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# SENSORY AND QUALITY ATTRIBUTES OF CAKE SUPPLEMENTED WITH SPINACH POWDER

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## ABSTRACT
The aim of this study is to investigate the production of functional cakes with enriched nutritional value and flavor with the addition of spinach powder (SP) to the formulation as a replacement for the wheat flour at different ratios. The addition of SP resulted in a significant decrease in the moisture content (26.63 - 28.96% for the batters and 12.75 - 22.33% for the cakes) and water activity (0.902 - 0.880 for the batters and 0.722 - 0.822 for the cakes) values ($P<0.05$). The addition of SP caused a significant change in the color of the batters and cakes. The vitamin C content of the batters and cakes increased depending on the amount of SP ($P<0.05$). The highest weight loss (14.83%) and cooking yield (89.40%) values were observed for the plain cake and cake with 10% SP, respectively, where this cake had the highest sensorial acceptability by the panelists.
**Keywords:** Cake, spinach powder, microwave, vitamin C, sensory analysis

# ISPANAK TOZU İLE ZENGİNLEŞTİRİLMİŞ KEKLERİN KALİTE PARAMETRELERİ İLE DUYUSAL ÖZELLİKLERİNİN BELİRLENMESİ

## ÖZ
Bu çalışmanın amacı, kek formülasyonuna ıspanak tozu ilavesi ile zenginleştirilmiş besin değeri ve lezzetiyle yeni fonksiyonel bir kekin üretilmesidir. Mikrodalga kurutucuda kurutulmuş ıspanak tozu kek formülasyonuna buğday unuyla yer değiştirme prensibiyle farklı oranlarda eklenmiştir. Kek formülasyonuna ilave edilen ıspanak tozu miktarı arttıkça nem içeriği (kek hamurlarında % 26.63-28.96 ve keklerde % 12.75-22.33) ve su aktivitesi (kek hamurlarında 0.902-0.880 ve keklerde 0.722-0.822) değerlerinde azalma meydana geldiği gözlenmiştir ($P<0.05$). Ispanak tozu ilavesi kek hamuru ve keklerin renk değerlerinde önemli bir değişime neden olmuştur. Ispanak tozu miktarına bağlı olarak C vitamini içeriğinde artış meydana geldiği görülmüştür ($P<0.05$). En yüksek ağırlık kaybı (%14.83) ve pişme verimi (%89.40) sırasıyla sade kek ve %10 ıspanak tozu içeren keklerde gözlenmiştir. Duyusal değerlendirme sonuçlarına göre, %10 ıspanak tozu içeren keklerin panelistler tarafından en yüksek kabul edilebilirliğe sahip olduğu gözlenmiştir.
**Anahtar kelimeler:** Kek, ıspanak tozu, mikrodalga, C vitamini, duyusal analiz

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## INTRODUCTION

Cereal products are consumed daily by the majority of the world population. The tendency of consumers for functional products has resulted in an increase in the development of different and healthier cereal products (Ayadi et al., 2009). The health-enhancing characteristics of plants such as green leafy vegetables, herbs, edible flowers, etc. in providing important components has lead to their use in food products (Lebesi and Tzia, 2011). Spinach contains phenolic compounds (like chlorophylls and carotenoids), fiber, vitamins (vitamin A, B complex, C, and K), and minerals (calcium, magnesium, potassium, iron, phosphorus, sodium, copper, sulfide, manganese, and zinc) (Toledo et al., 2003 and Çıtak Sönmez, 2009). For this reason, the use of spinach as a natural coloring agent and as a functional food ingredient, has a high potential for developing biologically active foods such as cakes. In addition, the consumption of leafy vegetables (spinach, cabbage, purslane, celery, etc) has been increasing especially as a result of changes in the consumer lifestyle. Spinach (*Spinacia oleracea* L.), which can be consumed as raw, boiled, canned, frozen, in bakery products, soups, etc. is a cool season annual vegetable (Ozkan et al., 2007, Citak and Sonmez 2009, and Çalışkan Koç and Dirim, 2017).

According to the Food and Agriculture Organization of the United Nations (FAO) and Turkish Statistical Institution (TUIK), the production of spinach is around 225.174, 222.177, 211.000, and 208.403 tons in Turkey from 2018 to 2015 respectively. Turkey rates fourth for spinach production in the World (FAOSTAT data: 2007 (Last accessed by Top 5 of anything: March 2015)).

Çalışkan Koç and Dirim (2017) reported that dried spinach in the form of powder is more feasible due to a long shelf life, mixing and dosing properties, and it can also be used as a food colorant and additive in different food formulations. Spinach powder can be obtained using several drying techniques such as: spray drying (Çalışkan Koç and Dirim, 2017 and 2018), microwave drying (Ozkan et al., 2007 and Dadali et al., 2007), hot air drying (Watanabe et al., 2016), freeze drying (King et al., 2001), and combined microwave–fan-assisted convection drying (Karaaslan and Tunçer, 2008). Nowadays, practical and ready to easy cooking systems such as microwave drying is generally preferred by both producers and customers. At the same time, microwave drying has many unique features such as low energy consumption and a short processing time related to its selective and volumetric heating compared to the traditional drying techniques (Song et al., 2016).

The improvement of the functional properties of cakes can be accomplished using several agents, however, the addition of food materials to improve the properties of cakes is a more interesting and promising application. For the improvement of cake quality in some studies, replacement of undesirable constituents like sugar and fats has been tried or in other studies improvements in the nutritional composition and functional properties have been tried with the addition of food components either from the waste of the food processing industry or the unused parts of food materials. In recent years, the addition of dietary fiber, fat replacer, and by-products to the bakery product formulation have received increasing attention from researchers and the food industry due to their beneficial effects on human health and functionality in production. Therefore, the enrichment of bakery products such as cakes with fiber and plant-based ingredients may be one of the efficient ways utilized to improve the nutritional value and sensorial properties. There are many studies related to the addition of fiber for example carob fiber, rice bran, potato fiber, pear cactus fiber etc. to bakery product formulations such as bread (Wang et al., 2002, Kaack et al., 2006, and Guevara-Arauza et al., 2014). The aim of this study was to improve the taste and nutritional value of cake using microwave dried spinach powder, that includes valuable compounds, and to check the consumer acceptance of this product.

## MATERIAL AND METHODS

### Raw Materials

The following raw materials: Spinach, wheat flour (0.98 g/100 g fat, 76.31 g/100 g carbohydrate, 10.33 g/100 g protein, Ova Un San. ve Tic. A.Ş.), sugar (Keskinkılıç Gıda San. ve Tic. A.Ş.), sunflower oil (Küçükbay Gıda San. ve Tic. A.Ş.), eggs (Keskinoğlu Gıda San. ve Tic. A.Ş.), baking powder (Dr. Oetker Gıda Sanayi ve Ticaret A.Ş.), and milk (3.1 g/100 g fat, 47 g/100 g carbohydrate 3.1 g/100 g protein, Yörsan Gıda Mam. San. ve tic. A.Ş.) were obtained from a local supermarket in Izmir, Turkey.

### Methods

### Microwave Drying of the Spinach Pulp

The spinach (on the day of purchase) was washed, stalks were removed, and the spinach juice removed using a juice extractor (Premier PRJ-607, Turkey). The remaining spinach pulp (50 g corresponding to a 5mm thickness in the petri dish) were dried in a domestic microwave oven (Arçelik MD500, Turkey) at 540 W microwave power for 750s. The spinach powder was obtained by grinding the dried material obtained in a blender (Tefal Smart, MB450141, Turkey), and then the particle size was further reduced by sieving the powder through a 350 micron screen. The spinach powder was then stored in glass jars in the fridge at 4±1ºC until further tests were carried out.

### Preparation and Baking of Cakes

For the preparation of the cake batter, the sugar (78.97g, weight/weight (w/w)) and eggs (51.53g, w/w) were mixed using a mixer (Kitchen Aid, 5K45SS, USA) set at the medium speed of the mixer for three minutes. Then, the flour (49.20g, w/w), baking powder (3.33g, w/w), and the other ingredients (23.45g oil and 24.88g milk, w/w) were added to the mixture, and again mixed at medium speed for five minutes. The obtained spinach powder was added to the cake formulations by replacing the wheat flour at different ratios 0% (control, plain cake), 4%, 6%, 8%, and 10% of the total weight of cake batter (wet basis). In the last stage, 200 g o f cake batter was weighed in a greased glass baking pan (22cm in diameter). Conventional baking was performed in an electrical oven (Beko, OIM22301X, Turkey) at 180°C for 14 min (Ergün, 2012). The oven was preheated for 5 minutes before placing the cake samples in it.

### Analysis Applied to the Spinach Powder, Cake Batters, and Cakes

The moisture content of the spinach powder, cake batters, and cakes were determined according to AOAC (Method no: 930.15, 2000). Water activity and color (CIE LAB, L*, a*, and b*) values were measured using a Testo-AG 400, German water activity measurement device (25±2°C) and a Minolta CR-400 Colorimeter, Japan (calibrated with a white standard plate), respectively. The percent weight loss (WL %) of the cakes during baking was calculated by using Equation (1):

$$WL\ (\%) = \frac{W_{cake} - W_{batter}}{W_{batter}} \times 100 \qquad (1)$$

where w denotes weight (g).

Percent cooking yield (CY%) of the cakes during baking was calculated using Equation (2):

$$CY\ (\%) = \frac{W_{cake}}{W_{batter}} x100 \qquad (2)$$

In order to measure symmetry, uniformity, and the volume index values, the cakes were cooled for 1h and then cut in half from the center and an analysis was performed using the cake measuring template method as described in the American Association of Cereal Chemists (AACCI Method no:10-91.01, 2000). This method takes the size of pans used for the cake production into account and determines these values in terms of millimeters. The vitamin C content values of the cake samples were determined according to Hışıl (2007). The indication principle of the vitamin C value is based on extraction with 10% oxalic acid and afterwards the addition of 2, 6-dichlorophenolindophenol solution. The absorbance was measured at 518 nm by a Varian cary 50 uV/Vis spectrophotometer.

### Sensory Evaluation of Cakes

In this study, the sensory evaluation, aimed to determine the effect of intensity and the acceptability of spinach powder in the cake formulation in terms of color, aroma, flavor, texture (spongy and elastic structure), porosity (spongy structure), odor, hardness (mouth feel and toughness), and general acceptability ratings. The scoring sensory tests were conducted by 10 panelists among the staff and students of the Department of Food Engineering (Ege University, İzmir, Turkey). Cakes were evaluated on the basis of overall acceptance. A five-point scale ranging from 1 (dislike extremely) to 5 (like extremely) was used for the evaluation of the quality parameters.

**Statistical Analysis**

All experiments were performed in duplicate and measurements were performed in triplicate. All data points shown in graphs represent the mean of the triplicate analysis. Statistically significant differences between samples were determined using ANOVA (analysis of variance, F-test for multiple samples or two samples with $\alpha = 0.05$, SPSS 20.0, SPSS Inc., Chicago, IL, U.S.A.). Significant differences are indicated by different letters when the p-value was below 0.05.

**RESULTS and DISCUSSION**

The moisture content and water activity values of the microwave dried spinach powder were found to be: 3.28±0.01% (wet basis) and 0.102±0.01, respectively. The values of water activity between 0.20 and 0.40 ensures the stability of the product while in storage against browning and hydrolitical reactions, oxidation, and enzymatic activity (Quek et al., 2007). For this reason, the microwave-dried spinach powder along with the low water activity values can be acceptably stable for long-term storage. The results of the analysis of moisture content and water activity for cake batters and cakes with different amounts of spinach powder are given in Table 1, respectively.

Table 1. The moisture content (%, wet basis) and water activity values of the cake batters and cakes (n=3)

| | Cake Batter | | Cake | |
|---|---|---|---|---|
| Amount of Spinach Powder Addition (as g/100 g of Total Weight) | Moisture Content (%) | Water Activity *($a_w$)* | Moisture Content (%) | Water Activity *($a_w$)* |
| Control | 28.24±1.10$^{b}$ | 0.902±0.004$^{c}$ | 22.33±0.50$^{d}$ | 0.822±0.022$^{d}$ |
| 4 | 28.96±0.12$^{b}$ | 0.894±0.009$^{b}$ | 16.40±1.15$^{c}$ | 0.768±0.004$^{c}$ |
| 6 | 28.70±0.33$^{b}$ | 0.902±0.014$^{c}$ | 13.24±1.19$^{b}$ | 0.731±0.031$^{b}$ |
| 8 | 27.80±0.06$^{a}$ | 0.890±0.005$^{b}$ | 13.72±1.50$^{b}$ | 0.735±0.007$^{b}$ |
| 10 | 26.63±0.35$^{a}$ | 0.880±0.006$^{a}$ | 12.75±3.43$^{a}$ | 0.722±0.071$^{a}$ |

$^{a-d}$ different letters in the same column indicate significant differences between average values ($P$ <0.05).

The moisture content of cakes is important for the sensory properties of cake (sometimes crumby cakes are not well accepted by the consumer) and microbial safety (high moisture can increase the microbial activity and leave the cake sticky, Oliveira et al., 2016). Significantly higher moisture content and water activity values were obtained from the plain cake batters and cakes when compared to the cake batters and cakes with spinach powder ($P$ <0.05, Table 1.). The moisture content values of the cake batters and cakes decreased according to the increasing amount of spinach powder, however, this decrease was not found to be significant for the cake batters with 0%, 4%, and 6% spinach powder (P >0.05). A further increase in the amount of spinach powder (beyond 6%) resulted in a significant decrease in the moisture content of the cake batter ($P$ <0.05). Since the wheat flour has a higher moisture content (10.88±0.05% (wet basis)) when compared to the spinach powder (3.28±0.01%), the replacement of the wheat flour with the spinach powder caused a significant decrease in the moisture content of both the batter and cake ($P$ <0.05). The moisture contents of cakes with spinach powder (12.75±3.43% -

16.40±1.15%) were found to be lower when compared to cake with orange flour (wheat flour + 12.5% orange flour, 25.55%), cake with passion fruit flour (wheat flour + 20% passion fruit flour, 27.50%) and cake with an orange flour and passion flour blend (wheat flour + 10% passion fruit flour associated to 6.25% orange flour, 31.49%, Oliveira et al., 2016). In addition, Oliveira et al. (2016) reported that cake with orange flour has a lower moisture content compared to plain cake (27.91%), whereas, the higher moisture content values were obtained for cake with passion flour and cake with the orange flour and passion flour blend. Different cake formultions, additives, the water holding capacity of the additives, baking conditions, etc. may be the reason for the differences.

Similar to the moisture content values, the water activity values of cake batters and cakes generally and significantly decreased depending on the increasing replacement ratio (*P* <0.05) and the lowest water activity values were observed from the cake with 10% spinach powder. The baking process caused around a 20.93% (plain cake), 43.37% (4% spinach powder addition), 53.87% (6% spinach powder addition), 50.65% (8% spinach powder addition), and 52.12% (10% spinach powder addition) moisture loss for the cake batter.

The color values of spinach powder were measured to be as L*=51.78±0.66, a*=-6.59±0.08, and b*=22.16±0.32. The color values of the cake batters, crust, and crumb (L*, a*, and b*) of the cake samples are shown in Figure 1.

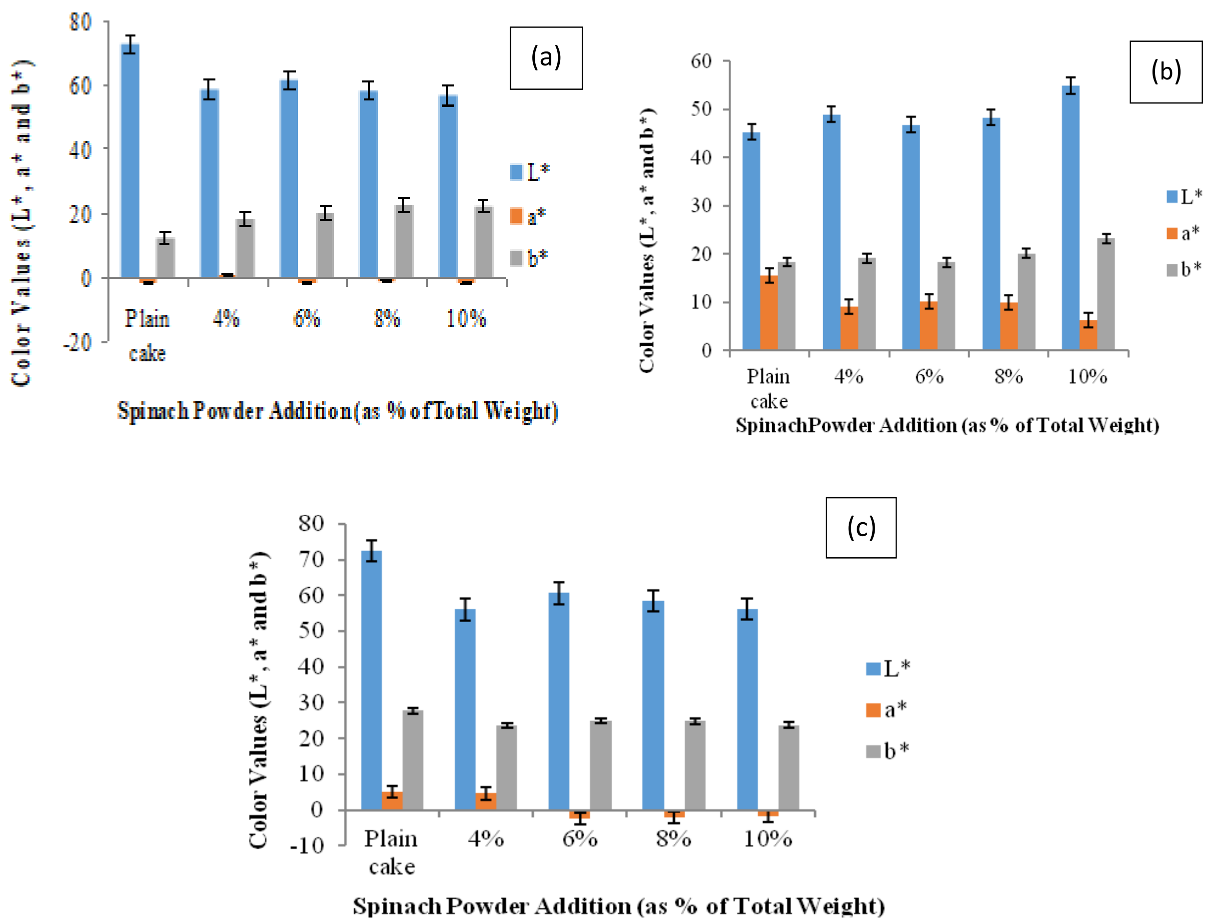


Figure 1. Color Values of Cake Batters (a), Crust (b), and Crumb (c) that containing different amount of spinach powder

The baking process alters the surface properties of the food and subsequently changes light reflection and product color. In addition, chemical reactions such as oxidation take place during baking due to heat effect. These reactions cause changes in the colour parameters from lighter yellow to darker yellow (Croguennec, 2016 and Soleimanifard et al., 2018). Besides, the effect of the baking process, the addition of spinach powders to the cake formulation also caused a significant difference in the color values of the batters and cakes (*P* <0.05). In addition, significant differences were observed between the crust and crumb of the plain cake and cakes with spinach powder (*P* <0.05). The brightness values of the cake batters and crumb significantly decreased depending on the increasing amount of spinach powder (*P* <0.05). It may be due to the darker color (lower L* value) of the spinach powder compared to the wheat flour. The a* values of the cake batters were generally found to be in the negative scale which indicates the green color except for the batter with 4% spinach powder. While the green color (negative a* values) of spinach was not found to be effective on the crust color, the a* values of the cake crumb attained negative values beyond the addition of 6% spinach powder. Generally, similar to the L* values, the addition of spinach powder to the cake formulation resulted in a significant decrease in the a* values of the cake batters, crust, and crumb. Galla et al., (2017) reported that the color values of biscuits decreased depending on the increasing amount of hot air-dried ((55± 2 °C for 8 h.)) spinach powder (L*=55.36, a*=-3.35, b*=13.91). The color values of the control biscuit, biscuit with 5%, 10%, and 15% spinach powder are L* = 66.15, a* = 11.86, and b* = 33.95, L* = 47.96, a* = 1.52, and b* = 14.26, L* = 42.07, a* = 0.40, and b* = 5.58, and L* = 40.74, a* = 0.61, and b* = 4.42, respectively. In addition, the biscuits have a dark color instead of green color which may be due to the browning of the spinach carbohydrates during baking. Similarly, in this study, the lower L* values of the spinach cakes may be due to the browning of the spinach powder during baking. The b* values of the cake batters significantly increased according to the increasing amount of spinach powder (*P* <0.05), while the b* values of the cake crust and crumb generally were not significantly affected with the additional spinach amount (P >0.05). Kim et al., (2001) studied the dextrin addition to the yellow cake formulation and they reported that the L* value of the cake with octenyl succinylated amylodextrin (OSAD) was significantly higher than the control cake, whereas, all cake with Maltodextrin (MD, MD+ amylodextrin (AD), and MD+OSAD) exhibited significantly lower values (*P* <0.05). The ΔE values of the cake containing MD were significantly higher than the control and the cake with AD or OSAD (*P* <0.05). Moreover, a greater darkness and yellowness were observed in the cake with MD and it was possibly caused by the browning reactions during baking.

Vitamin C is the least stable vitamin and easily oxidized to form a free radical. The most harmful factors affecting vitamin C are the availability of oxygen, prolonged heating in the presence of oxygen, and exposure to light (Klein and Kurilich, 2000). Thermal processes can be used in food processing techniques to prolong the shelf life of the food products or to prepare the final food product for consumption, but directly reduced the vitamin C content in the food products. Food processing techniques such as soaking, drying, cooking, etc. have a mainly negative affect on the vitamin C content in food products such as bread, cake, biscuit, etc. (Leskova et al., 2006 and Rakcejeva et al., 2011). Thus, the determination of the vitamin C content in food can be crucial to optimize the desired process time to minimize the vitamin content losses. The vitamin C results for the cake batters and cakes with spinach powder are given in Figure 2. According to the results, the vitamin C content of the cake batters and the cakes with spinach powder were found in the range between 0.018±0.003 and 0.033±0.001 (mg/100g). The vitamin C contents of the cakes were significantly increased proportionally to the amount of the spinach powder addition (*P* <0.05), whereas, in the cake batter, the vitamin C content was not significantly affected (P >0.05). Nursal and Yücecan, (2000) stated that the vitamin C loss for spinach after the cooking process (cooking for 5 minutes) decreased to 58% compared to the fresh or uncooked spinach. In another study, Ilow et al., (1995) determined vitamin C losses as 53.3% for the conventional cooking process. According to the vitamin C results, the maximum vitamin loss was found in the plain cake as 38.05% and the vitamin C loss for cakes with spinach powder were lower than the plain cake and in the range between 15.84 - 21.57%. It can be said that the spinach powder and the cake formulation matrix were adjusted positively and the addition of spinach powder to the cake formulation provides the vitamin C retention for better quality cakes and more valuable cereal products.

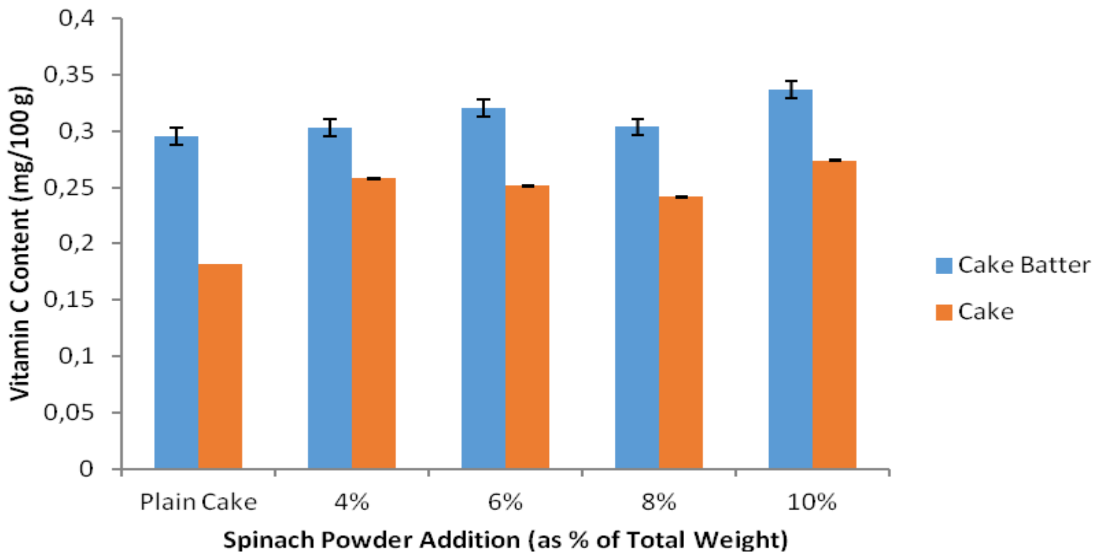


Figure 2. Vitamin C content of cakes (mg/100g)

**Weight loss, cooking yield, symmetry, uniformity, and the volume index values of cakes**

Weight loss is one of the main parameters which indicates the cake quality (Kahraman et al., 2008). The weight loss of cakes ranged between 10.51% and 14.83% (Table2). The weight loss of the control cake was found to be higher than the other cakes. It might be due to the higher moisture content of the plain cake batter or water holding capacity of the spinach powder. Because the addition of spinach powder increased the total solid content of the cake batter. In addition, the high fiber content of spinach which is related to a higher water holding capacity may be the reason for the lower amount of weight loss. Similarly, Gomez et al., (2007) reported that the yellow layer cakes containing hydrocolloids had lower moisture losses compared to the control cakes. Aydogdu et al., (2018) also reported that a higher amount of lemon fiber prevented the moisture loss of cakes when compared to the control cake due to the high water holding capacity of the lemon fiber. In addition, the weight loss of the cakes with spinach was found to be higher than pea, oat, apple, and lemon fiber-enriched cake (4.50 - 5.35%, Aydogdu et al., 2018), white layer cake (5.6 - 7.7%, Kahraman et al., 2008), and rice cakes (7.70 -10.7%, Turabi et al., 2008). According to the findings of this study, it can also be stated that spinach powder is an important additive in order to prevent moisture loss from the cake during baking. For this reason, it may be used in the cake formulation in order to reduce weight loss instead of gums. The cooking yield (%) of cakes ranged between 85.17% and 89.40% and generally increased depending on the increased amount of spinach powder. It may be due to binding a significantly greater amount of water using spinach compared to wheat flour. As a result, higher water retention resulted in higher cooking yield which is desired for cakes.

The symmetry, uniformity, and volume index values of the cakes are given in Table 2. The effect of replacing spinach powder with wheat flour in cake formulations on symmetry and uniformity (except for cake with 4% spinach powder) index values of the cakes were found to be statistically insignificant (P >0.05). All symmetry index values were found to be in the positive scale which implies that cakes principally rise in their central part. In addition, the symmetry index gives an idea about gas retention in the final baking phase (Gomez et al., 2008). In this study, the higher symmetry index values which are the expected behavior of the cakes is the rise in the central part and was observed from the cake with 10% spinach powder. The volume index values of samples ranged between 82.00 - 95.00mm, however, the addition of spinach to the cake formulation did not show a clear trend on the volume index values. The volume index value of plain cake was generally found to be higher than cakes with spinach except for the cake with 10% spinach powder. Hera et al., (2012) reported that cakes with a low volume show a low symmetry index. Similarly, in this study, the cake with 10% spinach powder has both higher symmetry and volume index values compared to other powders. Hera et al., (2012) also reported that there are some factors which are effective on the final volume of the cakes such as starch gelatinization, gas loss during processing, and possible structure collapse after baking. In this study, the replacement of wheat flour with spinach powder may have resulted in a lower starch gelatinization due to the low starch content of the spinach compared to wheat flour. Similarly, Seyhun et al., (2005) reported that the volume index of cake with pre-gelatinized starch added was found to be higher when compared to other cakes (control cake and cake with corn, potato, waxy corn or amylomaize starch), because the development of the structure and volume of the cakes can easily be completed during baking due to its already gelatinized structure. Among the spinach cakes, the highest volume index was observed as 95.00 mm in the cake with %10 spinach powder. It means that the cake had a desired convex shape.

Table 2. Weight loss, cooking yield, symmetry, uniformity, and volume index values of cakes (n=3)

| Amount of Spinach Powder Addition (as % of Total Weight) | Weight Loss (%) | Cooking Yield (%) | Symmetry Index (mm) | Uniformity Index (mm) | Volume Index (mm) |
|---|---|---|---|---|---|
| Control | 14.83±0.91$^{d}$ | 85.17±0.94$^{a}$ | 2.50±0.35$^{a}$ | 0.50±0.01$^{a}$ | 87.50±3.54$^{b}$ |
| 4 | 12.45±0.36$^{b}$ | 87.55±0.36$^{b}$ | 2.50±0.70$^{a}$ | 0.25±0.07$^{a}$ | 80.50±3.54$^{a}$ |
| 6 | 12.47±0.67$^{b}$ | 87.53±0.67$^{b}$ | 2.50±0.35$^{a}$ | 0.50±0.01$^{a}$ | 87.50±3.54$^{b}$ |
| 8 | 13.19±0.20$^{c}$ | 86.81±0.20$^{a}$ | 2.50±0.21$^{a}$ | 0.50±0.07$^{a}$ | 82.00±0.00$^{a}$ |
| 10 | 10.51±0.44$^{a}$ | 89.40±0.44$^{c}$ | 3.50±0.71$^{a}$ | 0.50±0.07$^{a}$ | 95.00±1.41$^{c}$ |

a-d different letters in the same row indicate significant differences between average values $P$ <0.05.

**Sensory Analysis**

Consumer research is one of the key applications for goods companies in order to make product decisions, such as the development and marketing of new products, the reformulation of existing products, the acceptance of suppliers and processes, and the establishment of quality control specifications. According to Mercier et al., (2016), the sensory evaluations showed that enrichment levels below 10% generally do not affect consumer acceptance, but higher enrichment levels significantly decrease it. For this reason, in this study, the spinach concentration was kept under 10%. Sensory evaluation data of the cakes are shown in Figure 3.

The sensory evaluation was used for the determination of the main sensory attributes of the spinach cake. The sensory evaluation based on the determination of the cake quality and general consumer acceptability showed that the cake with 10% spinach powder had greater acceptance by panelists and the sensory properties of the cake such as color, flavor, aroma, and overall acceptability were found to be greater than the other cakes. Although the flavor and aroma of the cake with 10% spinach powder had the highest scores, the odor of this cake was not desired by the panelists. According to the higher aroma scores of cakes with 10% spinach powder, it can also be stated that cake preserved the pleasant and characteristic aroma of spinach. The differences between the color, flavor, porosity, and texture scores were not found to be statistically significant (P >0.05), however, the aroma score of the cake with 10% spinach powder and the aroma score of plain cake and cake with 6% spinach powder were found to be significantly lower compared to the other cakes ($P$ <0.05). In addition, the hardness scores of cakes with spinach powder were found to be significantly higher compared to the plain cake ($P$ <0.05). The desired structure and texture of the cake is provided by starch gelatinization. The reason for higher hardness scores of cakes with spinach may be due to the low starch content of spinach compared to wheat flour. It may also be stated that after baking, and thus after starch gelatinization, the cake with spinach was not sufficiently formed to the desired cake structure by the panelists. In addition, the lower moisture content of the cake with spinach powder compared to the plain cake may also be the reason for higher hardness scores. Galla et al., (2017) reported that the biscuits with 5% hot air dried spinach powder (55± 2 °C for 8 h., 8.60% moisture content) was more acceptable compared to the biscuits with 10% and 15% spinach powder and the flavor scores decreased as the spinach powder increased and bitterness was noticed as an aftertaste in the biscuits with 15% spinach powder.

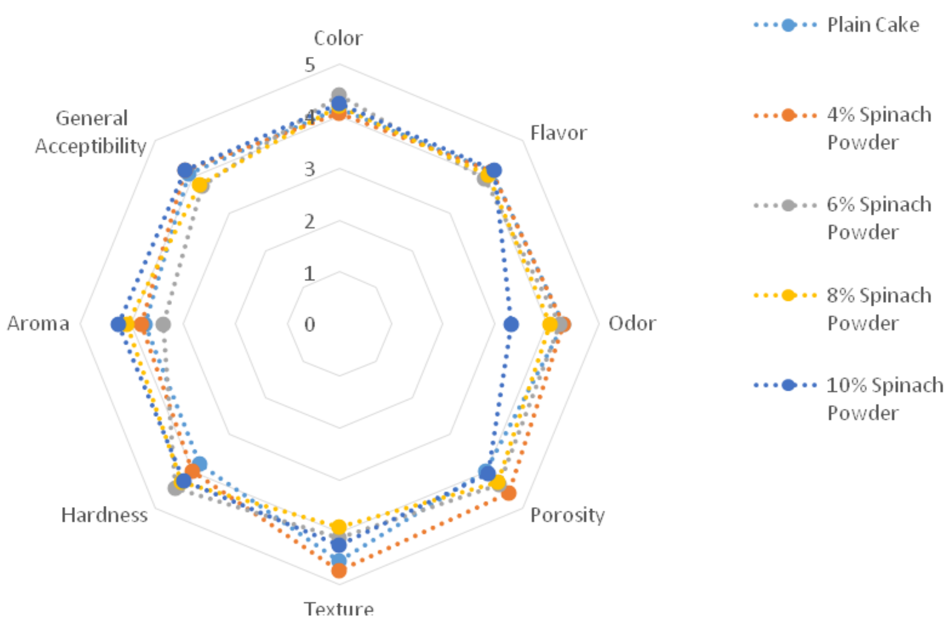


Figure 3. Results of sensory evaluations

**Conclusion**

In this study, the cakes with an alternative and improved formulation with the addition of microwave dried spinach powder were produced. The addition of spinach powder to the cake formulation resulted in a significant decrease in the moisture content and water activity values of both cake batters and cakes. The L* and a* values of cake batters and crumb generally decreased depending on the increasing amount of spinach powder. The addition of the spinach powder to the cake formulation resulted in a decrease in weight loss (10.51 - 14.83%), whereas, there was an increase in the cooking yield (85.17 - 89.40%) which is also desired for cakes. This may be due to the water binding properties of spinach. The cake with 10% spinach powder has both higher symmetry and volume index values compared to other powders which show the development of desired structure and volume. The results showed that there is a significant enhancement in the vitamin C content of cake made with spinach powder ($P$ <0.05). The cake with 10% spinach powder had the highest rating (4.25 for color, 4.20 for flavor, 4.25 for aroma, and 4.20 for overall acceptability) compared to the other samples. As a result of this study, it can be stated that the addition of spinach powder to the cake formulation will be a solution to increase the vitamin C content, cooking yield, symmetry and uniformity index values, color, flavor, aroma, and overall acceptability scores of the cakes.

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