Investigation some properties of pumpkin powder and its utilization in shortened cake as a shortening replacer

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Abstract

As pumpkin powder possessed high fiber (3.2%), low fat (0.8%), high swelling capacity (9.68 ml/g) and high water absorption index (3.46), it was an appropriate carbohydrate-based fat replacer, although its solubility index (47.99%) was also high. The size of sample particles was appropriate (98.40% smaller than 420 μm). In the second section, pumpkin powder was replaced with 20% and 40% shortening in the cake formulation containing 0% and 50% additional water. By increasing pumpkin powder, the fat content of cake decreased compared to the control. The high volume (257.33 cm³) was belonging to control and 20% replacement without increasing water level and then increasing shortening replacement decreased the volume to 225.67 cm³. By increasing replacement, the weight loss of cake decreased significantly. The cake crust treated with 40% shortening replacement and additional water was more yellow than control. The cake crust treated with 20% replacement and additional water possessed the lowest total color difference with control (2.80) and just its redness (9.30) was lower than control (11.71). As shortening replacer increased, the tendency of cake crumb to redness and yellowness developed. The cake crumb with 20% replacement and without additional water showed the lowest total color difference with control (5.52). Cake treated with 20% shortening replacement without additional water was better than other treated cakes because of its similar volume of the control and its more appropriate crumb color compared to other reduced-shortening treatments.

Keywords: Pumpkin, functional properties, Fiber, Cake, WAI and WSI

Introduction

It has been proved that cancer and heart diseases being common in developed countries have a connection with high intake of fat and diet comprising high in saturated fatty acids and cholesterol level, respectively. When consumers became more aware of the relationship between diet and health, the demands for safe and high-quality foods having less fat, cholesterol, sodium, sugar and calories increased (Grigelmo-Miguel et al., 2001). Among the main components of food, fat produces the highest energy and as a result, there is a major challenge in replacing the fat with other ingredients, especially in bakery products since possessing the high amount of fat (Felisberto et al., 2015). Fat replacers are the materials that have the ability to mimic some fat roles in reduced-fat products. They contain fewer calories than fats significantly and can be categorized as carbohydrate, protein and lipid-based components (Serin and Sayar, 2017). Carbohydrate-based fat replacers such as based on fruit (fiber), dextrin, modified starch and hydrocolloids via binding water, providing softness and desirable mouth-feel.
copy the fat characteristics (Serin and Sayar, 2017; Kalinga, 2010). Pumpkin has high nutritional values. It is rich in fiber. Fiber appeared to be a useful factor in preventing obesity, heart disorders and high blood pressure (Yasei Mehrjerdi et al., 2011). Pumpkin powder can be stored for a long period of time (Que et al., 2008). Pumpkin powder can be used in many kinds of food because of desirable flavor, smell, color, its water-soluble vitamins and high amount of fiber and beta-carotene (Hosseini Ghaboos, 2016). By applying this powder in process of noodles, bread or cake, nutrient content and sensory characteristics will be improved (Que et al., 2008). Hosseini Ghaboos (2016) added pumpkin powder to cake formulation up to 20% and reported that contents of beta-carotene, density, protein and firmness of cakes increased. Grigelmo-Miguel et al. (2001) claimed that substitution of fiber from peach with 10% oil in muffin developed firmness, protein and moisture. Also in a research partial replacement of margarine with β-glucan concentrates from barley and oat showed some changes in physical properties of resultant cakes (Kalinga and Mishra, 2009). Despite the water absorption by carbohydrate-based fat substitutes, their addition may also have some negative effects on the quality of resultant cake, for the reason of unavailability of water in the formulation. Therefore, in some cases, researchers mixed specific of them with water to form a gel, before preparing cake batter, or add more water in the fat-replaced cake formulation (Kalinga, 2010 and Felisberto et al., 2015).

Functional properties of powders including water absorption index (WAI), water solubility Index (WSI), and swelling capacity are intrinsic physicochemical properties that can affect the behavior of food during processing and storage (Saeleaw and Schleining, 2011). Carbohydrate-based fat replacers can mimic some of fat properties in reduced-fat bakery products via their abilities of binding water and swelling of their solid materials (Dadkhah et al., 2012). Nyam et al. (2013) and Miller (2007) have investigated the swelling capacity of pumpkin powder’s seed and rind and WAI and WSI of oat bran flour, respectively.

This aim of the research was to evaluate, some chemical and functional properties of pumpkin-flesh powder and its particle size distribution for assessing the appropriateness of selecting it as a carbohydrate-based fat replacer for bakery products, better understanding of its component and secondly, to evaluate the effect of using pumpkin powder as a shortening replacer with/without adding water on fat content, volume, weight loss and color of the cake.

Materials and Methods

Preparation of pumpkin powder

Pumpkin (Cucurbita moschata) was purchased from Meshginshahr. Pumpkin flesh was separated, converted into pieces by knife, cut into smaller pieces utilizing a slicer (Company Moulinex, Model Moulinette Universal Electronic), dried at 65°C for 8 hr in an oven (600, Memmert, Germany), milled and passed through a sieve (0.5 mm pore size). The pumpkin powder was packaged in polyethylene bags and stored at 5°C (Bhat and Bhat, 2013; Mirhosseini et al., 2015).

Chemical characteristics of pumpkin powder

Moisture, ash, crude fat and crude protein contents were estimated based on AOAC methodology No 925.40, 49, 920.39 and 955.04, respectively (AOAC, 1995). Crude fiber of pumpkin powder was estimated according to ISIRI (2010). By subtracting the sum of moisture, ash, crude fat, crude fiber and protein from 100, the percent of carbohydrate was obtained (AOAC, 1995).

Swelling capacity of pumpkin powder

0.2 g dried sample were weighed, transferred
into the conoid scaled tube, then 10 ml water was added and allowed resting for 18 hr to hydrate. After assessing the volume of hydrated powder, the swelling capacity was obtained, using the following equation (Escalada Pla et al., 2007):

\[
\text{swelling capacity (ml/g)} = \frac{\text{(volume of hydrated powder (ml))}}{\text{(initial weight of sample)}}
\]

Water absorption index (WAI) and water solubility index (WSI) of pumpkin powder

WAI and WSI were measured according to Anderson et al. (1969). 1 g pumpkin powder and 10 ml water were mixed in a 15-milliliter centrifuge tube vigorously, incubated in a water bath at 37°C for 30 min and finally centrifuged at 3000 g for 10 min. The supernatant was transferred to an evaporating dish previously dried and tarred to the nearest 0.01 g. The dish was maintained at 105°C for 5 h and after cooling was weighed to the nearest 0.01 g. The weight of sediment also was measured. WSI and WAI were calculated as follow:

\[
\text{WAI} = \frac{\text{(weight of sediment)}}{\text{(weight of sample)}}
\]

\[
\text{WSI} = \frac{\text{(weight of dried supernatant ×100)}}{\text{(weight of sample)}}
\]

Particle size distribution of pumpkin powder

Particle size distribution of pumpkin powder was assessed using four U.S. Standard sieves (40, 50, 80, and 100 mesh) and a test sieve shaker (Silicon Cert Laboratories, USA) according to Toma et al. (1979) with a slight modification. 10 g of powder was placed on the sieve with mesh 40 (the largest sieve), and the weight of powder remained on each sieve was determined after 10 min of shaking. The particle size was explained as the percentage of particles remained on each sieves and sub sieve.

Preparation of cake

The ingredients of shortened cakes were included pumpkin powder (did not exist in the full-fat formulation), wheat flour with moisture 12.76% and protein 10.04% (Moshtary Flour Co., Iran), sugar (Golestan Co., Iran), potassium sorbate (Dalian Future, China), white egg (Talavang Co., Iran), baking powder (Mahsa Co., Iran), salt (Crystal Co., Iran), vanilla (Polar Bear Vanilla, China), cake gel (Foleks Co., Turkey), shortening (Behshahr Industrial Co., Iran) and water. Five treatments were prepared in this study include the following: full fat sample (Control), samples that shortening was replaced with pumpkin powder at 20% and 40% by weight, respectively (20P and 40P), samples with 50% water increment in the cake formulations that shortening was replaced with pumpkin powder at 20% and 40% by weight, respectively (20PW and 40PW).

The cake batter was prepared according to Felisberto et al. (2015), transferred to the cake mold and then baked in the oven (Ariston, Italy) at 180°C for 28 min. In the end, after cooling (up to 25°C), it was packaged.

Weight loss

Weight loss was calculated according to Martínez - Cervera et al. (2011).

Fat

Fat content (%) was determined according to AACC method 30-25 using Soxtherm (Gerhardt Vapodest 30, Germany) (AACC, 2000).

Volume

The volume of cake was calculated according to AACC method 10-05 (AACC, 2000).

Crumb and crust colors of cake

Crumb and crust colors of cake were estimated using a colorimeter (Hunterlab-D25-9000, USA) based on a* (+a* = red and −a* = green), b* (+b* = yellow and −b* = blue), and total color difference, ΔE*, between the
control and treated samples. $\Delta E^*$ was calculated using the following equation. $L^+$ value is index of lightness and darkness of sample (Francis and Clydesdale, 1975; Hafez, 2012).

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

**Statistical analysis**

All tests were conducted in three replications. Analyses were performed in triplicate on each treatment. Evaluation of statistical differences of five treatments was carried out using Analysis of variance (ANOVA) in a completely randomized design (CRD) followed by Duncan’s multiple range test ($p<0.05$) with the aid of SPSS22 software.

**Results and Discussion**

**Chemical characteristics of pumpkin powder**

Chemical characteristics of pumpkin powder are shown in Table - 1. As can be seen, pumpkin powder was rich in crude fiber, ash and carbohydrate. The contents of chemical parameters of the tested powder were approximately similar to results found by Bhat and Bhat (2013) and Saeleaw and Schleining (2011). The fiber amount of pumpkin was analogous with oat flour one (Chappalwar et al., 2013). Spiller (2001) calculated the content of crude fiber of some foods, without counting water content, and claimed that the fiber amount of fresh pumpkin (13.1%) was higher than many of the examined fruits and cereals including plum (1.9%) and oatmeal (1.3%). The protein and fat contents of pumpkin powder were lower than an oat bran derivative (17.3% and 5.3%, respectively), a commercial carbohydrate-based fat replacer (Dadkhah et al., 2012). The pumpkin peel may possess more fat than its pulp and as a result, the amount of fat in pumpkin powder is low (Kuchtová et al., 2016). Shortenings generally contain nearly 100% fat. Since only 8% of examined pumpkin powder was fat and by knowing this fact that this component produces the highest energy among the main components of food, applying pumpkin powder as a shortening replacer, therefore, can decrease the fat content and energy of the product (Felisberto et al., 2015; Lai and Lin, 2006). These features (high fiber and low fat) of pumpkin powder can boost the possibility of its suitability for applying it as a carbohydrate-based fat replacer in some reduced-fat bakery products. Pumpkin powder has a longer shelf life than the fresh one because of its low moisture (Que et al., 2008). The presence of potassium (5185.11 mg/100 g), phosphorus (817.88 mg/100 g), calcium (616.73 mg/100 g), sodium (21.50 mg/100 g), and iron (14.07 mg/100 g) is the main reason of high contents of ash in pumpkin powder (El-Demery, 2011). Pitchkina et al. (1998) stated, a significant proportion of carbohydrates components of pumpkin powder was pectin. Pectin is one of the carbohydrate-based fat replacer (Kalinga, 2010).

**Swelling capacity of pumpkin powder**

The swelling capacity can be described as the proportion of the volume that a sample occupied after its immersion in water and gaining a balance to the actual weight. This property indicates how much matrix of fiber swell by water absorption (Escalada Pla et al., 2007). The swelling capacity of pumpkin powder is shown in Table - 2. As seen, its swelling capacity was greater than some fibers such as cellulose (6.2 ml/g), oat 401 (4.98 ml/g), wheat fiber (7.07 ml/g), apple fiber (6.89 ml/g), bamboo fiber (5.69 ml/g), powder of pumpkin peel (3.25 ml/g) and powder of pumpkin seed (7.85 ml/g), but was lower than Inulin (11.79 ml/g) (Rosell et al., 2009 and Nyam et al., 2013). By comparing the swelling capacity of pumpkin powder with aforementioned powders, it was found that pumpkin powder has a potential swelling capacity. The cellulose and apple powder are carbohydrate-based
Table –1. Chemical characteristics of pumpkin powder

<table>
<thead>
<tr>
<th>Properties</th>
<th>Moisture (%)</th>
<th>crude protein (%)</th>
<th>crude fat (%)</th>
<th>crude fiber (%)</th>
<th>Ash (%)</th>
<th>Carbohydrate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Values</td>
<td>6</td>
<td>6.21</td>
<td>0.8</td>
<td>3.2</td>
<td>6.735</td>
<td>77.055</td>
</tr>
</tbody>
</table>

Table – 2. Functional properties of pumpkin powder

<table>
<thead>
<tr>
<th>Functional Properties of Pumpkin Powder</th>
<th>Swelling Capacity (ml/g)</th>
<th>Water Absorption index</th>
<th>Water Solubility Index (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Values</td>
<td>9.68 ± 0.40</td>
<td>3.46 ± 0.19</td>
<td>47.99 ± 1.41</td>
</tr>
</tbody>
</table>

Fat replacer (Kalinga, 2010). Since the swelling capacity of pumpkin powder was higher than such materials, pumpkin powder can be categorized as a great potential fat replacer. Swelling capacity depends on the characteristics of each component, physical structure (porosity and crystallization) of fiber matrix, the amount of water-soluble fibers and even hydrophilic water-insoluble fibers including hemicelluloses and lignin (Daou and Zhang, 2011; Raghavendra et al., 2006). The pumpkin powder is rich in pectin, cellulose and hemicelluloses (Saeleaw and Schleining, 2011). These compounds have an outstanding role in water absorption and swelling of the powder. In addition, the high swelling capacity of pumpkin powder can be related to the shape and size of particles (Rosell et al., 2009 and Nyam et al., 2013).

**Water absorption index and water solubility index of pumpkin powder**

WAI is an indicator for evaluating the powder’s capability to absorb water and swell. These abilities cause the powder to improve consistency, performance and structure of food (Choi et al., 2012). WAI contents of pumpkin powder are shown in Table - 2. WAI of examined pumpkin powder was higher than hot-air dried sweet potato powder (4.01), pumpkin powder dried, by hot air (2.60), oat bran flour (2.2-3) and oat flour (2.85-3.35) (Hsu et al., 2003; Miller, 2007; Que et al., 2008; Choi et al., 2012). Chemical, physical and microstructure properties determine the water holding capacity of the fibers (Escalada Pla et al., 2007). Since soluble dietary fibers, such as pectin have the ability to absorb and maintain water, water holding capacity and possibly WAI of powder depends on the amount of this kind of fiber. Also, WAI can be influenced positively by hydrophilic water-insoluble fibers. However, the high protein and fat contents of powder prevent fibers to obtain their actual capacity of hydration. The crude protein and fat contents of pumpkin powder were low. This powder is rich in pectin and hydrophilic insoluble fiber, such as cellulose. Therefore, the higher amount of its WAI was justifiable (Daou and Zhang, 2011; Kuchtová et al., 2016; Nyam et al., 2013). WSI of pumpkin powder is shown in Table - 2. WSI of
pumpkin powder was more than hot-air dried sweet potato powder (11.98%), pumpkin powder dried by hot air (34.90%), oat bran flour (3%-8.8%) and oat flour (8.67%-11.08%) (Hsu et al., 2003; Miller, 2007; Que et al., 2008; Choi et al., 2012). Also, comparing the WSI access by this research with those obtained by Roongruangsri and Bronlund (2016), the WSI of the examined powder was less than the pumpkin powder, dried (by hot air) at 50°C and 60°C and higher than the sample dried at 70°C.

By knowing this fact that WSI indicates the range of starch degradation, the index determines the amount of released polysaccharides from starch granules or free soluble polysaccharides via adding water (Choi et al., 2012). Then, the probable reason of higher WSI of pumpkin powder than other mentioned powders and flours can be more degradation of starch granules during drying by hot air, as well as, higher soluble dietary fiber of the examined powder. Also, using the different temperatures for drying pumpkin could affect the amount of soluble polysaccharides and, therefore, the percent of WSI (Roongruangsri and Bronlund, 2016).

**Particle size distribution of pumpkin powder**

The particles retained on the sieves numbers 40, 50, 80, 100 mesh and the subsieve were greater than 420 μm, between 420-297 μm, between 297-177 μm, between 177-149 μm and less than 149 μm, respectively. Comparison of means (Fig.-1) indicated, that there was a significant difference (p<0.05) between the percentage of particle size of sample with the exception of those retained on the sieves with numbers 50 and 100 mesh (p>0.05). The highest and the lowest amounts of pumpkin powder were found on the sub- sieve and sieve number 40 mesh, respectively.

Chen et al. (1988), have reported that the apple fiber with particle size almost identical to pumpkin powder, showed higher water holding capacity compared to oat bran and wheat bran with larger particle sizes. Ahmed et al. (2014) evaluated the dispersions prepared by pumpkin powder with different particle size and stated, the elastic modulus of the smallest particle dispersion enhanced unexpectedly with increasing temperature. Also the microscopic observations showed a continuing network in the aforementioned dispersion, while larger particle dispersion displayed discontinuous one. Improving texture, consistency and increasing viscosity for producing reduced-fat product are some suitable properties of fat replacer (Kalinga, 2010). The size of solid particles of fat replacer may influence these characteristics. The results obtained by Ptitchkina et al. (1998) and Pongjanta et al. (2006), using pumpkin powder with particles smaller than 500 and 297 μm in cake formulations, are almost similar to the present study.

**Fat percentage of cake**

Comparison of means showed, that there was a significant difference (p<0.05) between the percentage of fat of different cakes which reduced with increasing the shortening-replacement level (Table - 3). Control and 40PW displayed the highest and lowest fat percent, respectively. Dadkhah et al. (2012) asserted that the fat content of cake decreased when an oat bran derivative was used as shortening replacer. The results of fat content is understandable because of reducing the amount of shortening in formulation and also being low content of fat in pumpkin powder that used as a fat replacer. Also, the reduction of fat content was desirable since one of the important purposes of utilizing fat replacer was decreasing the fat content of cake. Considering the lack of stage of sample drying in this test, the significant difference between 20P and 20PW and also between 40P and 40PW in case of fat content was due to a higher percentage of water in formulation and, as a result,
possibly greater moisture content of 20PW and 40PW compared to 20P and 40P, respectively.

**Volume of cake**

Figure 2 showed that the highest volume belonged to control and 20P (p>0.05) and their volume was not different significantly (p>0.05). Unlike 20P and 20PW, by adding additional water to a formulation with 40% replacement, the volume of cake increased significantly (p<0.05). The lowest volume of the cake was related to 40P. Lee et al. (2004) found that applying bran derivatives of oat as fat replacers up to 40% did not change the volume of cakes significantly, which was in agreement with the 20P volume of present study. Kalinga (2010) reported that adding additional water to samples treated with fat replacers increased the volume of cake, which was perceived in 40% treatments in this paper.

The binding of hydrocolloids, presented in pumpkin, to water molecules, possibly enhances the viscosity of the batter and thereby increasing the air maintenance in the structure of cake. Also, the surface activity of pectin of pumpkin could possibly stabilize the gas cells within the batter. Hence, the volume of cake treated with pumpkin powder (in the 20% replacement level) was not different from the control significantly (Pitchkina et al., 1998; Lee et al., 2004; Gomez et al., 2007). As previously mentioned, pumpkin powder has a high ability to bind the water and in other words, it generates low vapor during cooking (Skendi et al., 2010). By knowing this fact that the content of pumpkin powder in 40P was more than 20P, it can be said that a reason for lower volume and possibly higher firmness of 40P to 20P and control is reducing the amount of generated vapor. Moreover, shortening is an effective factor to maintain air in the batter

### Table - 3. Fat content of cake and Color parameters of cake crust and crumb

<table>
<thead>
<tr>
<th>Treatments**</th>
<th>Fat (%)</th>
<th>Crust Color</th>
<th>Crumb Color</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a*</td>
<td>b*</td>
<td>E*</td>
</tr>
<tr>
<td>Control</td>
<td>13.60 ± 0.00a</td>
<td>11.71 ± 1.08b</td>
<td>42.67 ± 0.21b</td>
</tr>
<tr>
<td>20P</td>
<td>10.57 ± 0.06b</td>
<td>15.43 ± 0.13a</td>
<td>42.70 ± 0.74b</td>
</tr>
<tr>
<td>40P</td>
<td>8.07 ± 0.06d</td>
<td>15.70 ± 0.00a</td>
<td>42.77 ± 0.03b</td>
</tr>
<tr>
<td>20PW</td>
<td>9.83 ± 0.06c</td>
<td>9.30 ± 0.00c</td>
<td>41.51 ± 0.91b</td>
</tr>
<tr>
<td>40PW</td>
<td>7.73 ± 0.06e</td>
<td>14.39 ± 1.17a</td>
<td>44.94 ± 1.48a</td>
</tr>
</tbody>
</table>

*Means ± standard deviation are shown for three replicates. Parameters with the same superscript letter were not significantly different at a level of 5%. **P = Pumpkin, W = Water

![Fig.-2. Volume of cakes](image.png)

Bars with the same letter were not significantly different at a level of 5%. P = Pumpkin, W = Water
and thereby producing the high-volume cake (Lee et al., 2004). Therefore, a reduction of 40% shortening in the formulations of 40P and 40PW likely led to decline in the volume of resultant cakes. Additional moisture of cake helps the consumer to chew and swallow easily, but if too much water is used, it would lead to reduced volume (Vander Voort, 1943). The volume of 20PW and 40PW treatments was lower than control and 20P most likely because of the increased dilution and thereby reducing the possibility of air entrapment in the batter (Lee et al., 2004). It should be noted that the high viscosity of batter more than the standard decreases the volume of cake (Rahmati and Tehrani, 2014). The low volume of 40P may be due to the possibly very high viscosity of batter caused by high level of water absorption via pumpkin powder. The volume of 40PW was higher than 40P one because the additional water in 40PW samples, likely, improved the batter viscosity and thus increased the volume of cake.

Weight loss of cake

According to the results shown in Fig. - 3, it can be realized that increasing the level of shortening replacement in the formulation decreased the weight loss of cake significantly (p<0.05) and the weight loss of cakes treated with the same amounts of pumpkin powder was not different significantly (p>0.05). In this case, control and 40P showed the highest and lowest weight loss (p<0.05). Zahn et al. (2010) also mentioned the loss weight of most reduced-fat cakes treated with different types of inulin (as the fat replacers) was less than full-fat cake and they related this to the reduction in the volume. In general, cakes containing more water in their formulation produce more water vapors during cooking (Román et al., 2015). Therefore, the greater weight loss would be anticipated in cakes treated with fat replacers and additional water (20PW and 40PW). On the other hand, Batters with higher volume due to more surface exposure to the air and thus more water evaporation during cooking, show the higher weight loss (Román et al., 2015). Although 40PW possesses additional water, the low-volume factor is dominant and thus weight loss was minor in comparison of high-volume samples (control and 20P). This fact also is valid for 40P to control and 20% treatments (20P and 20PW). The lower weight loss of 20P compared to control could be due to the water absorption capacity of pumpkin powder.

Color parameters of cake crust

The values of a* obtained for 20P, 40P and 40PW were the same (p>0.05), but more than other treatments (p<0.05) (Table - 3). By replacing shortening with pumpkin powder in the formulation, the crust of cake inclined to be redder. In 20% replacement level, additional water (in the 20PW formulation) decreased the value of a* of cake crust significantly (p<0.05). The results showed that the only significance difference among b* of treatment crusts belong to 40PW with a higher value (p<0.05) (Table - 3). The values of total color difference (∆E*) are given in Table - 3. The total color difference of all treatments with control was significant (p<0.05) and by increasing the

Bars with the same letter were not significantly different at a level of 5%. P=Pumpkin, W = Water.
amount of pumpkin powder in samples treated with additional water increased significantly (p<0.05). 40P and 20PW showed the highest and lowest values of ΔE*, respectively. The similar trends were observed by Kohajdová et al. (2011) who reported that by replacing wheat with apple fiber to 15%, generally, the redness, yellowness and ΔE* of cookies increased significantly. Davoudi et al. (2013) observed that the crust color of bread became redder by adding 10% and 15% pumpkin powder. Moreover, the bread crust containing 5% pumpkin powder showed the yellowness similar to the control, but it increased in response to higher amount of pumpkin powder. These reports agreed with the results obtained by current study except for redness of 20PW crust. Lim et al. (2014) found that replacing shortening with pectin gel was resulted in decreasing the redness of cake crust and increasing its ΔE* value and these were in agreement with the results for the crust of 20PW in current research. Pumpkin flour as a natural color is used in some products such as flour mixes and pasta, so to some extent, tending to red, yellow and dark colors in some bakery products is favorable (El-Demery, 2011). The high amount of beta-carotene in pumpkin powder could be the reason of the tendency to red and yellow color of cake crust containing this powder (El-Demery, 2011). In addition, the decomposed pigments, caused by heating of food, may incorporate in Millard reactions and produce compounds being responsible for changes in product color (Navarro-cortez et al., 2016). The higher content of water in 20PW to 20P and control probably slowed the rate of Millard reaction during cooking and thus its less redness was expected (Fatemi, 2002). The reason of more yellowness of 40PW compared to the control could be its high percent of the pumpkin along with, possibly, a lower rate of Millard reaction because of its high moisture content. As mentioned before water absorption of fiber was high. By adding a carbohydrate-based fat replacer in a food as a fat replacer more water molecules could be bounded and the water activity may become less (Sanchez et al., 1995). The reasons for the differences between ΔE* of 20P and 40P comparing to the control were firstly faster Millard reaction (because of less water activity of batter) during baking resulted in their darker crust and secondly a more tendency of 20P and 40P crusts to color of red (Navarro-cortez et al., 2016; Priecina and Karklina, 2014). Also, redness and yellowness trend of 40PW crust compared to control was resulted in high difference of ΔE*. In the case of 20PW crust because of less redness and similar yellowness to control, ΔE* was lower than other treatments. Furthermore, reducing the intensity of Maillard reaction can cause more brightness of products (Navarro-cortez et al., 2016). Therefore, limiting Maillard reaction could make the brightness of 20PW similar to the control and reduce its ΔE*. AS products treated with fat replacers are preferable that show more similar physical and sensory characteristics with high-fat ones, regarding cake crust, 20PW treatment would be a better option than others.

Color parameters of cake crumb

a*, b* and ΔE* of cake crumb are shown in Table - 3. The results showed that by raising shortening replacement both a* and b* of cake crumb were increased significantly (p<0.05). Except for the reduction of redness in 40% shortening-replacement level, rising water did not show any significant effect on a* and b* of the crumb of reduced fat treatments. ΔE* values of all treatment crumbs were different (p<0.05) from control in which increasing shortening replacement resulted in developed values of ΔE* significantly (p<0.05). Additional water in 20PW formulation increased the ΔE* values (p<0.05) in comparison to 20P. The lowest and highest values of ΔE* were observed in 20P and 40P treatments,
respectively. Rakcejeva et al. (2011) found that increasing the amount of pumpkin powder incremented the tendency to yellowness of cake crumb and this was in line with the finding of the current research. Kim et al. (2001) asserted that by increasing the percent of corn maltodextrin as a shortening replacer the color of cake crumb became redder, darker and yellower, presumably because of Millard reactions during cooking. Moreover, ΔE* value of the crumb of reduced-fat cake treated with maltodextrin was significantly different with control. These results are in line with the present results.

The color of cake crumb is affected by ingredients (Akesowan, 2007). It is reported that applying fiber in a cake formulation led the crumb color of cake to be similar to dietary fiber because temperature at the crumb of cake is not as high as the crust and thus, unlike the cake crust, caramelization and Millard reactions do not occur (Akesowan, 2007; Lebesi and Tzia, 2011). It is expected to observe the higher inclination to redness and yellowness of cakes treated with pumpkin powder because of high content of beta-carotene and its orange color (El-Demery, 2011; Mezzomo and Ferreira, 2016). On the other hand, the moisture of cake crumb has a key role in determining the color of crumb. It could decrease the lightness and, therefore, changes in the values of ΔE* (Francis and Clydesdale, 1975; Akesowan, 2007). The yellow and orange colors of pumpkin powder improve the color of food products and then consumer acceptance will be followed (El-Demery, 2011). However, as mentioned earlier, the least values of ΔE* is possibly more acceptable and thus 20P treatment was preferable in the case of crumb color.

Conclusion

High-percent crude fiber, low-content fat, satisfactory swelling capacity and high water absorption index, unlike high water solubility index, of pumpkin powder proved its suitability of being applied as a carbohydrate-based fat replacer in some bakery products like cake. Approximately, the range of pumpkin-powder size was appropriate for using it as a fat replacer in cake formulation. The weight loss of 20P was lower than control. Although 20PW showed the lowest values of ΔE* of cake crust, 20P treatment showed the similar volume with control and indicated the lowest ΔE* values of the cake crumb. As a result, the sample treated with 20% pumpkin powder without additional water was selected as optimized one. By knowing this fact that 40P and 40PW treatments had the lowest amount of fat and did not show the expected results as 20P did, it is suggested to add a suitable emulsifier to the formulation of 40P and use the lower amount of additional water in the 40PW formulation to obtain a satisfactory volume of product.

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