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Effect of Hazelnut Skin Addition on Quality Characteristics of Functional Crackers

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ABSTRACT

Hazelnut skin, an innovative by-product, has been classified as one of the richest sources of edible phenolic compounds in recent studies. In this study, hazelnut skin powder was used in cracker formulation at 5, 10, 15 and 20% ratios replaced with wheat flour, and some technological, chemical properties and bioactive components of cracker samples were determined. The hazelnut skin powder used as raw material has 5.1, 4.8, 3.9, 11.6, 1244 and 20 times higher ash, phytic acid, total phenolic content, DPPH, FRAP, CUPPRAC values than wheat flour, respectively. Increasing hazelnut skin powder in cracker production increased the darkness and redness of the cracker. High hazelnut skin powder usage ratios improved the spread ratio and reduced the hardness of the crackers. Increasing use of hazelnut skin powder in cracker increased the amount of ash, fat, phytic acid and resistant starch from 1.59%, 13.63%, 246.58 mg/100g and 0.97% up to 2.13%, 16.53%, 581.54 mg/100g and 2.15%, respectively. Antioxidant (DPPH, FRAP and CUPRAC) and phenolic substances (free, bound and total) increased significantly ($p<0.05$) at all hazelnut skin powder usage ratios. The high utilization ratios (15-20%) of hazelnut skin powder negatively affected overall acceptability of the crackers.

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Fındık Kabuğu İlavesinin Fonksiyonel Krakerlerin Kalite Özelliklerine Etkisi

ÖZET

Yenilikçi bir yan ürün olan fındık zarı, son yıllarda yapılan çalışmalarda en zengin yenilebilir fenolik bileşik kaynaklarından biri olarak sınıflandırılmıştır. Bu çalışmada, kraker formülasyonunda buğday unu yerine %5, 10, 15 ve 20 oranlarında fındık zarı tozu kullanılmış ve kraker numunelerinin bazı teknolojik, kimyasal özellikleri ve biyoaktif bileşenleri belirlenmiştir. Hammadde olarak kullanılan fındık zarı tozu, buğday ununa kıyasla sırasıyla 5.1, 4.8, 3.9, 11.6, 1244 ve 20 kat daha fazla kül, fitik asit, toplam fenolik içerik, DPPH, FRAP, CUPPRAC değerlerine sahiptir. Kraker üretiminde artan oranda fındık zarı tozu kullanımı, krakerin koyuluğunu ve kırmızılığını artırmıştır. Yüksek fındık zarı tozu kullanım oranları, yayılma oranını artırmış ve krakerlerin sertliğini azaltmıştır. Fındık zarı tozunun krakerde artan oranda kullanımı, kül, yağ, fitik asit ve dirençli nişasta miktarını sırasıyla %1.59, %13.63, 246.58 mg/100g ve %0.97'den %2.13, %16.53, 581.54 mg/100g ve %2.15'e yükselmiştir. Tüm fındık zarı tozu kullanım oranlarında antioksidan (DPPH, FRAP ve CUPRAC) ve fenolik maddeler (serbest, bağlı ve toplam) önemli ölçüde ($p<0,05$) artmıştır. Fındık zarı tozunun yüksek kullanım oranları (%15-20) krakerlerin genel kabul edilebilirliğini olumsuz yönde etkilemiştir.

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INTRODUCTION

Corylus avellana, known as hazelnut belonging to the Betulacae family, with an annual average production of 1 million tons, is a very popular tree nut due to its pleasant flavors and health-promoting effects (Pelvan et al., 2018). A small amount (10%) of hazelnut is consumed as a snack, and the rest is used in many different ways, including in the production of chocolate, dessert, pastry products and cooking oil (Platteau et al., 2011; Bozoğlu et al., 2019). After being harvested, the hazelnut goes through the stages of cracking, peeling and roasting, and during these processes, by-products are produced, including the hazelnut skin (Odabaş and Koca, 2016). After the hard skin is removed, the hazelnut obtained is surrounded by a brown perisperm (hazelnut skin) layer. This by-product, which is separated as waste during the roasting process, is responsible for 2.5% of the hazelnut kernel weight. Hazelnut skin is a by-product rich in of fiber (65%), polyphenolics, and proanthocyanins. These components make hazelnut skins an important by-product. For this reason, researchers are conducted to evaluate hazelnut skin in the production of food products in order to provide functional properties with antioxidant, phenolic and dietary fiber components of the end product (Anil, 2007; Durmus et al., 2021). In addition, Özdemir et al. (2014) demonstrated its potential to be used as a brown colored functional component in their studies. Dinkçi et al. (2021) used hazelnut shell as a functional additive in yoghurt in their research.

Cereal-based foods, prepared in different forms such as baked goods, pasta, snacks and others, are consumed as staple foods worldwide to meet energy and nutritional needs (Xu et al., 2020). Crackers are thin and brittle products prepared by using soft wheat flour together with fat, salt, and leavening agents, respectively. It is a snack food that is frequently preferred by consumers due to its unique taste, easy preservation, and cheapness (Polat et al., 2020). Also, as baked goods, crackers are seen as a healthy snack over deep-fried or sugar-filled alternatives. The increasing demand of consumers for healthy and functionally rich foods has increased the variety in these products, and in response to this increasing demand, various natural raw materials such as food industry by-products have started to take their place in the cracker formulation (Batista et al., 2019).

The aim of this study is to reveal the nutritional and functional properties of hazelnut skin through a snack product. More specifically, to reveal the effect of increased use of crust powder in cracker dough on the chemical composition and quality parameters (texture, diameter, thickness, spread rate and color) of crackers.

MATERIAL and METOD

Materials

Soft wheat flour, shortening, salt, powdered sugar, baking powder and baker's yeast were purchased from a market (Konya, Türkiye) and the protease enzyme was purchased from Vatan Enzim (Istanbul, Türkiye). The hazelnut skin was achieved from a local producer (Gürsoy) in Ordu, Türkiye. The hazelnut skin, which emerged as a product burned during the roasting of hazelnuts at 150 °C, was ground to 500 µm using a coffee grinder and stored at -18 °C until use.

Methods

Cracker production

The crackers were made with minor modifications to the procedure reported by Davidson (2016). The ingredients of crackers are displayed in Table 1. For control sample preparation; wheat flour (100 g), shortening (20 g), table salt (1.6 g), powdered sugar (1.5 g), baking powder (1.5 g), baker's yeast (0.2 g) and protease (0.01 g) were mixed in the kneader (Hobart N50, Offenburg, Germany) until a homogeneous dough was obtained. The dough was fermented in a chamber (Fimak FMD16, Konya, Turkey) for 20 minutes at 30 °C and 75-80 % relative humidity. Then, the fermented dough was formed into a 1 mm thick layer between two glass plates and shaped with a 50 mm diameter biscuit mold. It was baked in an oven (Fimak Rokon Classic FRN10G, Konya, Turkey) for 11 minutes at 180°C. Other crackers were formulated by replacing wheat flour with 5, 10, 15, and 20% levels of hazelnut skin powder. The crackers are displayed in Figure 1.

Figure 1. Samples of cracker containing 0-20% hazelnut skin powder
Şekil 1. %0-20 oranında fındık zarı tozu içeren krakerler örnekleri

Table 1. Formulation of crackers rich in hazelnut skin powder
Çizelge 1. Fındık zarı tozu açısından zengin kraker formülasyonu

	Control	Cracker with Hazelnut skin powder
Wheat flour	100	95, 90, 85, 80
Hazelnut skin powder	-	5, 10, 15, 20
Shortening	20	20
Table salt	1.6	1.6
Powdered sugar	1.5	1.5
Baking powder	1.5	1.5
Baker's yeast	0.2	0.2
Protease	0.01	0.01

Color properties

Color measurement of raw and cracker samples was performed using the Minolta CR 400 (Chroma Meter, Osaka, Japan). The measurement was made on the ground raw materials and at five different points on the surface of the crackers. L* (lightness, darkness), a* (red, green) and b* (yellow, blue) values were measured in raw materials and cracker samples. Hue (color essence) value was calculated with arctan (b*/a*) formula and SI (saturation index) value was calculated with $(a^{*2}+b^{*2})^{1/2}$ formula.

Physical properties

The diameter, thickness, spread ratio and textural properties of the end products were determined. The diameter and thickness were measured using five sample pieces by a caliper (Mitutoyo, Tokyo, Japan) according to the AACC method 10-54 (AACC, 2010), and values were reported in millimeters. The cracker spread ratio was determined by dividing the diameter by thickness.

The hardness and fracturability value of the crackers were analyzed by three-point bending (HDP/3 PB) tests on a TA-XT plus texture analyzer (Stable Micro Systems, Surrey, UK) equipped with a 5 kg loading cell. The measurement values of the texture analyzer were as follows: pre-test speed, 1.0 mm/s; test speed 1.0 mm/s; post-test speed, 10.0 mm/s. In the hardness and fracturability value measurements, 5 measurements were made for each sample and it was studied in 2 replications.

Proximate composition

Hazelnut skin powder, wheat flour and cracker samples were tested for their moisture (method 44–19), ash (method 08-01), protein (method 46-10) and fat content (method 30-10) (AACC, 1999). Resistant starch value of the samples was determined using Megazyme kit method (K-RSTAR 09/14, Megazyme International Ireland, Wicklow, Ireland) following manufacturer's instructions. The phytic acid value in the raw materials and cracker samples was extracted with 0.2 N hydrochloric acid solution and then treated with a certain amount of Fe+3 solution and precipitated. The amount of iron remaining in the serum part was determined spectrophotometrically, and the amount of phytic acid was calculated from the results obtained. Results are given in mg/100g (Haug and Lantzsch, 1983).

Analysis of antioxidant activity

The extraction method described by Yılmaz and Koca (2017) was used to determine the antioxidant activities of the samples. Extraction was performed by mixing 1 g of sample with 80% methanol, but without 1% acidification, as in free phenolic extraction.

Three methods were used in the antioxidant activity analysis of the samples.[1]For the analysis of the samples with the DPPH (2-2-Diphenyl-2-picrylhydrazil) antioxidant activity method, the method described by Beta et al. (2005) was used and the results were calculated as mg Trolox Equivalent/kg. [2]For the analysis of the samples with the FRAP (ferric reducing antioxidant power) antioxidant activity method, the method described by Gao et al. (2000) was used and the results were calculated as µmol Trolox Equivalent/g. [3]For the analysis of the samples with the CUPRAC (cupric ion reducing antioxidant capacity) antioxidant activity method, the method described by Apak et al. (2008) was used and the results were calculated as µmol Trolox Equivalent/g.

Analysis of free, bound and total phenolic content

Free and bound phenolic content was extracted defined to the method specified by Vitali et al. (2009). For the free phenolic extraction; raw materials and cracker samples (1 g) were mixed 10 ml of 1% acidified (HCl) methanol: water solution (80:20, v/v). Extraction was carried out by shaking the mixture at room temperature (24±1 ˚C) for 2 h. After extraction, the mixture was centrifuged at 3000 rpm to obtain the supernatant for analysis, and the separated supernatant was stored at -20°C for analysis. For bound phenolic extraction; 20 ml of methanol/H_2SO_4 (10:1) was added to the residue remaining after free phenolic extraction and the mixture was incubated in a shaking water bath for 20 hours at 85°C, then the cooled supernatant was separated by centrifugation was stored at -20°C until analysis.

The free and bound phenolic content of each extract was analyzed according to the Folin-Ciocalteu colorimetric method as performed by Naczk and Shahidi (2004). Total phenolic content was obtained by summing the free and bound phenolic content. Phenolic content was expressed as gallic acid equivalents (mg of GAE/ kg).

Sensory evaluation

Sensory evaluation was performed 24 hours after cooking by 12 people selected from the Engineering faculty of Necmettin Erbakan University, who were informed in advance. Sensory evaluation selected representative features (color, taste, odor, appearance, brittleness and overall acceptability) of crackers were assessed. These features were evaluated using 7 hedonic scales as described by Meilgaard et al. (1999). Scores ranged from 1 "unacceptable" to 7 "excellent". Informed consent was obtained from the panelist prior to their participation in the panel, and their individual judgments were kept confidential.

Statistical analysis

SPSS statistical program version 22.0 (SAS Institute Inc., Cary, NC, USA) was used for statistical data analysis. Tukey test was used to determine significant differences. p values <0.05 were regarded as significant.

RESULTS and DISCUSSION

The color value of raw and cracker samples

The color value of soft wheat flour, hazelnut skin powders and crackers are shown in Table 2. The color properties (L*, a* and b*) of hazelnut skin powder and refined wheat flour were determined as 44.21, 8.27 and 11.90 and 93.40, -5.24 and 15.44, respectively. The hazelnut skin powder demonstrated a lower L* and b*, higher a* value in comparison with refined wheat flour. Similarly, Durmuş et al. (2020) stated that the hazelnut skin color is darker than wheat flour. This may be related to the polyphenolic compounds that contribute to the high phenolic value of hazelnut skin. The a* and b* color values of raw materials were used in Hue and SI calculations, and Hue and SI for wheat flour and hazelnut skin were found to be 108.74 and 16.31 and 63.93 and 18.82, respectively.

Table 2. Color values of hazelnut skin powder-enriched crackers[1]

Çizelge 2. Fındık zarı tozu ile zenginleştirilmiş krakerlerin renk değerleri[1]

	*L**	*a**	*b**	Hue	SI
Raw materials					
Wheat flour	93.40±0.06	-5.24±0.04	15.44±0.08	108.74±0.02	16.31±0.09
HSP[2]	44.21±0.39	8.27±0.01	11.90±0.14	63.93±0.23	18.82±0.12
HSP ratio (%)					
0	77.10±0.58a	-2.25±0.13d	28.28±0.49a	94.59±0,24a	28.38±0,50a
5	53.85±1.01b	5.14±0.53c	16.90±0.16b	73.07±0,62b	17.67±0,19b
10	45.23±0.36c	5.87±0.13bc	13.61±0.30c	66.67±0,26c	14.82±0,27c
15	40.55±1.14d	6.55±0.18ab	11.93±0.24d	61.24±0,20d	13.61±0,12d
20	37.75±0.16e	6.78±0.27a	10.86±0.09e	58.02±0,45e	12.81±0,33d

[1]Means with the same letter within a column are not significantly different (p > 0.05). Hue: Hue angle, SI: Saturation index. HSP: Hazelnut skin powder.

When the color properties of the crackers were examined, it was found that the supplementary of hazelnut skin in the cracker formulation increased the darkness and redness values on the other hand b* value decreased. It has been reported that this increase may be relevant to the color characteristics and high phenolic value of the hazelnut skin powder (Ha et al., 2011). Similarly, Velioğlu et al. (2017) determined that the L* and a* values of bread, cake and cookie samples were significantly affected when wheat flour was replaced by hazelnut skin. Researchers reported that the use of 6% hazelnut skin decreased the L* value and increased the a* value in all samples.

Physical properties of cracker samples

Table 3 presents the physical properties of hazelnut skin powder enriched-crackers. The average diameter, thickness and spreading ratio values of the crackers were determined as 47.56 mm, 6.02 mm and 9.48, respectively (Table 3). While the addition of 10% or more hazelnut skin powder in cracker formulations decreased the diameter and thickness values, the spread rate increased with the use of 20% hazelnut skin powder and reached the highest value. Decrease in cracker diameter value was attributed to the high water holding capacity of the hazelnut skin powder. This situation increased the viscosity of the dough and made it difficult to spread the cookies (Park et al., 2015). Gluten is responsible for the increase in the thickness of the biscuit (Handa et al., 2012), and the decreasing gluten content may have caused a decrease in the thickness of the crackers. The spreading rate is a marker of cookie quality and a high spreading rate is desired for cookies and similar products (Barak et al., 2013). The texture properties of samples were displayed in Table 3. The textural character of samples are affected by the gluten strength, damaged starch ratio and water absorption capacity of the flour (Liu et al, 2021). The presence of hazelnut skin powder reduced the hardness value of the crackers. Fracturability value of the cracker containing 20% hazelnut skin powder was lower than the control sample. The lowest hardness values were found numerically in the crackers with 20% hazelnut skin powder addition, and the hardness values of the crackers with 15% and 20% hazelnut skin powder addition ratios were statistically in the same group. The decreased firmness value may be related to the insufficient formation of the gluten network due to the competition of dietary fiber, sugar and flour proteins for water (Kulthe et al., 2014).

Table 3. Physical properties of hazelnut skin powder - enriched crackers[1]
Çizelge 3. Fındık zarı tozu ile zenginleştirilmiş krakerlerin fiziksel özellikleri[1]

HSP ratio (%)	Diameter (mm)	Thickness (mm)	Spread ratio (W/T)	Hardness (g)	Fracturability (mm)
0	48.78±0.26a	8.52±0.96a	5.76±0.67c	4556.25±41.4a	36.99±0.95a
5	48.34±0.06a	6.80±0.42ab	7.14±0.41bc	3863.45±85.6b	36.30±1.41ab
10	46.68±0.25b	5.84±0.79b	8.03±1.08bc	3532.66±32.8c	35.41±0.15ab
15	46.44±0.34b	5.56±0.65b	8.40±0.93b	3003.31±57.8d	34.75±1.01ab
20	46.34±0.23b	3.52±0.40c	13.20±1.36a	2945.76±6.8d	34.00±0.44b

1Means with the same letter within a column are not significantly different ($p > 0.05$). HSP: Hazelnut skin powder.

Chemical composition of crackers

Chemical and bioactive component of crackers are displayed in Table 4 and 5. The moisture amount of wheat flour and hazelnut skin powder were determined as 10.25% and 7.52%, respectively. Ash, fat, phytic acid and resistant starch contents of hazelnut skin were determined considerably higher than that of refined wheat flour. A small numerical difference was determined between the protein contents of wheat flour and hazelnut skin powder. The ash, protein and fat contents hazelnut skins are in line with Özdemir et al. (2014) and Tunçil (2020) reports. Phytic acid and resistant starch contents of hazelnut skin powder were 4.8 and 1.8 times higher compared to wheat flour, respectively. Phytic acid is one of the important bioactive components of hazelnuts. Compared to cereal and legumes, phytic acid amount in nuts ranges from 0.1 to 9%, while in cereal and legumes this value varies between 0.06% - 2.2% and 0.2 - 2.9%, respectively. The phytate content in peanuts is affected not only by different hazelnut botanical varieties, but also according to factors such as environmental conditions, soil type, farming techniques and ripening stage (Schlemmer et al., 2009). Chemical compositions of crackers were compared according to ratio factor (Table 4). The moisture value of cracker samples changed from 4.34 to 4.94%. Crackers formulated with 20% hazelnut skin powder had the highest ash content than the other cracker samples, which may be due to the higher ash existence of hazelnut skin powder (2.68%) compared to wheat flour (0.53%). The addition of increasing hazelnut skin powder into the cracker formulation slightly reduced the protein amount of the control cracker from 9.41% to 9.10%, and the reduction was statistically insignificant ($p > 0.05$). These results according to the lower protein content of hazelnut skin powder (7.52%) than refined wheat flour (7.83%). Cracker samples prepared with hazelnut skin powder showed higher fat content compared to control cracker samples. As the hazelnut skin level increased in the formulation of crackers fat content increased from 16.63 to 19.53%. The phytic acid value of cracker samples changed between 246.58 and 581.54 mg/100 g. The phytic acid content of cracker samples increased with the use of hazelnut skin powder. Phytic acid chelates minerals, especially Ca, Mg, Fe and Zn, and limits the absorption of starch, amino acids, and proteins (Oatway et al., 2001). For this reason, foods with low phytic acid content are seen as more important in terms of nutrition. However, recent studies have reported that phytic acid contributes significantly to antioxidant activity. Barbhai and Hymavathi (2022) stated that phytic acid is a natural antioxidant source that promotes health and prevents diseases due to oxidative stress. The fact that hazelnut skin is a better source of resistant starch than wheat flour is also reflected in the cracker samples prepared with hazelnut skin powder addition. Replacing 20% of wheat flour with hazelnut skin powder increased the RS content of control crackers from 0.97% to 2.15%. The higher RS value of cracker samples than the raw materials used in the formulation may be related to the rich polyphenolics and proanthocyanins content of hazelnut skin. Deng et al. (2021) stated that the formation of amylose-proanthocyanidin and starch-polyphenol complexes increased the resistant starch content by decreasing the digestibility of starch. Khan et al. (2013) reported that the polyphenolic content of sorghum flour was responsible for the increase in the resistant starch amount of pasta samples.

Antioxidant activity and phenolic content of raw materials and cracker samples

Among the raw materials, antioxidant activity (DPPH, FRAP and CUPRAC) free, bound and total phenolic content of hazelnut skin powder were found to be higher compared to wheat flour. In the literature, it has been stated that hazelnut by-products are rich materials of natural antioxidants and polyphenolic (Locatelli et al. 2010). Also, Gu et al. (2003) reported that among the nuts, hazelnuts are rich in phenols and especially proanthocyanidins. Alasalvar et al. (2009) found that Turkish Tombul hazelnut skin showed high antioxidant/antiradical activity.

Table 4. Chemical properties of hazelnut skin powder-enriched cracker[1]
Çizelge 4. Fındık zarı tozu ile zenginleştirilmiş krakerlerin kimyasal özellikleri[1]

	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Phytic acid (mg/100 g)	RS (%)
Raw materials						
Wheat flour	10.25±0.07	0.53±0.01	7.83±0.13	0.78±0.03	247.24±4.92	1.04±0.03
HSP	7.52±7.52	2.68±0.03	7.52±0.18	11.37±0.04	1175.26±14.77	1.85±0.07
HSP ratio (%)						
0	4.94±0.04a	1.59±0.03d	9.41±0.31a	16.63±0.11e	246.58±8.92e	0.97±0.02d
5	4.79±0.02b	1.66±0.03d	9.27±0.25a	17.07±0.05d	388.27±2.46d	1.05±0.04cd
10	4.61±0.03c	1.82±0.00c	9.19±0.62a	18.36±0.13c	447.47±12.31c	1.24±0.06bc
15	4.49±0.03c	1.98±0.02b	9.14±0.06a	18.92±0.31b	494.48±4.93b	1.43±0.05b
20	4.34±0.05d	2.13±0.07a	9.10±0.25a	19.37±0.12a	581.54±2.46a	2.15±0.19a

[1]Means with the same letter within a column are not significantly different ($p > 0.05$). RS: Resistant starch, HSP: Hazelnut skin powder.

Table 5. Antioxidant activity and free, bound and total phenolic content of the hazelnut skin powder-enriched cracker samples[1]
Çizelge 5. Fındık zarı tozu ile zenginleştirilmiş krakerlerin antioksidan aktivite, serbest, bağlı ve toplam fenolik içeriği[1]

	DPPH (mg TE/kg)	FRAP (umol TE/g)	CUPRAC (umol TE/g)	FPC (mg GAE/ kg)	BPC (mg GAE/kg)	TPC (mg GAE/kg)
Raw materials						
Wheat flour	175.96±12.87	0.47±0.09	2.32±0.02	1481.44±3.64	2856.76±67.94	4338.20±75.83
HSP	2037.15±75.10	584.69±12.54	46.99±0.19	2250.70±50.78	5526.30±48.66	16779.80±84.63
HSP ratio(%)						
0	293.24±16.68d	1.36±0.08e	5.06±0.26e	1132.63±48.02e	2070.49±21.35c	3203.12±18.83c
5	426.56±42.25c	3.20±0.17d	9.30±0.51d	1294.54±73.02d	2348.43±44.87bc	3642.98±27.82c
10	516.79±74.89c	6.55±0.20c	16.94±0.24c	1617.75±84.26c	2618.70±38.34bc	4236.45±34.69b
15	1253.81±37.13b	14.89±0.32b	46.18±1.33b	1876.97±43.97b	2878.22±98.30ab	4755.19±23.20b
20	1707.68±15.31a	26.25±0.16a	59.49±1.85a	2201.55±25.14a	3393.19±10.89a	5594.75±34.69a

[1]Means with the same letter within a column are not significantly different ($p > 0.05$).DPPH; 2.2- diphenyl-1-picrylhydrazyl. FRAP; Ferric reducing antioxidant potential. CUPRAC; Cupric ion reducing antioxidant capacity. FPC; Free phenolic content. BPC; Bound phenolic content. TPC; Total phenolic content. HSP: Hazelnut skin powder.

When the antioxidant activity of crackers containing hazelnut skin powder was compared with the control, the use of increasing hazelnut skin powder increased the DPPH, FRAP and CUPRAC values from 293.24 up to 1707.68 mg TE/kg, 1.36 upto 26.25 umol TE/g and 5.06 upto59.49 umol TE/g, respectively. This may be due to the high antioxidant activity of hazelnut skin powder. Condensed tannins in hazelnut skin contribute greatly to the antioxidant content of hazelnut skin (Lainas et al., 2016). Similarly, Pelvan et al. (2018) stated that the antioxidant component in hazelnut skin was high as a result of the analysis they performed on hazelnut and hazelnut skin using DPPH, ORAC and ABTS methods. Parallel to the antioxidant capacity values, the phenolic content of the cracker samples increased by 1.9, 1.6 and 1.9 with the use of 20% hazelnut skin. Pelvan et al. (2018) stated that the roasted hazelnut skin has about 710 times more total phenolic acid content than the roasted hazelnut, in which most of the phenolic content is in the skin. Hazelnut skin was rich in total phenolics than wheat flour, which may have been reflected in the cracker samples.

Sensorial analysis

Sensorial properties of crackers are demonstrated in Figure 2. The color characteristics of the cracker formulated with 5% hazelnut skin powder was higher than the other samples. Usage of hazelnut skin powder at a high rate (15-20%) caused a decrease in appearance scores and the cracker sample with 20% hazelnut skin addition was evaluated with the lowest score of appearance. The use of 5% hazelnut skin was similar to the control and provided a higher taste score than all other cracker samples. The use of 10–20% hazelnut skin powder in formulations caused a decrease in the odor score compared to control. The brittleness values of the cracker samples were evaluated with numerically close scores, and the samples with 20% hazelnut skin powder addition were found to be less brittle statistically. The use of 5% hazelnut skin powder provided the highest overall acceptability score among all cracker samples.

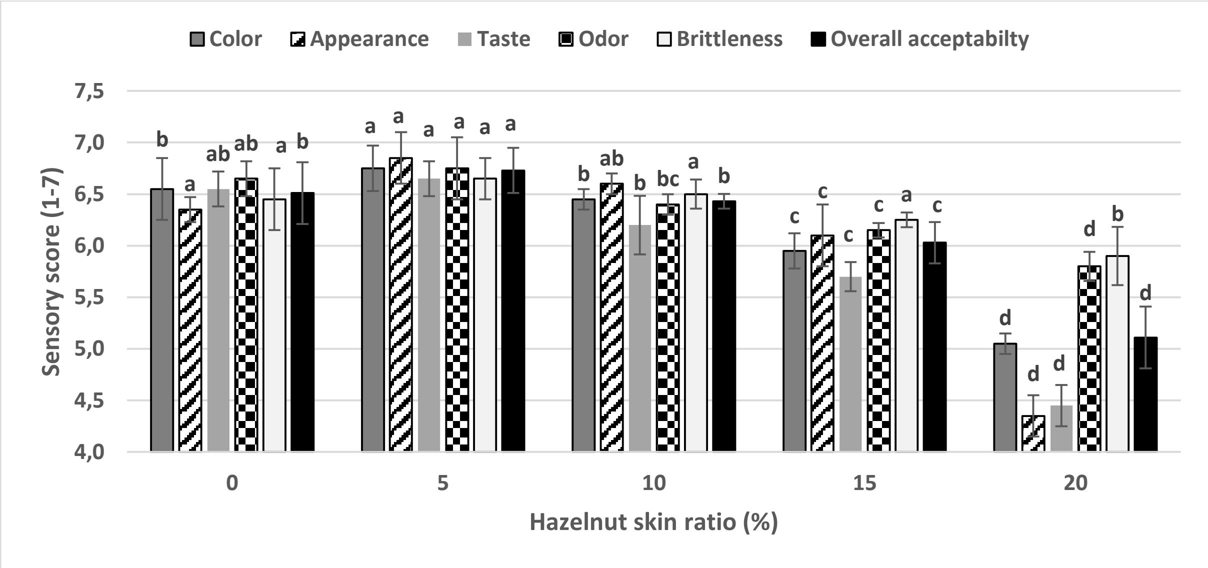

Figure 2. Sensory attributes of crackers containing hazelnut skin powder.
Şekil 2. Fındık zarı tozu içeren krakerlerin duyusal özellikleri.

CONCLUSION

Hazelnut skin occurs as a by-product during the roasting phase of roasted hazelnut production. Since the hazelnut skin is rich in polyphenolic content, consist of phenolic acids, flavonoids and flavonols, which have a health-promoting effects, it can be preferred for enrichment of foods. Evaluating the use of such a valuable ingredient in food formulations is highly valuable. The addition of hazelnut skin powder into crackers improved the resistant starch, antioxidant activity and phenolic content. The significant reduction in L* and b* color value of cracker samples might be due to the color properties of hazelnut skin powders. With the addition of hazelnut, the hardness values of the crackers decreased and the spreading rate increased. The data revealed that the addition of up to 10% hazelnut skin could be considered a potential ingredient for producing functionally crackers.

The results obtained from this study may be a precursor to the use of a low-value industrial by-product in functional food formulations that contribute to the formation of resistant starch as a rich source of phenolic compounds and as a natural coloring agent. Data on chemical content obtained from analyzes of hazelnut shells showed that this by-product is very rich in health-promoting antioxidants and phenolics. More studies are needed to investigate the effects of hazelnut shell powder in different food formulations.

Declaration of Competing Interest

The author declares that she has no known competing financial interests or personal relationships that may appear to affect the work reported in this article.

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