Fındık Zarının Fırıncılık Ürünlerinde Kullanımı

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Fındık zarı, fındık tanesini tamamen saran ve iç fındığın kavrulması sırasında yan ürün olarak açığa çıkan ince ve kahverengi perisperm tabakasıdır. Fındık zarının antioksidan kapasitesi yüksek olup, diyet lif olarak da değerlendirilmektedir. Fındık zarının bu özellikleri sebebiyle ekmek, kurabiye ve kek yapımında kullanılması, üretilen fırıncılık ürünlerinin bazı fizikokimyasal ve duyusal özelliklerinin tespit edilmesi için mevcut çalışma yürütülmüştür. Çalışma kapsamında buğday ununa % 4, 6, 8 ve 10 seviyesinde fındık zarı ilave edilerek karışım unlar elde edilmiştir. Unlara ait reolojik özellikler ekstensograf ve farinograf ölçümleri ile belirlenmiş olup, fındık zarı miktarı arttıkça unun su tutma kapasitesinin (%61,8'den %67,1'e), gelişme zamanının (4,3 dakikadan 10,7 dakikaya) ve stabilitesinin (8,2 dakikadan 17,2 dakikaya) arttığı tespit edilmiştir. Fındık zarına ait toplam fenolik madde içeriği kuru maddede 209,750 mg GAE/g olarak bulunmuştur. %10 fındık zarı içeren unla üretilen ekmek, kurabiye ve keklerde fenolik madde içeriği sırasıyla 19,427, 9,777 ve 13,126 mg GAE/g olarak belirlenmiştir. Duyusal analiz sonuçlarına göre renk, koku ve tat yönünden en yüksek ($P < 0,05$) skoru elde eden kurabiye örnekleri %8 fındık zarı içeren örnekler olurken, çalışma kapsamında üretilen tüm ekmek ve kek numuneleri panelistler tarafından aynı oranda toplam beğeni skoru elde etmiştir ($P > 0,05$). Sonuç olarak fırıncılık ürünleri üretiminde fındık zarı ilavesinin yeni ürünlerin üretiminde önemli bir alternatif olabileceği belirlenmiştir.

Anahtar Kelimeler: Fındık zarı, fırıncılık, ekmek, kek, kurabiye

The Use of Hazelnut Testa in Bakery Products

Hazelnut testa is the thin brown perisperm which wraps the hazelnut kernels, and obtained as a by-product after the roasting process of hazelnut. It has good antioxidant and dietary fiber properties. Hence, the present study was carried out to utilize hazelnut testa in the production of bread, cookie and cake, and evaluate some physicochemical and sensorial properties of the samples enriched with hazelnut testa. The wheat flour samples substituted with hazelnut testa at levels of 4, 6, 8 and 10 % were used in product recipes. The rheological properties of flour mixes were evaluated using extensograph and farinograph measurements. Increased amounts of testa resulted to higher water absorption (61.8 to 67.1%), development time (4.3 to 10.7 min) and stability (8.2 to 17.2 min) values of flour. Total phenolic content (TPC) of hazelnut testa was determined to be 209.750 mg GAE/ g dry matter. TPC of bread, cookie and cake samples which were produced using flour containing 10% testa were 19.427, 9.777 and 13.126 mg GAE/ g dry matter, respectively. Cookies prepared with flour containing 8% testa had the highest scores for color, smell and taste ($P < 0.05$) where the panelists liked all breads and cakes according to overall acceptability equally ($P > 0.05$). Consequently, the use of flour mixes enriched with hazelnut testa could be an effective way to put functional bakery products in the food market.

Key Words: Hazelnut testa, bakery, bread, cake, cookie

Introduction

Cereal products are consumed daily by the majority of the population and they provide a convenient medium for delivering healthy compounds to consumers that is why, for years, the food industry has focused on increasing the nutritional value of these products (Ktenioudaki and Gallagher, 2012). While the consumers have been becoming more aware of the connection between their diet and diseases, studies have been carried out to find some natural ingredients to enhance nutritional value and overall acceptability of bread, cookie and cakes that are well-known bakery products.

Bread is the most economical and basic food consumed in all over the world, especially in Turkey. There are wide range of researches conducted by manufacturers and researchers to reformulate this highly demanded product using several natural additives including green tea extract (Wang et al., 2007), sorghum flour (Yousif et al., 2012), grape seed extract (Peng et al., 2010), buckwheat (Lin et al., 2009), barley flour (Holtekjolen et al., 2008) and dry onion skin (Gawlik-Dziki et al., 2013). All and more than these were studied for the purposes such as increasing antioxidant properties, dietary fiber content, and overall acceptability of bread.

Researchers have also shown great interest to improve cookie formulations with several ingredients such as; unripe banana flour to avoid fat and digestible carbohydrates (Agama-Acevedo et al., 2012), fibres from apple, lemon, wheat and wheat bran to improve nutritional properties (Bilgiçli et al., 2007), germinated brown rice to improve acceptability (Chung et al., 2014), microalgal biomass for colouring (Gouveia et al., 2007), some medicinal plants to enhance organoleptic and nutritional properties (Pankaj Sharma et al., 2013), whole barley flour to evaluate its cookie making behavior (Paras Sharma and Gujral, 2014), sunflower seed to increase sensory attributes (Škrbić and Cvejanov, 2011) and buckwheat flour to develop a gluten-free product (Torbica et al., 2012).

Nowadays, dietary fiber content, enhanced antioxidant property and natural sweetening are the main concerns for cake production in bakery industry. Watermelon rinds (Al-Sayed and Ahmed, 2013), oat fiber (Majzoobi et al., 2015), fibers obtained from cereals (Gómez et al., 2010) and cheonnyuncho powder (Kim et al., 2012) are the latest examples for substances added into the formulation of cakes by several studies.

Hazelnut is an all-purpose agricultural product as a whole that means the industry and researchers have been focusing on utilization of all by-products of this nut besides the valuable inner grain (Arslan et al., 2012; Contini et al., 2008; Çöpür et al., 2013; Oliveira et al., 2007). Turkey is by far the World's largest hazelnut producer, accounting for more than three-quarters of annual World-wide production (Anil, 2007). The latest statistics released from Food and Agriculture Organization of the United Nations for 2012 present that Turkey with the annual production of 660.000 tonnes is the biggest hazelnut producer which is followed by Italy and USA with the production quantities of 85.232 and 30.000 tonnes/year, respectively (FaoStat, 2014).

Testa, pellicle and skin are the common names used in literature to define the thin brown perisperm that wraps hazelnut kernels. Hazelnut testa is obtained as a by-product after the roasting process of hazelnut. Numerous studies have indicated that this by-product has good antioxidant and dietary fiber property (Contini et al., 2008; Locatelli et al., 2010; Montella et al., 2013; Özdemir et al., 2014). Because of the high natural antioxidant content, hazelnut testa could potentially be used as nutraceuticals and dietary supplements (Alasalvar et al., 2009). However, hazelnut testa is still generally used as an additive in animal rations or considered as a waste product. While there were some attempts carried out on the use of hazelnut testa in food products to enhance antioxidant properties and increase dietary fiber content (Anil, 2007; Contini et al., 2012), to the best of our knowledge there are no reports on the use of hazelnut testa in cookie and cake production.

The aim of this study was to evaluate some physicochemical and sensorial properties of bread, cookie and cake samples produced with utilization of hazelnut testa substituted of wheat flour at different ratios.

Materials and Methods

Materials

Hazelnut testa (perisperm from *Corylus avellana* L., "Tombul" cultivar from Ordu, Turkey) was supplied by S.E.P. Hazelnut Company (Düzce, Turkey) as a by-product of hazelnut roasting procedure using a fluidized bed-based tunnel type hot air dryer. The testa constitutes 10% of the whole kernel that roasted at medium level at 160°C for 15 min. The testa samples were kept in the dark at refrigerator temperature (0-4°C) until they were used in production. All the ingredients used in the preparation of bread, cookie and cake samples were obtained from Eksun Flour Factory (Tekirdağ, Turkey). All the reagents and chemicals used were of analytical reagent grade.

Proximate Composition

Wheat flour, the main ingredient, was analyzed for protein (American Association of Cereal Chemists [AACC] 46-12.01), moisture (AACC 44-19.01), ash (08-03.01), Zeleny sedimentation (56-61.02), falling number (56-81.03) wet gluten and gluten index (38-12.02) according to the AACC methods. Moisture, ash, protein, fat and crude fiber of hazelnut testa were determined according to the methods described by AACC (2000).

Sample Preparation

The formulations for bread, cookie and cake samples were given in Table 1. The flour blends consisting of wheat flour and hazelnut testa were prepared with proportions of 100-0 (control), 96-4, 94-6, 92-8 and 90-10 (dry basis), respectively. The flour blends were used in the production immediately.

Table 1. Formulations of bread, cookie and cake samples

Ingredients	Hazelnut testa substituted for wheat flour in bread formulation (%)					Hazelnut testa substituted for wheat flour in cookie formulation (%)					Hazelnut testa substituted for wheat flour in cake formulation (%)				
	0 (Control)	4	6	8	10	0 (Control)	4	6	8	10	0 (Control)	4	6	8	10
Wheat flour (g)	1000	960	940	920	900	250	240	235	230	225	220	211.2	206.8	202.4	198
Hazelnut testa (g)	0	40	60	80	100	0	10	15	20	25	0	8.8	13.2	17.6	22
Water (mL)	640	675	700	725	750	-	-	-	-	-	-	-	-	-	-
Salt (g)	15	15	15	15	15	-	-	-	-	-	-	-	-	-	-
Yeast (g)	35	35	35	35	35	-	-	-	-	-	-	-	-	-	-
Sugar (g)	-	-	-	-	-	75	75	75	75	75	175	175	175	175	175
Egg (piece)	-	-	-	-	-	1	1	1	1	1	2	2	2	2	2
Baking powder (g)	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8
Butter (g)	-	-	-	-	-	150	150	150	150	150	62.5	62.5	62.5	62.5	62.5
Sunflower oil (mL)	-	-	-	-	-	-	-	-	-	-	50	50	50	50	50
Milk (mL)	-	-	-	-	-	-	-	-	-	-	100	100	100	100	100

Bread Making: Bread dough was prepared using a straight dough method. Firstly 35 g fresh yeast (*Saccharomyces cerevisia*, Pakmaya, Turkey) was dissolved in water at 30℃. Flour, salt, water and fresh yeast were mixed in laboratory type spiral mixer (SP-12D, Diosna, Dierks & Söhne GmbH, Osnabrück, Germany). The addition of water was done continuously throughout first mixing period and the temperature of the added water was 4℃. Mixing was conducted for 2 min at low speed (32 rpm for spiral), followed by 6 min at high speed (64 rpm for spiral). The average dough temperature was measured automatically and recorded for all samples. First fermentation was conducted at 30℃ for 15 min. Then the dough was cut and molded as 450 g pieces and left for final fermentation at 39 ℃ and 80% relative humidity for 50 min. Baking was done at 220℃ for 28 min in an electric oven (Sveba Dahlen, DC52, Fristad, Sweden) with automatic steaming for 4 s at the beginning of the baking process. Finally the baked bread was taken out of the oven, cooled to room temperature for 1 h. Spesific volume of the samples was measured using rapeseed replacement method and results were given in cm^3/g.

Cookie Making: The ingredients given in Table 1 were mixed in laboratory type mixer with dough hook attachment (KitchenAid, 5KPM5, St.Joseph, MI, USA). The dough was taken out from the mixer and rolled out to disks having the diameter of 6 cm and the thickness of 1 cm. Each disk having approximately 40 g weight was placed on a stainless steel baking tray and baked at 200 ℃ for 30 min. At the end, the baked cookies were taken out of the oven, cooled to room temperature for 1 h.

Cake Making: The sponge cake formulas including different ratios of hazelnut testa were given in Table 1. The whole egg and sugar were mixed in laboratory type mixer with wire whip attachment (KitchenAid, 5KPM5, St.Joseph, MI, USA) until the mixture had white-creamy appearance. Then the rest of the ingredients was added and mixed until getting homogeneous mixture for about 4 min. For each cake, 450 g cake batter was put into cake pan and baked at 170℃ for 45 min in the oven. The baked sponge cakes were taken out of the oven, cooled to room temperature for 1 h.

Extensograph and Farinograph Measurements

Effect of replacement of wheat flour with 0, 4, 6, 8 and 10% hazelnut testa on extensograph and farinograph characteristics was studied according to the AACC methods 54-10 and 54-21, respectively. Extensograph (Brabender, Duisburg, Germany) was used to determine energy (cm^2), resistance to extension (BU), extensibility (mm) and maximum resistance (BU) for 45, 90 and 135 min. Farinograph (Brabender, Duisburg, Germany) was used to determine water absorption (%), development time (min), stability (min) and degree of softening (FU) using 300 g mixing bowl.

Determination of Total Phenolic Contents (TPC) of the samples

Extraction of total phenolics was performed as described by Hung et al. (2009). Briefly, 1 g of sample was extracted with 10 mL of 80 % ethanol. After the centrifugation of the suspention, supernatant was collected. Extraction was repeated two times, and the supernatants were pooled. Folin-Ciocalteu method was used for the determination of TPC of the samples (Singleton and Rossi, 1965). 5 mL Folin–Ciocalteau reagent (diluted 1:10 v/v with water) was added to the tube containing 1 mL of diluted extract and after 3 minutes 4 mL of sodium carbonate solution (7.5%) was added. The mixture was incubated for 2 h and the absorbance of green-blue complex was read at 765 nm using UV-Vis spectrophotometer (UV-1208 Shimadzu, Japan). A calibration curve was generated using gallic acid (1-200 mg/l) as standard, and the results were expressed as mg gallic acid equivalents (GAE) per g dry matter.

Color Measurements

Color measurement (L, a, b values) of bread (crust and crumb), cookie (whole) and sponge cake (crumb) samples was performed using Hunter-Lab tristimulus colorimeter (D25LT, Hunter Associates Laboratory, Reston, Virginia, USA). The calibration of colorimeter was done using black and white tiles provided. All samples were filled in standard petri dishes (i.d. 50 mm) avoiding any gap. Six replicate measurements were performed and the average of the results was used. In the Lab color space, L, a and b values indicate the lightness, red/green and yellow/blue coordinates, respectively. The total color difference (ΔE) between all three coordinates were also determined using the following equation:

$$\Delta E = [\Delta L^2 + \Delta a^2 + \Delta b^2]^{1/2}$$

Sensory Evaluation

Sensory evaluation was conducted by a group of 11, semi-trained panelists from the staff members of Food Engineering Department, Faculty of Agriculture, Namık Kemal University. The bread samples were evaluated for color, smell, taste, appearance, texture and overall acceptability while there was one additional property for cookies as melting in the mouth. In addition to these sensory properties for bread, the sponge cake samples also evaluated for cohesiveness and pore formation. Each sample was coded with a randomly selected 3-digit numbers. A seven-point hedonic scale (1: dislike extremely, 7: like extremely) was used for sensorial analysis (Larmond, 1977).

Statistical Analysis

Analysis of variance and significant differences among means were tested by one-way ANOVA and Duncan's multiple range tests at the level of $P \leq 0.05$ using PASW Statistics 18 software.

Results and Discussion

Proximate Composition of Wheat Flour and Hazelnut Testa

The wheat flour used for the production of bread, cookie and cake samples had 13.30% protein, 13.50% moisture, 0.65% ash, 33.8% wet gluten, 76% gluten index, 381 s falling number and 49 mL Zeleny's sedimentation value. According to the results of the chemical analysis, hazelnut testa was determined to contain 8.20% protein, 8.78% fat, 6.02% moisture and 1.87% ash in dry basis. While protein and ash contents are similar to that reported by other researchers (Anil, 2007; Locatelli et al., 2010; Özdemir et al., 2014), there is a significant difference especially for fat content (Locatelli et al., 2010; Montella et al., 2013) indicated as 21.2 and 39.48% for the cultivars Tonda Gentile Trilobata and Nocciola Piemonte, respectively. These differences could result from the use of different hazelnut cultivar, different roasting process or extraction protocols.

Effect of Hazelnut Testa Addition on Rheological Properties of Flour

Effect of hazelnut testa addition on the extensograph and farinograph characteristics of wheat flour is presented in Table 2.

Addition of increasing amount of testa from 0 to 10% resulted to 8.6% increase in water absorption capacity of flour (from 61.8 to 67.1%). This finding is in accordance with Pankaj Sharma et al. (2013) who stated that the increasing amount of leaf powder addition positively affects the water absorption capacity of wheat flour according to interaction between hydroxyl groups of added material and water. In the present study farinograph results showed that the higher amount of testa addition resulted to the higher development time (4.3 to 10.7 min) and stability (8.2 to 17.2 min) values of wheat flour. Similar results were obtained by Anil (2007) and Peressini and Sensidoni (2009) who reported significant increase in development time and stability of flour containing hazelnut testa and soluble dietary fiber, respectively. While this finding was explained by the antioxidant content of testa which results to more strict dough by Anil (2007), there are some dissimilar indications in literature (Yousif et al., 2012). Gas cell expansion in the dough at proofing and baking steps of bread making process is related to dough extensibility characteristics obtained from extensograph measurements (Ktenioudaki and Gallagher, 2012). As presented in Table 2, the higher the hazelnut testa addition the lower the extensibility values of dough (166 to 88 mm) which refers to stronger dough with addition of fiber in formulation.

Table 2. Extensograph and farinograph measurements of flour mixes

Characteristics	Control (0%)			4%			6%			8%			10%		
	Proving time (min)			Proving time (min)			Proving time (min)			Proving time (min)			Proving time (min)		
	45	90	135	45	90	135	45	90	135	45	90	135	45	90	135
Extensograph															
Energy (cm^2)	114	135	141	117	138	126	107	139	131	108	136	118	106	120	107
Extensibility (mm)	166	156	159	125	125	113	109	105	100	96	93	84	88	82	74
Maximum resistance (BU)	545	682	697	714	865	904	724	1047	1077	860	1134	1134	933	1134	1134
Farinograph															
Water absorption (%)	61.8			63.7			64.6			65.6			67.1		
Development time (min)	4.3			7.7			7.8			8			10.7		
Stability (min)	8.2			14			17.5			17.5			17.2		
Degree of softening (FU)	71			468			528			542			527		

TPC of Hazelnut Testa, Flour Mixes and Products

The TPC of hazelnut testa and the wheat flour used in the present study was found as 209.750 and 11.688 mg GAE/ g dry matter, respectively. In the literature, there are several findings for phenolic content of hazelnut skin. While the highest phenolic content was found as 680 mg GAE / g hazelnut testa extract by Contini et al. (2012), 638 mg catechine equivalent / g extract was reported by Locatelli et al. (2010). However, the above mentioned studies were both designed to work on phenolic extracts of hazelnut testa. Some researchers used caffeic acid or ferulic acid as standards so the respective comparison is quite difficult. In accordance with our results, Özdemir et al. (2014) reported the total phenolic compounds of the hazelnut testa as 233 mg GAE/g. In summary, the possible differences in phenolic content of the hazelnut testa might be due to the different extraction procedures and calculation methods. In our study, as expected, the higher the testa addition in recipe, the more the total phenolic content the product has. Özdemir et al. (2014) reported that hazelnut testa is rich in free soluble phenolic compounds of which catechin, epicatechin, epicatechin gallate, gallocatechin, epicalocatechin gallate and gallic acid are the main phenolic fractions (Özdemir et al., 2014).

TPC of control sample and bread samples made using the testa added flour samples at the percentages of 4, 6, 8 and 10 % were 2.057, 6.690, 10.581, 14.991, and 19.427 mg GAE/g dry matter, respectively. The TPC of cookie samples were 1.568, 4.977, 6.545, 8.080 and 9.777 GAE/g dry matter and those of cake samples were 1.678, 6.457, 8.050, 11.342 and 13.126 GAE/g dry matter, respectively. Our findings showed that while the flour samples contained equal amount of hazelnut testa in the formulation, the highest TPC was found for bread that is followed by cake and cookie samples. This difference could be attributed to the differences in the formulation and also the differences in the dry matter content because of the different baking processes applied for different products.

Table 3. Color values of bakery products.

Sample	*L*	*a*	*b*	*ΔE*
Bread crumb				
Control	78.63±2.06a	-0.41±0.04e	17.47±0.35a	
4%	48.05±0.71b	3.81±0.12d	8.89±0.41b	32.04±0.78d
6%	42.96±0.04c	4.94±0.07b	8.03±0.04c	37.28±0.05c
8%	39.44±1.12c	5.29±0.01a	7.92±0.14c	40.74±1.90b
10%	32.98±0.92d	4.72±0.01c	6.95±0.17d	47.13±0.90a
Bread crust				
Control	30.91±0.44b	10.26±0.13a	12.26±0.27a	
4%	28.36±0.33c	7.90±0.00b	9.93±0.00d	4.2±0.2b
6%	32.16±0.04a	7.68±0.22b	11.53±0.01b	2.97±0.17c
8%	32.12±0.02a	6.93±0.22c	10.99±0.11c	3.77±0.18b
10%	28.03±0.40c	6.72±0.12c	8.73±0.11e	5.79±0.29a
Cookie				
Control	74.25±0.10a	6.93±0.05a	26.13±0.15a	
4%	59.42±0.40b	2.39±0.01d	16.06±0.05b	18,5±0,31d
6%	55.10±0.00c	4.81±0.11c	14.92±0.09c	22,29±0,05c
8%	50.00±0.18d	4.76±0.00c	13.47±0.12d	27,44±0,19b
10%	48.22±0.51e	5.70±0.05b	12.28±0.00e	29,52±0,45a
Cake				
Control	71.20±0.54a	0.40±0.01e	20.99±0.10a	
4%	48.75±1.31b	3.39±0.08d	10.28±0.10b	25,07±1,19c
6%	45.13±0.55c	4.32±0.05c	9.42±0.13c	28,79±0,47b
8%	41.14±0.21d	4.84±0.07b	8.62±0.04d	32,81±0,2a
10%	39.47±0.03d	5.12±0.09a	8.20±0.00e	34,54±0,02a

The TPC values in wet basis were similar to each other (data not shown). However, there are significant differences in the TPC values given in dry matter basis, probably because of the differences in the dry matter values of the end products. Due to the highest moisture content in the end products, bread samples had the highest TPC values when expressed as GAE/g dry matter.

Color Values of the Products

The hazelnut testa used in this study had dark red-brown color and coarse structure. Therefore, bakery products had different color and overall appearance than the control samples. Color values of bakery products prepared with hazelnut testa addition are given in Table 3.

Bread: Similar to the findings of Anil (2007), significantly (P < 0.05) different "*L*" (lightness) values for the crust of hazelnut testa added bread samples were measured than that of control. However, the results were lower than the findings of Anil (2007). It could result from the differences in the baking procedures and also from the roasting procedure, cultivar of the hazelnut or particle size of hazelnut testa used. "*a*" value of crust of the control sample was determined to be the highest, following a gradual decrease with the increase in the testa percentage in testa added samples. Anil (2007) also reported that the control sample had the highest "*a*" value indicating the redness. "*b*" values of the testa added samples were also lower than that of control sample which indicates the yellowness of the samples.

The crumb color was also determined to be affected by the testa addition. The "*L*" value decreased with the increase in testa percentage in the formulation, indicating the decrease in the lightness of the samples. "*b*" values also decreased with the increase in the testa percentage. This confirms the reduction in yellow tone with the testa addition. Having a negative "*a*" value indicating the greenness, the crumb of the control bread sample had the lowest "*a*" value among the samples. All other samples had measurements above zero which indicate that red tone is dominating over green (Popov-Raljić et al., 2013) in all testa added samples. The differences among the "*a*" values of the crumb and crust of the bread samples can be attributed to the Maillard and caramelization reactions which occurred especially in the crust of the bread samples. Similar tendency of "*a*" value was observed which was well explained by Anil (2007) according to the effects of Maillard and caramelization reactions. It is also known that during the baking process, "*L*" value of the samples decreases while "*a*" and "*b*" values increase with the increase in baking time and temperature (Açar, 2010)

As it can be seen in Table 3, *ΔE* values of the samples were also calculated. *ΔE* is a single value that takes into account the differences between the "*L*", "*a*", and "*b*" of the sample and control sample (Whetzel, 2016), hence it is more easy to compare the samples in terms of color values. There is a gradual increase in the *ΔE* values of the bread samples with the increase in testa percentage showing the increase in color difference between the samples and the control. In spite of the color of the products gradually changed from golden-brown to dark reddish-brown, the hazelnut added bread could be preferable, as also concluded by the sensorial analysis results indicating that the testa added samples does not differ significantly from the control sample (P < 0.05).

Cookie: Hazelnut testa addition affected the "*L*", "*a*" and "*b*" values of the cookie samples significantly (P < 0.05). The lightness of the control sample of cookies was significantly higher than those of the testa added cookie samples (P < 0.05). It is also valid for "*b*" values of the cookie samples, confirming the highest yellow tone in the control sample. These findings were in accordance with the study of Garcia-Serna et al. (2014) in which coffee silverskin extract was used as a natural coloring in the production of stevia biscuits. They reported that the addition of solid ingredients, such as coffee silverskin rich in dietary fibre, significantly affected (P <0.05) the colour of the biscuits. Regarding the "*a*" value indicating the redness, except the 6% and 8% testa added samples, the samples were also significantly different from each other (P < 0.05). *ΔE* values of the cookie samples show the increase in the total color difference between the testa added samples and the control with the increase in testa percentage.

Cake: Similar to the results obtained for cookie samples, "*L*" and "*b*" values were also lower for testa added samples than the control sample, indicating the decrease in lightness and yellowness. As a result of the increasing testa addition to the cake flour, "*a*" values significantly increased showing the increase in redness value (P < 0.05). *ΔE* values of the cake samples also indicate the increase in the total color difference with the increase in testa percentage.

Young and Whittle (1985) categorized color differences as imperceptible differences (0–0.5), slight differences (0.5–1.5), just noticeable differences (1.5–3.0), marked differences (3.0–6.0), extremely marked differences (6.0–12.0) and colors of different shades (above 12.0). In the general evaluation of the *ΔE* values of the samples, marked differences of colors in the crust of bread samples were detected. However, it can be concluded that testa addition caused completely different color shades in cookie, cake and bread crumb samples.

Overall appearance of the samples:

Fig. 1a presents the overall appearance of bread samples where the control sample could be indisputably recognized among other samples. As expected due to the low wheat flour ratio, specific volumes of the loaves were 6.94 cm^3/g for control and 4.68 cm^3/g for 10% testa added samples. Fig. 1b shows the high spot and side view of the cookie samples. Except the color difference, the diameter, height and overall physical appearances were same for all cookie samples. As it can be seen from the Fig. 1c the increasing amount of hazelnut testa addition did not result in an observable difference in volume and height of cake samples. Because of the baking powder existed in the formulation, low wheat flour ratio was not effective on the leavening of the end product. Except the color difference, the cake samples have the similar appearance.

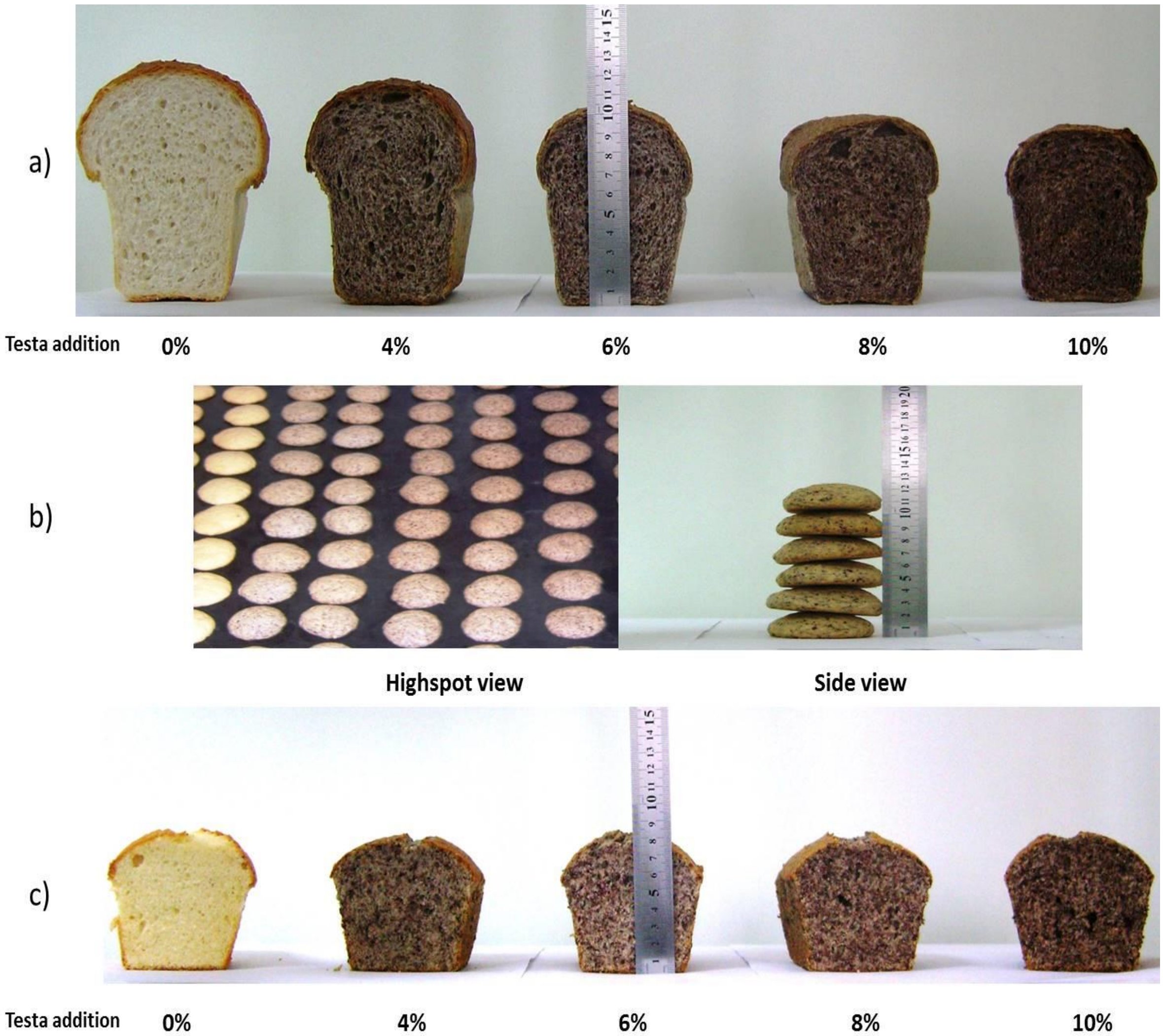

Figure 1. (a) Overall appearance of the bread samples, (b) High spot and side view of the cookie samples, (c) Overall appearance of the cake samples.

Table 4. Results of sensory evaluation for bakery products [1, 2]

Sample	Color	Smell	Taste	Appearance	Texture	Melting in the mouth	Cohesiveness	Pore formation	Overall Acceptability
Bread									
Control (0%)	4.83±0.59ab	4.67±0.62	4.50±0.59ab	5.33±0.56ab	5.00±0.49a	-	-	-	4.92±0.47
4%	4.83±0.30ab	4.33±0.33	4.50±0.30ab	5.67±0.30a	5.33±0.43a	-	-	-	4.85±0.20
6%	5.00±0.22ab	4.83±0.40	4.67±0.25ab	5.00±0.49ab	5.00±0.49a	-	-	-	4.93±0.24
8%	5.17±0.43a	5.00±0.42	5.50±0.49a	5.00±0.33ab	4.83±0.30a	-	-	-	5.08±0.33
10%	3.83±0.33b	4.50±0.65	3.50±0.36b	4.00±0.56b	3.50±0.44b	-	-	-	4.08±0.42
Cookie									
Control (0%)	4.54±0.63ab	3.89±0.51c	4.15±0.52b	4.41±0.51	-	5.31±0.34	-	-	4.67±0.43ab
4%	4.02±0.48b	4.15±0.34bc	4.67±0.43ab	4.41±0.43	-	5.06±0.27	-	-	4.54±0.23ab
6%	4.54±0.30ab	4.15±0.20bc	4.15±0.28b	4.54±0.36	-	4.54±0.30	-	-	4.40±0.26b
8%	5.44±0.27a	5.31±0.39a	5.70±0.30a	5.31±0.39	-	5.06±0.43	-	-	5.44±0.27a
10%	4.67±0.43ab	5.19±0.28ab	5.31±0.34ab	5.06±0.34	-	4.80±0.57	-	-	5.06±0.34ab
Cake									
Control (0%)	4.93±0.54	4.15±0.62b	4.54±0.63	5.44±0.51	-	-	5.44±0.39a	5.83±0.34a	5.19±0.48
4%	4.80±0.30	4.67±0.19ab	4.93±0.26	4.93±0.38	-	-	4.80±0.45ab	5.57±0.38ab	4.93±0.26
6%	5.31±0.28	4.93±0.26ab	4.80±0.30	5.19±0.28	-	-	4.28±0.39ab	5.19±0.34abc	5.06±0.19
8%	5.31±0.28	5.31±0.28ab	5.31±0.28	5.31±0.34	-	-	4.80±0.41ab	4.28±0.39c	4.93±0.32
10%	5.06±0.43	5.57±0.47a	5.19±0.55	5.19±0.39	-	-	4.02±0.48b	4.41±0.51bc	4.67±0.48

[1]*Scale of 1 (dislike extremely) to 7 (like extremely).*

[2] *The results are given as means ± standard error. For each hazelnut testa ratio values within a column followed by the different letter are significantly different (P<0.05).*

Sensorial Evaluation

Bread: The results of sensorial evaluation are given in Table 4. According to the smell and overall acceptability scores, the panelists liked all breads equally ($P > 0.05$). The results for appearance and texture indicated that the panelists preferred all samples except the one with 10% testa addition ($P < 0.05$). The sample with 8% hazelnut testa addition received higher score ($P < 0.05$) for color and taste than that of other bread samples. Our results are in agreement with literature (Anil, 2007) as it was reported that "5-10% hazelnut testa addition can be recommended in bread-making". However, to make a comparison it should be noted that the bread prepared with 10% hazelnut testa addition received the worst scores for color, taste, appearance and texture.

Cookie: In food industry, numbers of additives labeled as artificial hazelnut flavoring, nature-identical hazelnut aroma and natural hazelnut aroma are used in cookie production due to not only the difficulties of using but also the relatively higher price of natural hazelnut kernel. The sensorial evaluation of the cookies obtained from the present study (Table 4) showed that the hazelnut testa addition improves overall acceptability of the product significantly ($P < 0.05$). The cookies prepared with 8% testa addition had the highest scores for color, smell and taste ($P < 0.05$) where the panelists liked all cookie samples according to the appearance and melting in the mouth properties equally ($P > 0.05$). The basic point that may affect the panelists choices could be remarked as the unique hazelnut flavor released from the testa added samples. The results showed that almost all samples prepared with testa addition received good scores compared with control sample except for the melting in the mouth property. This fact may be due to the increased fiber proportion in that samples including hazelnut testa compared with control one. Although the parameters were different in the sensorial evaluation, similar results were obtained in literature for barley flour added cookies as lower total sensory scores received by the samples prepared with high barley flour addition in cookies (Škrbić and Cvejanov, 2011).

Cake: The cake recipes containing hazelnut are demanded in both household meals and industrial ready to eat cake production due to its unique flavor. As it can be seen in Table 4, the panelists gave equal scores ($P > 0.05$) for the cakes according to color, taste, appearance and overall acceptability. However, the scores of pore formation and cohesiveness were affected negatively ($P < 0.05$) by the increase in hazelnut testa addition. This fact may be due to the adverse effect of fiber on textural property of cake dough. Similar tendency have been observed in literature in which increasing fiber addition decreased the cohesiveness of cake (Gómez et al., 2010; Kim et al., 2012) and cookie samples (Pankaj Sharma et al., 2013). Moreover, as expected, increasing in hazelnut testa ratio in cake formulation resulted significantly higher smell scores ($P < 0.05$) for all samples.

Conclusion

Addition of hazelnut testa in the formulations of bakery products was found practicable. Enrichment with hazelnut testa positively affected the sensorial quality of cookie and cake, especially in the meaning of smell and taste. Our results showed that the use of flour mixes enriched with hazelnut testa can lead to the production of nutritionally valuable bakery products according to high phenolic content. As a result, producing bakery products with flour containing hazelnut testa at levels of 8% for cookie and bread, and 6% for cake could be an effective way to put functional products on the market without compromising the sensorial quality. Nevertheless, those were not in the scope of this study, cautions should be paid to; (i) aflatoxin content of the hazelnut testa, (ii) allergenity of hazelnut, (iii) acrylamide risk of roasted testa and (iv) occurrence of polycyclic aromatic hydrocarbons (PAHs) in roasted testa for further researches that will focus on utilization of this unique by-product in food production.

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