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BIOACTIVE AND PHYSICOCHEMICAL PROPERTIES OF WILD FRUIT POWDER ADDED SPONGE CAKE

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ABSTRACT

This study had investigated the effects of the addition of wild fruit (elaeagnus, hawthorn, medlar, myrtle) on the physicochemical and functional properties of sponge cakes. For this purpose, fruits powders at the level of 5 and 10% were used in cakes which were determined by sensory acceptance test. Myrtle had the highest TPC and DPPH activity while elaeagnus had the lowest values. Analyses of the cake samples were carried out at 1$^{st\ h}$, 7th and 14th d. Texture profile analysis (TPA) revealed that the addition of fruit powder resulted in decrease in the hardness and chewiness values of cake samples compared to the control group. Among the samples, the control group had the highest L^* and b^* values and the samples containing medlar powder had a higher redness value. As the storage time increased, L^* and a^* values were also increased, whereas b^* values decreased. The examination of TPC and DPPH activity of the cake samples at 1st, 1st h and 14th d showed that the addition of fruit powders caused an increase in both parameters. The results of the present study suggested that the use of specific proportions of wild fruit powders in cakes positively affects the physicochemical and bioactive properties of sponge cakes.

Keywords: Elaeagnus, Functional cake, Hawthorn, Medlar, Myrtle

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Introduction

Functional foods supply the body's basic nutrients and provide additional benefits to human physiology and metabolic functions. Thereby, these foods contribute to preventing diseases and achieving a healthier life (İşleroğlu & Yıldırım, 2005). Research studies and consumer demands show that natural products can be used to improve the textural and functional properties of cakes. Gupta, Bawa, and Semwal (2009) reported that the use of barley flour in cakes affects nutritional and functional properties. In other studies, soapwort extract was replaced with egg white Celik, Yılmaz, Işık, and Üstün (2007) and banana powder was replaced with flour (Park, Lee, & Chun, 2010). In low calorie sponge cakes, usage of erythritol and turmeric powder was reported to decrease the stiffness value in sponge cakes (Seo, Park, & Jang, 2010). By the replacement of wheat flour with gamma aminobutyric acid, the bioactive characteristics of cakes were increased and this was found to be beneficial to human health. Lee and Lin (2008) found that replacement of sugar with 75% isomaltooligosaccharide syrup decreased the stiffness and total bacteria count resulting from long storage.

Hawthorn (*Crataegus* spp.), belonging to the Rosaceae family has been used in the pharmaceutical and food industries in China and European countries. Hawthorn berries contain high amounts of caffeic, malic, tartaric, citric acid and organic acid making up 3-6% of the total dry fruit (Chang, Zuo, Chow, & Ho, 2006). Hawthorn flowers and fruits contain epicatechin, hyperoside and chlorogenic acids, which are responsible for free radical scavenging activity (Tadić et al., 2008)

Medlar (*Mespilus germanica* L) is a fruit belonging to the family of Rosaceae. Ayaz, Demir, Torun, Kolcuoglu, and Colak (2008) proved its phenolic content to decrease with ripening. Elaeagnus (*Elaeagnus angustifolia* L.) has 4-hydroxybenzoic and caffeic acids as its principal phenolic compounds. In Iranian folk medicine, it is used for its anti-inflammatory and analgaesic properties. Decoction and infusion of its fruit is considered to be a good remedy for fever, jaundice, asthma, tetanus and rheumatoid arthritis (Ahmadiani et al., 2000).

Myrtle *(Myrtus communis*) fruits and leaves contain phenolic acids, such as ellagic, gallic, caffeic and flavonoids including cathechin, myricetin, hesperidin, esculin and patuletin in methanol extracts. Myrtle can be used as a natural antioxidant as it shows strong antioxidant properties and has a high level of phenolic content. Amensour, Sendra, Abrini, Perez-Alvarez, and Fernandez-Lopez (2010) reported phenolic compounds to be the major contributors of the antioxidant activities of *Myrtus communis.* Moreover, this fruit could be used as an easily accessible source of natural antioxidants and as a food supplement.

The cake, which can be produced with several methods, is very important in bakery product industry since the production and the consumption of it increase continuously as a result of the increase in population, urbanization, and easement of access and application of new technologies. Cake products can be produced in wide variety of formulations all over the world. The differences in the formulation of the cakes make them attractive not only for their pleasing flavors but also for their appearance. Sponge cake has a special and important place in the variety of cakes (Dizlek, 2003; Dizlek & Altan, 2015).

The aim of this study was to utilize hawthorn, medlar, elaeagnus and myrtle as wild fruit powders in the production of sponge cakes by partially replacing them with wheat flour. To the best of the author's knowledge there is no report on the use of wild fruits in the formulation of sponge cake. Therefore, the effects of wild fruit replacement on the chemical and textural properties, total phenolic content, antioxidant activity and staling of sponge cakes were investigated.

Materials and Methods

Materials

Hawthorn (*Crataegus* spp.), medlar (*Mespilus germanica* L) and elaeagnus (*Elaeagnus angustifolia* L.) samples were obtained from Kayseri, Turkey and myrtle *(Myrtus communis* L.) samples were obtained from Mersin, Turkey. Sugar, eggs, vanillin, salt, flour, baking powder and surfactant (monoglyceride and diglyceride ester) were purchased from local markets.

Methods

Chemical Analyses

The fruits were dried and grounded at room temperature for a month, and then the samples were sieved through a 0.5 mesh. Moisture of the cake, fruit and the fruit ash contents were determined following AACC methods (AACC, 2000).

Cake Preparation

The creaming process was used for the preparation of the samples as described Özer, Dizlek, Kola, and Altan (2004). Initially, 100 g eggs were mixed in a mixer at a speed of 1 for 2 minutes (Kitchen Aid Classic, USA). Then 19.3 g surfactant and 60 g water were added and mixed at the same speed and time. After this, 144 g sugar was added and mixed for 2 min at the same speed. Two hundred grammes of wheat

flour (or wheat flour and fruit powder), 6.9 g of baking powder, 0.8 g of salt and 1.5 g of vanillin were added and mixed in the same way. Finally, the batter was mixed for 30 s at speed 4. A standard amount of batter (40 g) was placed in 8-cup non-stick muffin pans and baked for 30 min at 210 °C in a laboratory oven with air circulation (Kenwood, Model NW796, China). After baking, the cake samples were carefully taken out of the muffin pans and cooled at room temperature for an hour (Dizlek, 2015). The cakes were packed in polypropylene bags and were stored at room temperature in a dry place. Fruit powders were used at 5% and 10% levels in the sponge cake form and these cakes were compared to control cakes which were fruit-free in the composition. These are abridgments:

H5: 5% Hawthorn, H10: 10% Hawthorn, M5: 5% Medlar, M10: 10% Medlar, E5: 5% Elaeagnus, E10: 10% Elaeagnus, My5: 5% Myrtle, My10: 10% Myrtle.

Texture and Colour Properties of Cakes

Texture profile analysis was performed using at texture analyzer (Stable Micro System, TA-XT2Plus, England). The upper parts of the cakes were removed and cake crumb texture profile analyses were performed. A 50 mm diameter probe was used and the device was calibrated to 5 g weight. The initial force was 10 g and force was applied to the samples twice. Between the first and second, landings were set to 5 seconds delay, the probe was reduced to 10 mm/sec until the center of sample's deformation was 40%. The pre-test speed of 1mm/sec, test speed of 1mm/sec and post-test speed of 10mm/sec were set up and hardness, springiness, chewiness and adhesiveness were obtained 1 h, 1 d, 7 d and 14 d after baking.

Colour analyses of the crust and crumb of the cake samples were determined with a colour measurement device (Konica-Minolta, CR400, Japan). The device was calibrated with the standard calibration scale, then readings were taken through samples and values were recorded in the form of L^* (0=black, 100=white), a^* (+value=red, -value=green) and b^* (+value=yellow, -value= blue).

Total Phenolic Content of Cake Samples

Cakes were cut into slices and dried in the oven at 40 °C for 24 h. Then they were sieved through a 35 mesh screen. One gram of cake and 10 mL of 80% methanol were added and shaken at 200 rpm at 37 °C for 2 h. The mixture was centrifuged (Nüve, NF 800R, Turkey) at 3100 *g* for 10 min. The filtrate was used for analyses.

The Folin Ciocalteu procedure of Sudha, Baskaran, and Leelavathi (2007) was followed. One hundred microlitres of sample and 900 µL water were added and then 1 mL of 10% diluted Folin-Ciocalteu reagent and 2 mL of 10% Na_2CO_3 solution were added. At room temperature, the mixture was incubated in dark place for an hour. For a control sample, 0.5 mL of distilled water was used. The absorbance was read at 765 nm by using a spectrometer (Shimadzu UV-1700, Japan). The data were expressed as gallic acid equivalents (GAE) in mg per g of dry-material.

Free Radical-Scavenging Activity of Cake Samples

The procedure of Wronkowska, Zielińska, Szawara-Nowak, Troszyńska, and Soral-Śmietana (2010) was used for estimation. DPPH (2,2-diphenylpicrylhydrazyl) solution was prepared by dissolving 10 mg of DPPH in 25 mL of 80% methanol. Two hundred and fifty microliters of DPPH solution and 2.11 mL of 80% methanol were added and 100 µL of methanolic extract was mixed. The mixture was incubated at room temperature in the dark. The absorbance was measured at 517 nm by using a spectrometer (Shimadzu UV-1700, Japan). The ability to scavenge the DPPH radical was calculated by the following formula:

Free-radical scavenging activity (%): $[1- (A_s/A_0)] \times 100$

Where A_0 is the absorbance of the control and A_s is the test sample.

Sensory analysis

Sensory analysis of the cake samples was conducted to identify fruit powder rate by ten panelists in the Department of Food Engineering at Erciyes University, Kayseri, Turkey. For this purpose, fruits' powders at the level of 5 and 10% were used in cakes, which were preliminarily determined by sensory acceptance test. Cake samples were evaluated for overall acceptance on a nine-point hedonic scale ranging from 1 (extremely dislike) to 9 (extremely like). In addition, samples were evaluated for appearance, odour, flavour, texture and overall acceptability.

Statistical Analysis

Statistical differences between values were evaluated by the Tukey multiple comparison test at the level of $p<0.05$ using the SPSS (17.0.1 (SPSS Inc., Chicago, Illinois, US) software package.

Results and Discussion

Chemical Analyses

The moisture and ash content of the wild fruit samples and wheat flour are presented in Table 1. Özcan, Hacıseferoğulları, Marakoğlu, and Arslan (2005) found that hawthorn had an ash content of 2.28%. Hacıseferoğulları,

Özcan, Sonmete, and Özbek (2005) have reported that medlar had 2% ash content. Aydın and Özcan (2007) found the ash content of myrtle as 0.72%. Differences among the chemical compositions of fruits may be due to variability of growing conditions and variety. We investigated the effects of bioactive and physicochemical properties of wild fruits on cake samples. Lu, Lee, Mau, and Lin (2010) indicated that cake with green tea extract and the control group exhibited no differences in terms of moisture content. In this study, at the end of the 14 d storage; moisture content of cake samples containing medlar, 5% elaeagnus and myrtle were close to control group; whereas cakes with hawthorn powder had higher moisture content. As expected, the moisture content of cake samples decreased statistically at the end of the 14th d. ($p<0.05$).

In the preliminary experiments, the sensory analyses showed that sponge cakes containing high level of fruit powder rated lower scores. Therefore, 5 and 10% fruit powder were decided to be replaced with wheat flour.

As shown in Figure 1, cake samples containing 10% hawthorn powder had the highest moisture content (30%) at the first analyses. The sample of cake containing 5% hawthorn powder is the closest sample to the control group.

Table 1. Chemical analysis of wild fruit and wheat flour

Sample	Moisture (%)	Ash (%)*
Wheat Flour	$13.95^{a}\pm 0.2$	$0.60^{d}\pm 0.1$
Hawthorn	$11.4^{c} \pm 0.4$	$4.9^{a} \pm 0.1$
Medlar	$7.8^{e}\pm 0.4$	$2.8^{b} \pm 0.1$
Elaeagnus	$13.3^{b} \pm 0.3$	$1.9^{c} \pm 0.1$
Myrtle	$8.1^{d} \pm 0.2$	$2.4^{b} \pm 0.1$

a–e, means within a column with different letters are significantly different ($P<0.05$).
Results are given as the mean values ± standard deviation.

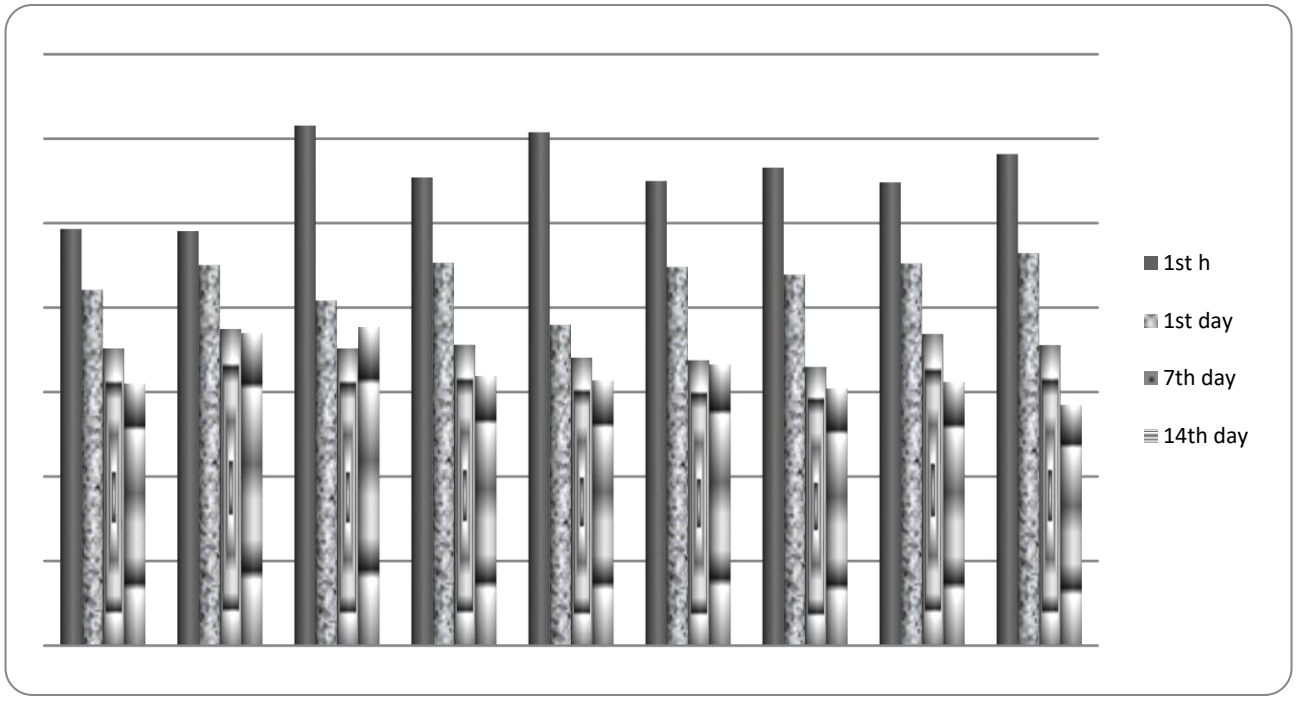
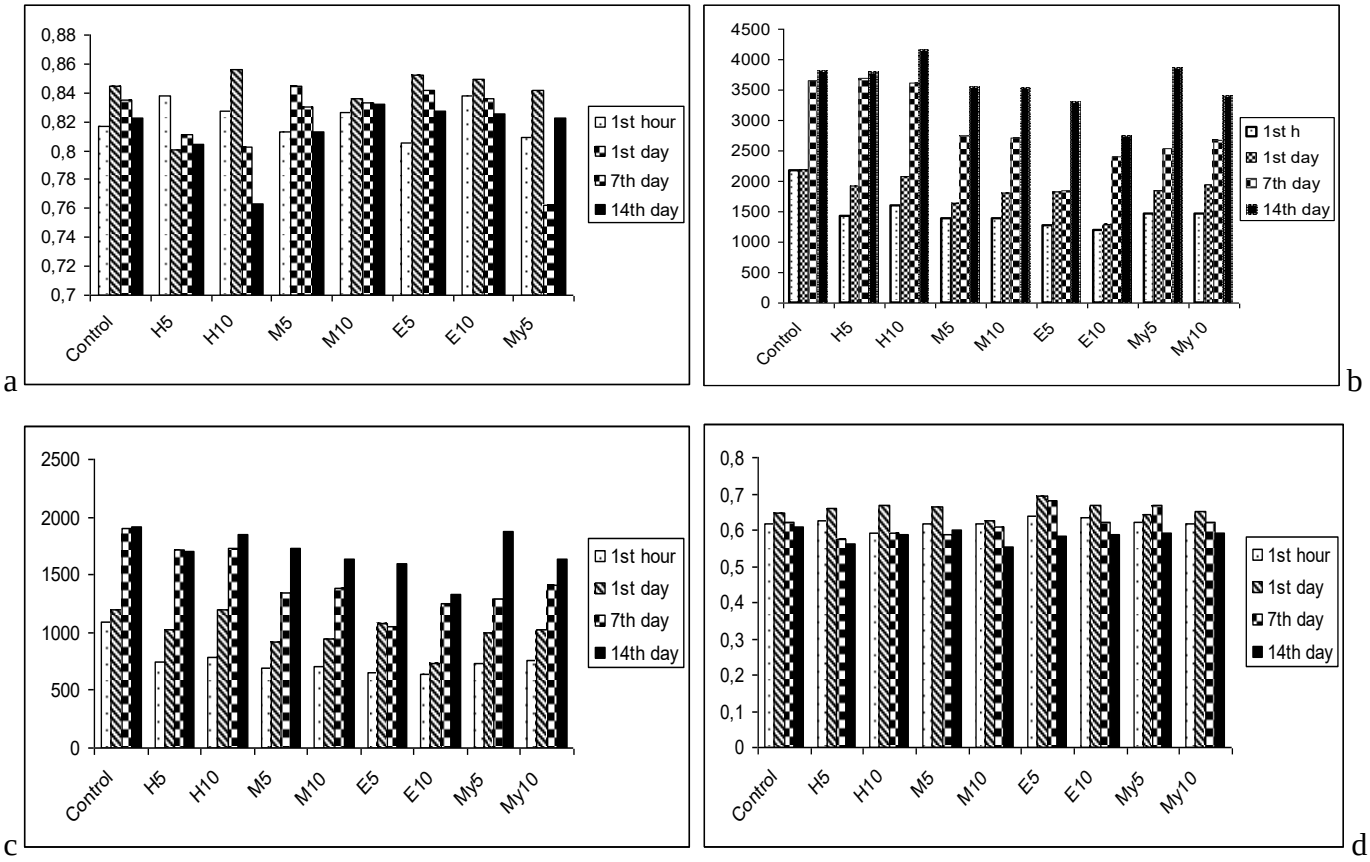


Fig. 1. Moisture content of sponge cake samples

Textural Characteristics of Cake Samples

Figure 2 displays the TPA results of cakes examined in the 1st h after baking. Fruit powder containing cakes had a lower stiffness value than the control group and the values were identical after the 1st and 7th d. At the end of 2 weeks periods, H10 cake samples had higher values than the control group. In this study, cake samples containing fruit powders had higher moisture values during all storage periods. The springiness and cohesiveness values were statistically insignificant ($p>0.05$) among the cake samples. As in hardness values, the chewiness values of cakes containing fruits were lower than the control group. These values were determined for all storage periods. Use of fruit powder affected the hardness value and resulted in an increase in the shelf life. In particular, the use of elaeagnus powder positively affected hardness value at the end of 14th d storage.



H5: 5% hawthorn powder, H10: 10% hawthorn powder, M5: 5% medlar powder, M10: 10% medlar powder, E5: 5% elaeagnus powder, E10: 10% elaeagnus powder, My5: 5% myrtle powder, My10: 10% myrtle powder

Figure 2. TPA profile of the sponge cakes after 1st h, 1st, 7th and 14th d: (**a**) crumb springiness; (**b**) crumb hardness; (**c**) crumb chewiness; (d) crumb cohesiveness

Ertaş and Çoklar (2008) used different types of molasses instead of sugar and found that after 21 d storage, cakes containing molasses had lower values than the control group. In a study, in which barley flour was replaced with wheat flour, at the 96th and 120th h, the hardness values of cake samples containing 30% barley flour were lower than the control. Ronda, Gómez, Blanco, and Caballero (2005) used some sugar alcohols and oligosaccharides instead of sugar in sponge cake. Especially when isomaltose was used, the stiffness value was lower than the control; while oligofructose, polydextrose and mannitol had higher values than the control. In one study, the use of 10% banana powder resulted in hardness values get close to the control, however when the powder level increased, the hardness value also increased. Jia, Kim, Huang, and Huang (2008) found that when 10, 40 and 70% levels of almond flour were replaced with wheat flour; stiffness was significantly reduced with the increase in almond flour.

Colour Properties of Cake Samples

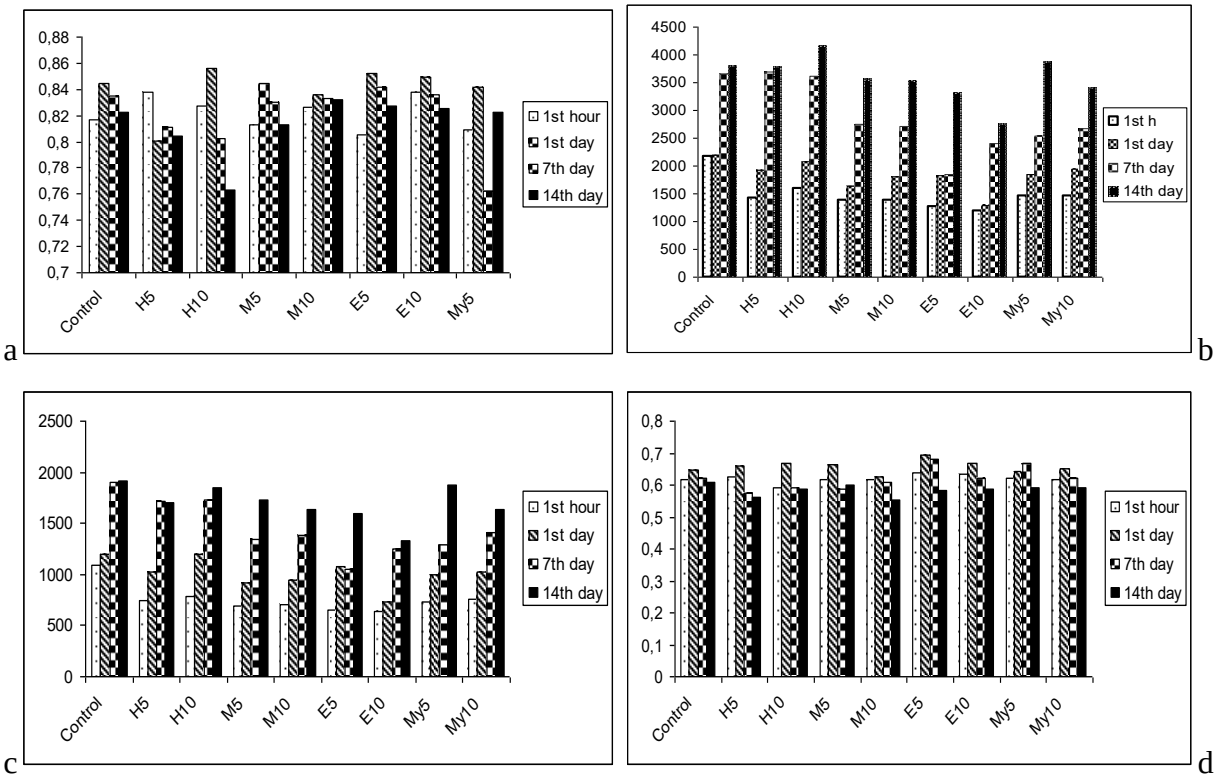
Colour parameters are important for formulations or processing. In cake analysis (Table 3), cake colour was measured as crust and crumb values and the lightness of the crust was found to be lower than that of the crumb due to exposure to high temperature. The control group had the highest *L** values in crumb at 1st h after baking and H5 sample had the nearest value to control; while M10 had the lowest *L** value. The highest difference in crumb redness value was obtained from the cake sample containing 10% medlar powder, which was an expected result because of the colour contribution of medlar fruit. Fruit powder containing cake samples had a higher *a** value than the control group. It was determined that *L** and *a** values increased with the addition of fruit powder.

As shown in Table 4, the highest *L** value was measured in the control group in crust. The *L** value of the control and H5 samples decreased at the end of the storage period of 14 d. In this study, E5 had the highest *a** value after 1 h baking. Among the sponge cake samples, statistically significant ($p<0.05$) differences were found during the storage period. H5 had the highest value 1 h after baking; while E10 had the highest value at the end of the 14th d.

Capriles et al. (2008) reported that control group had the highest *L** value and with the increase of amaranth flour the value decreased. Lu et al. (2010) also reported that the *L** value decreased with the addition of green tea extract. Capriles et al. (2008) pointed out that the use of amaranth flour in cakes decreased the *L** value. Lu et al. (2010) reported that the addition of green tea extract powder to cake samples lowered the *L** value of the crumb compared to the control sample.

Total Phenolic Content of Cake Samples

As expected, the TPC content significantly ($p<0.05$) increased with the addition of fruit powder. The TPC of myrtle was the highest; but in cake samples M10 had the highest TPC value (Figure 3). The control had a value of 266 mg GAE/100 g dry sample and M10 had 1678.9 mg GAE/100g dry sample 1 h after baking. In one study; TPC increased from 2.07 mg/g to 3.15 mg/g with the addition of 25% apple pomace (Sudha et al., 2007). In this study, at the end of 14 day storage period, the TPC of the samples decreased.



H5: 5% hawthorn powder, H10: 10% hawthorn powder, M5: 5% medlar powder, M10: 10% medlar powder, E5: 5% elaeagnus powder, E10: 10% elaeagnus powder, My5: 5% myrtle powder, My10: 10% myrtle powder

Figure 2. TPA profile of the sponge cakes after 1st h, 1st, 7th and 14th d: (**a**) crumb springiness; (**b**) crumb hardness; (**c**) crumb chewiness; (d) crumb cohesiveness

Table 2. Crumb colour values of sponge cake samples

Samples	*L**				*a**				*b**			
	1st hour	1st day	7th day	14th day	1st hour	1st day	7th day	14th day	1st hour	1st day	7th day	14th day
Control	79.67^{Ba} ± 0.44	79.95^{Ba} ± 0.57	79.91^{Ba} ± 0.32	80.74^{Aa} ± 0.51	4.43^{Ad} ± 0.24	4.46^{Ad} ± 0.33	4.21^{Ad} ± 0.23	4.06^{Ade} ± 0.36	24.81^{Ca} ±0.56	26.18^{Ba} ±0.68	27.80^{Aa} ± 0.66	28.34^{Aa} ± 0.33
5% Hawthorn	70.50^{Ab} ± 0.52	70.65^{Ab} ± 0.51	70.43^{Ab} ± 0.39	70.68^{Ab} ± 0.35	2.94^{ABe} ± 0.24	2.92^{ABe} ± 0.21	2.63^{Be} ± 0.13	3.32^{Ae} ± 0.48	23.68^{Bb} ± 0.17	22.54^{Cc} ± 0.43	25.30^{Ab} ± 0.61	22.86^{ABc} ± 0.98
10% Hawthorn	69.21^{Ac} ± 0.57	68.95^{Ac} ± 0.72	67.09^{Bc} ± 0.80	64.66^{Cd} ± 0.44	4.73^{Ad} ± 0.25	3.95^{Bd} ± 0.34	4.69^{Ad} ± 0.54	4.82^{Ad} ± 0.59	22.38^{Cc} ± 0.47	24.28^{Bb} ± 1.14	25.64^{Ab} ± 0.59	24.52^{BCb} ± 0.39
5% Medlar	62.26^{CBe} ± 0.92	63.27^{Bd} ± 0.46	61.22^{Ce} ± 0.62	64.76^{Ad} ± 1.15	6.30^{Bc} ± 0.46	7.06^{Ab} ± 0.47	7.04^{ABb} ± 0.39	7.08^{Ab} ± 0.53	18.66^{Abe} ± 0.44	14.73^{Cf} ±0.50	18.40^{Ae} ± 0.49	16.41^{Bg} ±0.38
10% Medlar	57.79^{Bf} ± 0.57	56.34^{Cf} ± 0.38	57.70^{Bf} ± 0.95	61.10^{Ae} ± 0.31	8.95^{Aa} ± 0.26	8.96^{Aa} ± 0.42	9.30^{Aa} ± 0.39	9.03^{Aa} ± 0.71	17.83^{Aef} ± 0.54	17.85^{Ae} ± 0.48	18.04^{Ae} ± 0.62	17.59^{Af} ± 0.36
5% Elaeagnus	69.54^{Ac} ± 0.31	68.19^{Bc} ± 0.75	66.38^{Cc} ± 0.89	66.36^{Cc} ± 0.47	2.98^{ABe} ± 0.42	2.72^{Ce} ± 0.29	4.61^{Ad} ± 0.19	3.35^{Be} ± 0.22	19.11^{Bde} ±0.55	19.13^{Bd} ± 0.51	20.96^{Ad} ± 0.89	21.68^{Ad} ± 0.28
10% Elaeagnus	64.69^{Bd} ± 0.38	63.79^{Cd} ± 0.40	66.45^{Ac} ± 0.86	67.19^{Ac}± 0.26	4.86^{Ad} ± 0.27	4.08^{ABd} ± 0.37	4.43^{BCd} ± 0.46	3.66^{Ce} ± 0.36	17.33^{Cg} ± 0.42	19.15^{Bd} ± 0.46	21.23^{Acd} ± 0.51	19.56^{Be} ± 0.32
5% Myrtle	63.17^{Be} ± 0.72	63.24^{Bd} ± 0.57	64.97^{Ad} ± 0.60	64.81^{Ad} ± 0.60	6.72^{Ac} ± 0.24	6.33^{Bc} ± 0.16	5.39^{Cc} ± 0.25	5.67^{Cc} ± 0.19	20.10^{Bd} ± 0.74	18.53^{Cde} ± 0.46	22.31^{Ac} ± 0.61	19.56^{Be} ± 0.53
10% Myrtle	59.93^{Bf} ± 0.50	59.21^{Be} ± 0.52	60.76^{Af} ± 0.86	60.75^{Ae} ± 0.34	7.96^{Ab} ± 0.18	7.10^{Bb} ± 0.61	7.49^{ABb} ± 0.32	7.18^{Bb} ± 0.32	18.76^{Ce} ±0.72	22.23^{Ac} ± 0.59	22.10^{Acd} ± 0.52	21.13^{Bd} ± 0.39

a–f: means within a column with different letters are significantly different (P<0.05). A-C: means within a row with different letters are significantly different (P<0.05). Results are given as the mean values ± standard deviation.

Table 3. Crust colour values of sponge cake samples

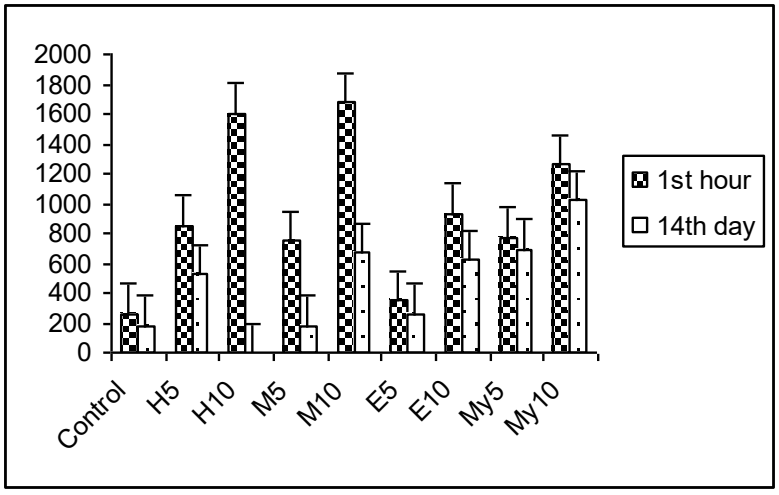
Samples	*L**				*a**				*b**			
	1st hour	1st day	7th day	14th day	1st hour	1st day	7th day	14th day	1st hour	1st day	7th day	14th day
Control	79.26^{Aa} ± 0.41	73.25^{Ca} ± 0.42	74.68^{Ba} ± 0.62	74.78^{Ba} ± 0.61	11.40^{Ae} ± 0.25	8.04^{Bb} ± 0.52	6.34^{Ce} ± 0.28	4.68^{De} ± 0.35	32.33^{Ab} ± 0.36	32.02^{Aa} ± 0.97	29.59^{Bc} ± 0.66	30.22^{Bbc} ± 0.32
5% Hawthorn	66.32^{Ab} ± 0.66	63.94^{Bb} ± 0.65	64.19^{Bb} ± 0.36	64.58^{Bb} ± 0.58	11.97^{Ade} ± 0.35	12.15^{Aa} ± 0.39	10.66^{Bde} ± 0.31	11.16^{Bc} ± 0.47	33.42^{Aa} ± 0.31	28.06^{Dc} ± 0.39	30.61^{Bbc} ± 0.53	29.39^{Cc} ± 0.66
10% Hawthorn	63.71^{Ac} ± 0.59	61.48^{Cc} ± 0.50	62.79^{Bc} ± 0.46	62.65^{Bc} ± 0.34	12.18^{Bd} ± 0.38	13.11^{Aa} ± 0.26	10.37^{Cd} ± 0.53	9.85^{Cd} ± 0.36	26.96^{Ce} ± 0.60	33.14^{Aa} ± 0.69	30.34^{Bbc} ± 0.31	29.96^{Bbc} ± 0.29
5% Medlar	60.51^{Bd} ± 0.42	60.29^{Bd} ± 0.43	60.74^{ABd} ± 0.85	61.70^{Acd} ± 0.63	13.05^{Ac} ± 0.52	11.74^{Ba} ± 0.47	10.53^{Cde} ± 0.34	11.31^{Bc} ± 0.13	31.76^{Ab} ± 0.63	24.13^{Ce} ± 0.61	27.45^{Bd} ± 0.28	27.21^{Bcd} ± 0.80
10% Medlar	56.81^{Bg} ± 0.53	54.84^{Ch} ± 0.46	59.36^{Ae} ± 0.80	59.15^{Af} ± 0.36	13.37^{Ac} ± 0.41	13.49^{Aa} ± 0.29	11.32^{Bc} ± 0.42	10.38^{Cd} ± 0.31	30.27^{Ac} ± 0.50	29.57^{Ab} ± 0.83	27.94^{Bd} ± 0.58	27.73^{Bd} ± 0.61
5% Elaeagnus	59.71^{Bde} ± 0.36	57.20^{Cg} ± 0.28	60.52^{Ad} ± 0.77	60.72^{Ade} ± 0.35	14.92^{Ab} ± 0.17	14.05^{Aa} ± 0.55	11.96^{Cab} ± 0.69	12.79^{Ba} ± 0.31	26.88^{Ce} ± 0.71	25.93^{Cd} ± 0.50	31.08^{Ab} ± 1.17	29.44^{Bc} ± 0.37
10% Elaeagnus	55.02^{Dh} ± 0.29	57.20^{Cf} ± 0.28	59.18^{Bc} ± 0.57	60.13^{Aef} ± 0.57	15.93^{Aa} ± 0.46	15.53^{Aa} ± 0.48	12.64^{Ba} ± 0.56	12.32^{Bb} ± 0.31	25.00^{Bf} ± 0.56	32.83^{Aa} ± 0.65	32.59^{Aa} ± 0.51	32.81^{Aa} ± 0.34
5% Myrtle	58.78^{Cf} ± 0.60	60.30^{Bd} ± 0.75	64.43^{Ab} ± 0.41	60.86^{Bde} ± 0.70	12.91^{Ac} ± 0.28	12.17^{Ba} ± 0.62	10.321^{Dd} ± 0.36	11.3^{Cc} 7± 0.22	28.38^{Ad} ± 0.63	24.36^{Ce} ± 0.62	28.22^{Ad} ± 0.21	26.47^{Be} ± 0.12
10% Myrtle	59.03^{Be} ± 0.26	58.48^{Be} ± 0.67	60.77^{Ad} ± 0.40	60.88^{Ade} ± 0.45	12.93^{Ac} ± 0.19	12.15^{Ba} ± 0.10	11.86^{Cab} ± 0.34	11.24^{Dc} ± 0.27	27.21^{Ae} ± 0.45	29.65^{Ab} ± 0.43	30.46^{Abc} ± 0.45	30.62^{Ab} ± 0.31

a–f: means within a column with different letters are significantly different (P<0.05). A-D: means within a row with different letters are significantly different (P<0.05). Results are given as the mean

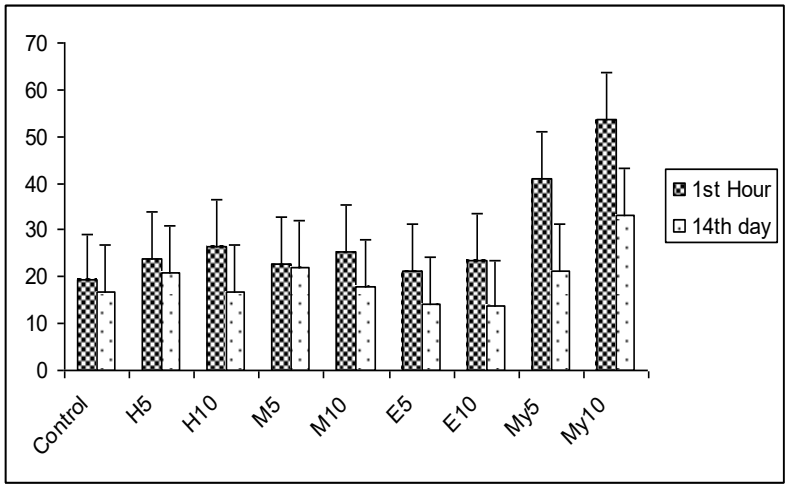
DPPH Activity of Cake Samples

As in TPC, the DPPH activity of the control group was lower than fruit powder containing sponge cake samples (Figure 3). Myrtle had the highest DPPH activity and the myrtle containing My10 sample had the highest value among the cake samples. Fruits have high antioxidant activity and this property decreased, however continued in sponge cakes.

Chang et al. (2006) investigated the effect of storage temperature on phenolics stability in hawthorn fruits and found that phenolic compounds were stable at 4°C, but they were unstable at temperature above 40°C. In particular, at room temperature (23°C) after 6 months storage, 50% degradation was observed in epicatechin and procyanidin-B_2. In addition, phenolic stability was reported to decrease at 4°C, 23°C and 40°C after 6 months storage in hawthorn drink. Catechins lost 70% of their initial components at room temperature after 6 months storage. For hawthorn fruit, it is more effective to store at low temperatures. And also, these results are similar with DPPH activity results. Lu et al. (2010) showed that green tea extract increased the antioxidant activity of cakes. It was identified that after 14 d storage the antioxidant activity of all cake samples decreased, but cakes containing elaeagnus had lower antioxidant activity than control group. In one study regarding the antioxidant activity of polyphenols in extracts of myrtle used for the preparation of myrtle liqueur, the initial value of myricetin-3-*O*-rhamnoside was determined as 1.7 mg/mL; however the value was reported to decrease to 0.5 mg/mL after 12 months storage.



a



b

H5: 5% hawthorn powder, H10: 10% hawthorn powder, M5: 5% medlar powder, M10: 10% medlar powder, E5: 5% elaeagnus powder, E10: 10% elaeagnus powder, My5: 5% myrtle powder, My10: 10% myrtle powder

Figure 3. (a) TPC and (b) DPPH activity of the sponge cakes

Conclusions

In this study, the effect of wild fruit powders was evaluated in terms of sponge cake properties. The result of the present investigation revealed that wild fruits such as hawthorn, medlar, elaeagnus and myrtle can be used in bakery products to improve functional properties after conducting preliminary sensory analysis to assess product acceptability. Although sponge cakes are exposed to high temperatures for a long period of time during baking, samples are able to maintain their TPC and DPPH activity. In particular, elaeagnus may be used as asolution for the stiffness, which negatively affects the shelf life of bakery products. The findings of this research implied that wild fruits in powdered form or their extract can be considered as functional ingredients to provide functional improvements in bakery products.

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