	1.13 ± 0.30^{gh}	91.22 ± 0.00^{abc}
F3	20.18 ± 0.04^{a}	610.77 ± 7.07^{a}	52.12 ± 0.96^{a}	1.12 ± 0.32^{h}	95.81 ± 6.95^{a}

*Mean values with same letters in the same column are not statistically different ($p > 0.05$).

(1.72 mg/g) was found in sample A1, whereas in sample F3, this value decreased to 1.12 mg/g. On the contrary, the use of different additives in noodle production in previous studies has led to phytic acid increase in noodle samples (Demi et al., 2010; Bilgiçli, 2009). In our study, the decrease in phytic acid values is believed to be caused by the roasting process applied to the terebinth fruit. Although phytic acid has very important functions for the plant, it has some negative effects on human body. The most important of these is that it creates a complex with some essential minerals such as Ca, Fe, Zn, Mn to prevent their absorption. In addition, it can also be effective by binding a large part of the phosphorus as phytate phosphorus in its body or by interacting with some amino acids (Egli et al., 2004). From this point of view, it is desirable for food to have a low amount of phytic acid. However, recent studies on the effect of phytic acid on human health have shown that phytic acid has positive effects due to its anticancer and antioxidant effect (Tolay et al., 2005).

Digestibility is an important parameter in terms of nutrition. The biological use of the protein in any food depends primarily on its amino acid profile and digestibility (Akıllıoğlu & Yalçın, 2010). As a result of protein digestibility analysis, protein digestibility rates of cooked noodle samples were found between 74.39% and 95.81% (Table 5). Table 5 shows protein digestibility values increased in samples depending both on the increase of terebinth addition ratio and roasting temperature ($p < 0.05$). In their study which was conducted on egg noodles with obtained from local markets in Bolu, Turkey and from noodle factories, Akıllıoğlu & Yalçın (2010) found the protein digestibility ratio of the samples between 76.5% and 98.1%. The protein digestibility values of the samples were found to be between 76.82% and 87.15% in a study conducted by Casagrandi et al. (1999) on spaghetti with pigeon pea flour addition. The values obtained in our study were in agreement with all these literature results.

3.6 Sensory properties

The values of sensory characteristics (color, brightness, hardness, stickiness, taste-aroma, general acceptability) of noodles with terebinth addition are given in Table 6. The noodles were evaluated within 1-5 scale. According to this, the color values were determined as 2.94-4.53, the brightness values were 2.89-4.37, the hardness values were 3.20-4.76, the stickiness values were 3.10-4.43, the taste aroma values were 3.00-4.58 and the general acceptability value was 3.00-4.57.

The addition of terebinth roasted at different temperatures resulted in a general decrease in all sensory feature scores of the samples ($p < 0.05$). It is desirable that the noodles have a smooth, glossy surface and sharp corners (instead of round) (Nagao, 1996). In addition, noodles should not get doughy after cooking (Kim, 1996).The highest score for the color feature was in sample E1, and the lowest score was in sample F3. When the brightness values are examined, it was seen that the brightness value decreases as the addition ratio increases. The highest score (4.37) for brightness belonged to sample E1 while the lowest score (2.89) belonged to sample F3. That noodles are desired to have a moderate level of hardness. In terms of hardness (mouth sensation) which was determined by sensory analysis, sample C1 received the highest score (4.76) while sample E3 received the lowest score (3.20). In other words, sensory hardness decreased as the terebinth addition ratio increased. When the stickiness of the noodle samples were examined, the panelists gave the highest score (4.43) to sample A1, and the lowest score (3.10) to sample D2.

Table 6. Sensory scores of terebinth added noodle samples*.

Samples	Color	Brightness	Hardness	Stickiness	Taste-aroma	Overall acceptability
Control	3.91 ± 0.02^{f}	4.11 ± 0.01^{b}	4.40 ± 0.06^{d}	4.17 ± 0.08^{b}	4.00 ± 0.00^{f}	4.05 ± 0.07^{f}
A1	3.53 ± 0.04^{h}	4.10 ± 0.02^{b}	4.62 ± 0.06^{b}	4.43 ± 0.02^{a}	4.54 ± 0.03^{a}	4.55 ± 0.01^{a}
A2	3.32 ± 0.02^{i}	3.43 ± 0.02^{f}	4.12 ± 0.01^{g}	3.79 ± 0.02^{g}	4.21 ± 0.02^{c}	4.13 ± 0.03^{e}
A3	4.14 ± 0.03^{d}	3.21 ± 0.02^{h}	3.44 ± 0.00^{k}	3.54 ± 0.03^{j}	3.34 ± 0.01^{j}	3.45 ± 0.00^{k}
B1	3.89 ± 0.01^{f}	3.79 ± 0.02^{d}	4.65 ± 0.02^{b}	4.13 ± 0.02^{bc}	4.58 ± 0.03^{a}	4.57 ± 0.02^{a}
B2	3.68 ± 0.02^{g}	3.38 ± 0.06^{fg}	4.12 ± 0.01^{g}	4.09 ± 0.04^{cd}	3.78 ± 0.00^{h}	3.90 ± 0.01^{g}
B3	3.67 ± 0.01^{g}	3.33 ± 0.00^{g}	3.64 ± 0.03^{j}	3.63 ± 0.05^{i}	3.57 ± 0.02^{i}	3.35 ± 0.02^{l}
C1	4.21 ± 0.02^{c}	3.92 ± 0.05^{c}	4.76 ± 0.02^{a}	4.03 ± 0.04^{e}	4.39 ± 0.08^{b}	4.55 ± 0.00^{a}
C2	4.00 ± 0.00^{e}	3.47 ± 0.03^{f}	3.80 ± 0.07^{i}	3.89 ± 0.00^{f}	4.14 ± 0.04^{d}	4.24 ± 0.02^{d}
C3	3.86 ± 0.03^{f}	3.63 ± 0.10^{e}	3.98 ± 0.03^{h}	3.45 ± 0.00^{k}	3.79 ± 0.02^{h}	3.79 ± 0.02^{h}
D1	4.37 ± 0.05^{b}	4.11 ± 0.01^{b}	4.35 ± 0.02^{de}	3.89 ± 0.01^{g}	4.07 ± 0.06^{e}	4.35 ± 0.02^{c}
D2	4.13 ± 0.02^{d}	3.68 ± 0.02^{e}	3.80 ± 0.03^{i}	3.10 ± 0.01^{m}	4.22 ± 0.00^{c}	4.11 ± 0.00^{e}
D3	3.67 ± 0.01^{g}	3.12 ± 0.01^{hi}	3.46 ± 0.03^{k}	3.32 ± 0.02^{l}	3.79 ± 0.02^{h}	3.56 ± 0.00^{j}
E1	4.53 ± 0.04^{a}	4.37 ± 0.05^{a}	4.27 ± 0.06^{ef}	3.71 ± 0.07^{h}	4.23 ± 0.01^{c}	4.45 ± 0.01^{b}
E2	4.00 ± 0.00^{e}	3.68 ± 0.02^{e}	4.31 ± 0.03^{ef}	3.66 ± 0.01^{i}	4.19 ± 0.04^{cd}	4.43 ± 0.02^{b}
E3	3.58 ± 0.03^{h}	3.10 ± 0.14^{i}	3.20 ± 0.03^{l}	3.15 ± 0.05^{m}	3.25 ± 0.04^{k}	3.22 ± 0.00^{m}
F1	4.39 ± 0.08^{b}	3.81 ± 0.05^{d}	4.52 ± 0.05^{c}	4.05 ± 0.07^{de}	4.33 ± 0.00^{b}	4.21 ± 0.02^{d}
F2	3.68 ± 0.02^{g}	3.60 ± 0.06^{e}	4.26 ± 0.05^{f}	4.00 ± 0.00^{e}	3.90 ± 0.01^{g}	3.65 ± 0.03^{i}
F3	2.94 ± 0.08^{j}	2.89 ± 0.16^{j}	3.70 ± 0.11^{j}	3.58 ± 0.03^{j}	3.00 ± 0.00^{l}	3.00 ± 0.00^{n}

*Mean values with same letters in the same column are not statistically different ($p > 0.05$).

Sample B1 got the highest score (4.58) regarding taste-aroma property. Other noodles with terebinth addition had varying taste-aroma values while the lowest score (3.00) was received by sample F3. The scores given to noodles in terms of general acceptability ranged between 3.00 and 4.57. In terms of general acceptability, sample B1 was the most acceptable, meanwhile the sample F3 was the least acceptable.

4 Conclusions

In this study, the effect of roasted terebinth fruits on noodle quality at different temperatures was investigated. Terebinth addition to noodle formulation increased the nutritional value of the samples in terms of ash, protein, fat, dietary fiber, total phenolic content and antioxidant content. The dark color of the raw and roasted terebinth fruits caused the noodles to appear darker, more red and more yellow. While weight and volume increase of noodle samples decreased with terebinth addition, cooking loss values increased. The addition of terebinth resulted in a general decrease in all sensory features of the samples, but all panelists stated they could still consume the noodles with terebinth addition. It has been concluded that the use of terebinth in noodle formulation increases especially nutritional properties (total dietary fiber, total phenolic content and antioxidant activity) and that terebinth can be a suitable component in noodle enrichment.

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