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Effects of Level and Particle Size of Date Fruit Press Cake on Batter Rheological Properties and Physical and Nutritional Properties of Cake

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ABSTRACT

Date Press Cake (DPC) is a by-product of date fruit juicing, which has remained mostly underutilized in food products. The main objective of this research was to investigate the viability of adding DPC in cake formulation. Thus, different levels (0, 10, 20, 30, and 40%) and particle sizes (210 µm= DPC_{210} and 500 µm= DPC_{500}) of DPC were used in cake formulation. The results showed that DPC had higher fiber, ash, and fat content than cake flour. Increasing the level and reducing the particle size of DPC increased batter consistency, firmness, stickiness, cohesiveness and viscosity. Inclusion of DPC increased cake density, reduced pH and crust moisture content, but these were not affected by DPC particle size. The samples became harder and less cohesive as the level of DPC increased. DPC_{210} resulted in softer and less cohesive cakes compared to the DPC_{500}. Addition of DPC improved the antioxidant content of the cakes, particularly when DPC_{210} was added. Overall, the sample produced with 10% DPC_{210} had acceptable sensory characteristics.

Keywords: Agricultural by-product, Bioactive compounds, Cake quality, DPC, Value-added product.

INTRODUCTION

The fruits of date palm (*Phoenix dactylifera* L.) are commonly consumed worldwide. Date palm is generally cultivated in the arid and semiarid regions and is the most important commercial crop in the Middle East. The major date fruit producers of the world are Egypt, Iran, and Saudi Arabia. However, there is an increasing interest in date palm growing in other parts of the world such as Australia, USA, and some parts of Europe (Ashraf and Hamidi-Esfahani, 2011). The increasing interest in date fruit production is related to its pleasant sweet taste, profitability of date processing industry, high nutritional value and numerous health benefits known for date fruit including anti-cancer, anti-inflammatory, anti-mutagenic and hepato-protective effects (Al-Farsi *et al.,* 2005; Bouhlali *et al.,* 2017).

Fresh date fruit can be consumed directly; however, date processing and packaging can ensure high quality standards expected by consumers. Date fruits are commonly processed into date juice, date syrup, and date paste with many applications in other foods such as confectionary, bakery, and dairy products (Al-Farsi and Lee, 2008; Bouaziz *et al.*, 2010; Jridi *et al*., 2015; Majzoobi *et al.*, 2016). Date juicing results in about 17-28% Date Press Cake (DPC) as a by-product containing ground seeds, date fruit peel and pulp. Al-Farsi *et al.* (2007) reported that the seedless DPC of some date varieties had an average of 4.39% protein, 1.72% fat, 1.95% ash, 82.36% carbohydrate and 28.57% dietary fiber and high quantities of antioxidants.

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However, it is mostly used as animal feed or discarded into drains and open lands causing great economical loss and environmental issues due to its bulky nature and high moisture content (Al-Farsi and Lee, 2008; Ashraf and Hamidi-Esfahani, 2011). Determination of the chemical composition and nutritional value of some fruit press cakes including apple, pineapple, orange and strawberry have shown that these are rich sources of nutrients and bioactive compounds (Gómez and Martinez, 2018; O'Shea *et al.*, 2015). Thus, it is worthwhile to investigate the nutritional and health benefits of DPC as an available and economical material to be used in value-added food products.

Cakes are amongst the popular foods providing energy, but have limited amount of essential nutrients such as dietary fiber, vitamins, minerals and antioxidants. To promote their nutritional value, some fruit press cakes such as apple and berry pomace have been added to the cake formulation. Nevertheless, this can compromise cake quality in terms of volume, texture and sensory attributes (Roham *et al.,* 2015; Sudha *et al.*, 2007). To diminish some of these undesirable effects, controlling the percentage and particle size of fiber sources have been suggested as effective strategies (Gómez *et al*., 2010; Majzoobi *et al.*, 2012, 2013).

To the best of our knowledge, there is no published research to show the utilisation of DPC as a functional ingredient in cake production. The main objectives of this study were to evaluate the effects of different levels (0-40%) and particle sizes (210 and 500 µm) of DPC in the formulation of a sponge cake by studying their effects on batter rheological properties and cake quality.

MATERIALS AND METHODS

Wheat flour (Sapidan Milling Factory, Marvdasht, Iran) with a dry gluten content of 9.79% and pH of 6.09, white fine sugar, fresh pasteurized semi-skim milk (2% fat; Pegah-e-Fars, Shiraz, Iran), sunflower oil (Ladan Oil Factory, Shiraz, Iran), baking powder, vanilla powder, lecithin (all from Golpoodr Factory, Gorgan, Iran) and fresh whole eggs were locally purchased. DPC from Shahani dates was produced by a fully automated production line and gifted by Ghand-e-Khorma Minoo Company, Shiraz, Iran. Chemicals required for analytical tests were purchased from Merck, Darmstadt, Germany.

Production of DPC with Different Particle Sizes

To obtain small particle sizes of DPC, it was grinded using a laboratory grinder and then sieved through mesh sizes of 70 and 35 to obtain particle sizes of 210 and 500 µm named DPC210 and DPC500, respectively. These samples were kept in sealed polyethylene bags and stored at -18°C for further application.

Determination of Chemical Composition and pH

Chemical composition of wheat flour, DPC210 and DPC500 including moisture, protein, ash, gluten, fiber and fat content was determined according to the Approved Methods of the AACC (2000) and carbohydrate content by difference. To measure pH, 10 g of each sample was mixed well with 100 mL distilled water and left to stand for 20 minutes. Then, the pH of the suspension was determined using a calibrated pH meter at 25°C.

Determination of the Antioxidant Content and Antioxidant Activity

An exact amount of DPC (5 g, dry basis) was mixed with methanol (30 mL, 99.5%) in a centrifuge tube using a vortex mixer for 5 minutes. Then, it was centrifuged at 5,000×g for 10 minutes at room temperature and the supernatant was collected. The pellet was mixed with 30 mL methanol and centrifuged

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under the described condition, and repeated twice. The supernatant from each step was collected in the same volumetric flask and the final volume was made to 100 mL with methanol. The extracts from DPC210 and DPC500 were used for determination of Total Flavonoid Content (TFC) using aluminum chloride colorimetric method as described by Van Hung *et al.* (2009). Total Phenolic Content (TPC) of the extracts was measured by Folin-Ciocateau reagent as described by Velioglu *et al.* (1998). Radical scavenging capacity (antioxidant activity) of the extracts was determined using 2, 2-DiPhenyl-1-PicrylHydrazyl (DPPH) and the half maximal Inhibitory Concentration (IC50) of the DPC was obtained from the standard curve compared to that of standard/commercial antioxidant (vitamin C) (Mazidi *et al.*, 2012).

Cake Recipe and Batter Preparation

Cakes were prepared according to the following recipe: 160 g wheat flour, 29.2 g sugar, 90 g eggs, 21.2 g sunflower oil, 100 g milk, 5 g baking powder, 0.8 g lecithin and 1 g vanilla. For DPC enriched cakes, different amounts of the flour (0, 10, 20, 30, and 40%, w/w) were replaced by DPC of each particle sizes separately while all other components remained unchanged.

Whole egg and vanilla were whipped well with sugar in a mixer (Kitchen–Moulinex mixer, Model HM 1010, Beijing, China) at medium speed, for 2 minutes, then; milk was added and mixed for 2 minutes to obtain a thick cream. Afterward, cake flour mixed well with baking powder was added gradually. Finally, the oil was added to the recipe and gently mixed to obtain cake batter with the right consistency.

Determination of the Batter Density

To determine batter density, a glass tube was filled with either batter or water and the weights of batter and water were measured at 25°C. To obtain batter density, the weight of the batter was divided by the weight of the water (Majzoobi *et al.*, 2012).

Measurement of Batter Viscosity Using a Rapid Visco Analyzer (RVA)

Batter (28 g) was poured into an aluminum RVA canister and placed in a RVA (RVA Starch Master 2, Perten, Australia), and mixed at 160 rpm for 1 minute at 25°C prior to measuring batter viscosity at 25ºC.

Batter Rheological Properties

Rheological properties of the batter were measured using back extrusion test in a Texture Analyzer (Stable Microsystems, TAXT-2i Texture Analyzer, Godalming, Surrey, UK). In this test, a load cell with a maximum capacity of 30 kg was applied. A cylindrical glass container (70 mm height and 50 mm width) was filled with 60 mL batter at 22°C. The test was conducted at a pretest speed of 2 mm s^{-1}, test speed of 2 mm s^{-1}, post-test speed of 10 mm s^{-1}, distance of 8 mm and trigger force of 5 g using a cylindrical probe with a diameter of 40 mm. From the resulting curves, firmness was defined as maximum positive force (kg), consistency was determined using the positive area of the curve (kg s), viscosity was determined using the negative area of the curve (kg s), and cohesiveness from the ratio of areas (A2/A1) from force *vs.* distance curves (Cevoli *et al.*, 2013).

Cake Preparation

Cake batter (150 g) was transferred into a rectangular Teflon pan (40 mm width, 120 mm length, 50 mm height) and baked in an electric oven (Industrial Nan-e-Razavi, Iran) at 180˚C until a brown crust and a strong crumb (non-sticky) were formed (about 30 min). After baking, the pans were cooled down at room temperature for 1 hour and

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then the cakes were removed from the pans, packed in polyethylene bags, sealed, coded and stored at 25˚C for further experiments.

Cake Moisture Content

Firstly, cake crust and crump were separated using a shape knife and crumbled. Then about 2 g of the crumbled crumb and crust was dried separately in an electrical oven at 130°C until constant weight. The moisture content was calculated from the difference in the weight of the sample before and after drying divided by the initial weight of the sample.

Cakes Antioxidant Activity and Antioxidant Content

Cake extract was prepared in the same method described for DPC before. The extract was used to determine total phenolic content, total flavonoid content and IC50 according to the methods of Van Hung *et al.* (2009), Velioglu *et al.* (1998) and Mazidi *et al.* (2012).

Cake Textural Properties

Textural properties of the cakes were measured with a Texture Analyzer (Stable Microsystems, TAXT-2i Texture Analyzer, Godalming, Surrey, UK) by performing a two-bite compression test. A cubic piece of crumb (2 cm) was cut from the center of the cake. TPA was performed at a pretest speed of 5 mm s^{-1}, a test speed of 0.25 mm s^{-1}, a time interval of 10 seconds and a strain deformation of 25% by an aluminum cylindrical probe with a diameter of 75 mm. Hardness of texture was obtained from maximum force of the first bite of TPA test (F1) and the ratio of areas (A2/A1) from force *vs.* distance curves was used to calculate cohesiveness (Bourne, 2002).

Empirical Sensory Evaluation of the Cakes

Sensory evaluation was carried out using a 9-point hedonic test with 32 in-house untrained panelists (16 females and 16 males, age between 20-40 years) who were familiar with sensory evaluation tests on cakes. Samples were coded with three random digits, placed in disposable colorless plates and presented to the panelists. The panelists were asked to evaluate the samples and score them between 1 (disliked extremely) to 9 (liked extremely). Experiments were performed in isolated booths under daylight at 22°C.

Statistical Analysis

The average and standard deviation of triplicate experiments were calculated using Excel (Microsoft 2007). A completely randomized design was applied to determine significant differences among the samples from Analysis Of Variance (ANOVA). Duncan's multiple range test ($P < 0.05$) was used to determine the significances within treatments using the statistical software of Statistical Package for Social Science 16 (SPSS) (SPSS, Inc., New Jersey, USA).

RESULTS AND DISCUSSION

Chemical and Antioxidant Content of the DPC

The results of chemical composition of the cake flour and DPC with different particle sizes are presented in Table 1. Based on the results, DPC500 and DPC210 had significantly higher ash, fat, carbohydrate, and fiber content than the flour. However, the flour had higher protein content than the DPC500 and DPC210. Thus, addition of DPC to the flour can improve the nutritional value of the cakes by increasing fiber and ash (mineral) contents. Variation in particle

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Table 1. Chemical composition (%), Total Phenolic Content (TPC, mg gallic acid equivalents g^{-1}), Total Flavonoid Content (TFC, mg quercetin g^{-1}) and IC50 (mg mL^{-1}) of cake flour and date press cake with particle size of 500 (DPC500) and 210 µm (DPC210) (n= 3).[a]

Samples	Moisture	Ash	Fat	Protein (N × 6.25)	Carbohydrate	Fibre	TPC	TFC	IC50
Flour	10.75 ± 0.18[a]	0.50 ± 0.17 [b]	1.44 ± 0.08[c]	9.78 ± 0.93[a]	77.52 ± 1.35[b]	0.52 ± 0.02[b]	nd	nd	nd
DPC500	6.67 ± 0.38[b]	2.65 ± 0.05[a]	4.48 ± 0.29[b]	6.30 ± 0.35[b]	73.22 ± 0.32[a]	6.67 ± 0.38[a]	16.18 ± 0.04 [b]	1.84 ± 0.05 [b]	1.46 ± 0.69 [b]
DPC210	6.70 ± 0.31[b]	2.48 ± 0.14[a]	5.37 ± 0.22[a]	6.41 ± 0.79[b]	72.34 ± 1.07[a]	6.70 ± 0.31[a]	18.78 ± 0.03 [a]	1.95 ± 0.04 [a]	1.39 ± 0.60 [a]

[a] Different letters in each column show significant statistical difference (P< 0.05), nd: Not determined.

size had no significant effect on the chemical composition of the DPC except for the fat content. It was found that the smaller particle size fraction (DPC210) had slightly higher fat content than the larger particle size (DPC500), which was unexpected because the DPC500 had higher quantity of crushed seeds, which are high in fat content. However, the higher fat content of DPC210 may be due to its larger surface area with the fat extracting solvent during the test resulting in higher extraction of fat from this sample.

The DPC in this research had lower fat, protein, and ash content than strawberry and blackberry press cakes, but higher fat, ash, and protein content than apple, orange, and pineapple press cakes (Sudha *et al.,* 2007; O'Shea *et al.,* 2015; Kosmala *et al.,* 2017).

The results also showed that DPC210 had higher TPC and TFC but lower IC50 (higher antioxidant activity) than the DPC500. This can be mostly attributed to the larger surface area of DPC210 and hence better extractability of the bioactive compounds of this sample. Although DPC500 contained more seed particles which are rich in bioactive compounds (Al-Farsi *et al*., 2007) they remained inaccessible during the extraction process resulting in lower measurement of bioactive compounds and antioxidant activity.

Many factors affect the antioxidant content and activity of the date fruits and its products including date variety, growth condition, processing method, and antioxidant measurement method. Al-Farsi *et al.* (2007) reported that date seeds had higher phenolic content (~ 39.44 mg g^{-1}) and antioxidant activity than seedless press cake (2.76 mg g^{-1}) followed by date syrup (1.33 mg g^{-1}). Thus, high quantities of bioactive compounds remain in the DPC after juicing of the date fruits making the press cake a valuable and nutritious by-product.

Compared to other fruits press cakes, the date press cake (current research) had higher phenolic and flavonoid contents than apple press cake (4.41 and 1.45 mg g^{-1}, respectively) (Rana *et al.,* 2015), but lower phenolic content than blackcurrant (28.46 mg g^{-1}) and raspberry (24.28 mg g^{-1}) (Viskelis *et al.,* 2017), and lower flavonoid content than strawberry press cake (18.84 mg g^{-1}) (Sójka *et al.* 2013).

Physical and Rheological Analyses of Batter

Batter density is an indication of aeration during mixing and, generally, lower density is related to higher aeration and hence higher volume of the final product. Viscosity has a great influence on batter density and cake volume as it determines the ability of the batter to preserve gas during mixing and baking. However, only an optimum viscosity can result in proper cake quality, hence controlling batter viscosity is decisive. Table 2 shows that the batter density and viscosity were

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Table 2. Physical and rheological proeprties of the cake batters containing different levels of date press cake with particle size of 500 (DPC500) and 210 μm (DPC210) (n=3).[a]

Sample	0%	10%	20%	30%	40%
	Density (g cm^{-3})				
DPC500	1.06 ± 0.03 ^{Ab}	1.09 ± 0.02^{Ab}	1.10 ± 0.02^{Aab}	1.12 ± 0.02^{Aa}	1.14 ± 0.03^{Aa}
DPC210	1.06 ± 0.03^{Ab}	1.08 ± 0.02^{Ab}	1.13 ± 0.01^{Aa}	1.14 ± 0.01^{Aa}	1.15 ± 0.01^{Aa}
	Viscosity (mPa s)				
DPC500	3528 ± 30^{Ae}	4055 ± 25^{Bd}	5122 ± 22^{Bc}	6872 ± 20^{Bb}	> 8000^{Aa}
DPC210	3528 ± 22^{Ac}	4542 ± 31^{Ab}	> 8000^{Aa}	> 8000^{Aa}	> 8000^{Aa}
	Stickiness (g)				
DPC500	142.14±7.48 ^{Ae}	153.22±5.74 ^{Bd}	169.74±11.69 ^{Bc}	228.05±14.82 ^{Bb}	245.38±9.70 ^{Ba}
DPC210	142.14±7.48 ^{Ae}	204.34±13.16 ^{Ad}	253.54 20.46 ^{Ac}	450.10±18.01 ^{Ab}	662.91±42.11 ^{Aa}
	Firmness (g)				
DPC500	236.04±43.07 ^{Ac}	263.47±14.89 ^{Ac}	321.45±18.48 ^{Bbc}	401.38±133.34 ^{Bb}	517.22±89.59 ^{Ba}
DPC210	236.04±43.07 ^{Ad}	418.58±79.01 ^{Acd}	769.15±146.63 ^{Ac}	1744.65±439.45 ^{Ab}	2952.48±32.80 ^{Aa}
	Consistency (g sec)				
DPC500	443.66±0.51 ^{Ae}	593.31± 34.75 ^{Bd}	704.98±56.77 ^{Bc}	1164.89±77.98 ^{Bb}	1422.01±80.60 ^{Ba}
DPC210	443.66± 0.51 ^{Ae}	799.34± 99.54 ^{Ad}	1437.17±144.61 ^{Ac}	2168.72±176.02 ^{Ab}	4829.48±373.74 ^{Aa}
	Cohesiveness				
DPC500	408.88±31.74 ^{Ad}	483.41±36.89 ^{Bcd}	647.54±60.85 ^{Bbc}	792.43±249.56 ^{Bb}	982.82±135.47 ^{Ba}
DPC210	408.88±31.74 ^{Ae}	851.68±125.45 ^{Ad}	1234.47±125.59 ^{Ac}	1916.43±185.67 ^{Ab}	2377.75±72.54 ^{Aa}
	Index of viscosity (g sec)				
DPC500	235.67± 20.79 ^{Ac}	232.90±13.67 ^{Bc}	252.18±21.14 ^{Bc}	321.09±86.26 ^{Bb}	385.77±26.85 ^{Ba}
DPC210	235.67± 20.79 ^{Ae}	345.44±71.23 ^{Ad}	468.04±18.21 ^{Ac}	631.29±17.79 ^{Ab}	830.36±169.21 ^{Aa}

[a] For each characteristic, different capital letters in each column and small letters in each row (for each characteristic) indicate significant statistical difference (P< 0.05).

affected by addition of DPC level and its particle size. Batter density and viscosity showed increasing trends with addition of the DPC concentration. These changes can be explained with regard to the higher fiber content of the DPC compared to the flour. Fiber compounds are capable of forming hydrogen bonds with water and hence reducing water mobility, which results in higher viscosity. In addition, DPC is a rich source of simple sugars including glucose and sucrose, which can interact easily with water molecules and increase the batter viscosity. Nevertheless, the flour contains starch as the main carbohydrate, which cannot interact easily with water at ambient temperature in which the batter is produced. DPC also contains other water soluble materials (e.g. organic acids and amino acids) as well as minerals, which can increase batter viscosity. It was found that the batter density was not affected by the particle size of DPC. However, DPC210 resulted in higher viscosity than the DPC500. This can be related to the larger surface area of smaller particles, which promote more interactions with water.

Similar results were found with addition of various fibers (wheat bran, oat bran and cellulose) different particle sizes (Gômez *et al.*, 2010), different levels, and particle sizes of rice bran (Majzoobi *et al.*, 2013) to wheat flour cakes and oat fiber, inulin and guar gum to gluten-free cakes (Gularte *et al.*, 2012).

The results of the batter rheological tests (Table 2) showed that the batter stickiness, firmness, consistency, cohesiveness and viscosity increased dramatically with increasing the percentage of the DPC. Similar results have been reported by Jridi *et al.* (2015) for dairy dessert enriched with date by-product. These changes are attributed to the high fiber and sugar content of DPC, which have high affinity to form hydrogen bonds with water and reduce water mobility. It is also possible that the constituents of the DPC affect the structure and functionality of flour proteins, which requires further studies. Fat is another component of DPC (4.48% in DPC500 and 5.37% in DPC210) which can affect batter properties. Lipids often soften cake batter and reduce viscosity; however, this type of effect for the DPC lipids was not observed on the batters. It is possible that the DPC lipids were not accessible effectively to interact with other molecules and reduce viscosity. It is also likely that the negative effect of DPC lipids on batter viscosity was counteracted by the positive effect of fibers and sugars.

Table 4 also shows that changes in the particle size of DPC had significant effects on the batter rheological properties. It is possible that the larger surface area of DPC210 facilitates more interactions between fiber and proteins with water and hence resulting in higher viscosity, firmness, consistency, stickiness and cohesiveness of this sample as compared to the DPC500.

Antioxidant Content of the Cakes

DPC appeared as a rich source of antioxidant and hence increasing the level of DPC promoted TPC and TFC but reduced IC50 (i.e. higher antioxidant activity) of the cakes (Table 3). In general, cakes containing DPC210 showed higher antioxidant content and lower IC50 than those produced with DPC500, which can be related to the better extractability of the antioxidant content from the DPC with a smaller particle size. The data shows that the TPC and TFC of the cakes increased to a maximum of 67.97 and 42.54% with addition of DPC to the cakes, however, Sudha *et al.* (2007) reported a 50% increase in TPC with inclusion of 25% apple pomace fiber in cakes. Comparing the bioactive compounds of the cake with the DPC, it was found that the DPC had higher total phenolic and flavonoid compounds and lower IC50. This indicates that bioactive compounds of DPC were partially destroyed or deactivated during baking of the cakes.

pH, Density and Moisture Content of Cake

The results (Table 4) showed that increasing DPC level reduced cake pH from 7.83 to 7.03, but changing the particle size had no significant effect on the pH. The presence of natural acidic components in DPC including organic acids (e.g. malic, oxalic, citric, succinic, formic, and isobutyric acids), antioxidants (e.g. ferulic, vanillic, and syringic acids), acidic amino acids (e.g. glutamic acid) can reduce the pH of the

Table 3. Total Flavonoid Content (TFC), Total Phenolic Content (TPC) and IC50 of the cakes containing date press cake with particle size of 500 (DPC500) and 210 μm (DPC210) (n= 3).[a]

Samples	DPC (%)				
	0%	10%	20%	30%	40%
	TFC (mg g^{-1} of sample)				
DPC500	0.919 ± 0.017 [Ad]	0.962 ± 0.009 [Bd]	1.117 ± 0.006 [Bc]	1.130 ± 0.004 [Bb]	1.273 ± 0.010 [Ba]
DPC210	0.919 ± 0.017 [Ae]	1.055 ± 0.010 [Ad]	1.244 ± 0.008 [Ac]	1.284 ± 0.006 [Ab]	1.318 ± 0.008 [Aa]
	TPC (mg g^{-1} of sample)				
DPC500	6.90 ± 0.01 [Ae]	7.84 ± 0.01 [Bd]	8.76 ± 0.01 [Ac]	9.48 ± 0.01 [Ab]	10.36 ± 0.01 [Ba]
DPC210	6.90 ± 0.01 [Ae]	8.23 ± 0.01 [Ad]	8.37 ± 0.01 [Bc]	9.88 ± 0.35 [Ab]	11.59 ± 0.01 [Aa]
	IC50 (mg g^{-1})				
DPC500	872.67 ± 11.06 [Aa]	635.33 ± 9.45 [Ab]	490.33 ± 6.51 [Ac]	457.33 ± 4.73 [Ad]	365.33 ± 7.02 [Ae]
DPC210	872.67 ± 11.06 [Aa]	609.33 ± 6.11 [Bb]	460.67 ± 7.02 [Bc]	335.33 ± 7.02 [Bd]	292.33 ± 4.73 [Be]

[a] For each characteristic, different capital letters in each column and small letters in each row (for each characteristic) indicate significant statistical difference ($P < 0.05$).

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Table 4. pH, density (g cm^{-3}), crumb and crust moisture content (%) of the cakes containing date press cake with particle size of 500 (DPC500) and 210 µm (DPC210) (n= 3).[a]

Samples	0%	10%	20%	30%	40%
	pH				
DPC500	7.83 ± 0.04 ^{Aa}	7.46 ± 0.03 ^{Ab}	7.31 ± 0.05 ^{Ac}	7.13 ± 0.08 ^{Ad}	7.03 ± 0.05 ^{Ae}
DPC210	7.83 ± 0.04 ^{Aa}	7.50 ± 0.10 ^{Ab}	7.28 ± 0.07 ^{Ac}	7.08 ± 0.03 ^{Ad}	7.04 ± 0.12 ^{Ad}
	Density (g cm^{-3})				
DPC500	0.33 ± 0.00 ^{Ac}	0.36 ± 0.01 ^{Ab}	0.36 ± 0.01 ^{Ab}	0.37 ± 0.02 ^{Ab}	0.38 ± 0.01 ^{Aa}
DPC210	0.33 ± 0.00 ^{Ad}	0.35 ± 0.00 ^{Ac}	0.36 ± 0.01 ^{Ac}	0.40 ± 0.01 ^{Ab}	0.45 ± 0.00 ^{Ba}
	Crust moisture (%)				
DPC500	10.71 ± 0.55 ^{Aa}	9.84 ± 0.83 ^{Aa}	8.02 ± 0.24 ^{Ab}	7.88 ± 0.50 ^{Ab}	7.44 ± 0.63 ^{Ab}
DPC210	10.71 ± 0.55 ^{Aa}	9.05 ± 1.27 ^{Aab}	8.12 ± 0.13 ^{Ab}	6.75 ± 0.44 ^{Ac}	6.71 ± 0.23 ^{Ac}
	Crumb moisture (%)				
DPC500	28.46 ± 0.15 ^{Aa}	28.36 ± 0.45 ^{Aa}	28.80 ± 1.55 ^{Aa}	29.26 ± 0.36 ^{Ba}	29.47 ± 0.56 ^{Ba}
DPC210	28.46 ± 0.15 ^{Ab}	28.71 ± 0.08 ^{Ab}	29.28 ± 0.87 ^{Aa}	30.81 ± 0.10 ^{Aa}	30.89 ± 0.56 ^{Aa}

[a] For each charactriestics, different capital letters in each column and small letters in each row indicate significant statistical difference (P< 0.05).

cakes. Similar results have been obtained by addition of date by-products to a dairy dessert (Jridi *et al.,* 2015) or other agricultural by-products such as wheat germ and carrot pomace powder to cake recipes (Majzoobi *et al.,* 2016).

Density of the cake is negatively correlated with cake volume, which in turn affects the texture and customer acceptance. The results (Table 4) show that the density of the control increased from 0.33 to 0.38 g cm^{-3} with addition of DPC500 and to 0.45 g cm^{-3} with inclusion of DPC210. This can be correlated to the decrease in the air volume incorporated into the batter and can be explained by the increase in the batter viscosity caused by DPC (see Table 2). High viscosity will obstruct gas incorporation into the batter during mixing. Dilution of gluten content due to the addition of DPC may impair gas retention capacity of the batter during baking (Gomes *et al.*, 2015). Another possible reason that requires further investigation is the effects of DPC components on starch gelatinization, which in turn can affect cake volume by controlling cake expansion during baking.

Understanding the moisture content of the cake is important since it affects color, textural and sensory properties of the cakes. Table 4 shows that addition of DPC reduced the moisture content of the cakes mostly by producing a drier crust. Changes in the DPC particle size had no significant effect on crust moisture content. Nevertheless, DPC210 resulted in higher crumb moisture content when used at high concentrations (30 and 40%) which may be attributed to the higher water retention capacity of the smaller particles due to their larger surface areas.

Cake Textural Properties

Based on the results (Table 5), with increasing the level of DPC, the hardness of the cakes increased, while cohesiveness reduced significantly. The cakes containing DPC210 had softer texture than those made with DPC500, but the cohesiveness of these samples did not differ significantly. Similarly, increased hardness has been reported for cakes formulated with apple pomace (up to 25%) (Sudha *et al.*, 2007), oat fiber (up to 30%) (Majzoobi *et al.*, 2015) and rice bran (up to 30%) (Majzoobi *et al.*, 2013). Some studies have shown that cake textural properties have a positive correlation with its volume (Gómez *et al.*, 2010). Thus, the reduction in cake volume can be a reason for textural changes of the

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Table 5. Textural parameters of the cakes containing Date Press Cake (DPC) with particle size of 500 and 210 µm (DPC500 and DPC210, respectively) (n= 3).[a]

Sample	0%	10%	20%	30%	40%
	Hardness (g)				
DPC500	357.62 ± 29.88 [Ad]	473.66 ± 34.50 [Ac]	501.41 ± 73.03 [Abc]	585.19 ± 42.27 [Ab]	864.72 ± 40.11 [Aa]
DPC210	357.62 ± 29.88 [Ac]	363.59 ± 31.03 [Bc]	426.35 ± 39.07 [Bbc]	447.54 ± 42.40 [Bb]	813.58 ± 35.00 [Ba]
	Cohesiveness				
DPC500	0.644 ± 0.013 [Aa]	0.630 ± 0.014 [Aa]	0.618 ± 0.014 [Aa]	0.642 ± 0.020 [Aa]	0.562 ± 0.020 [Ab]
DPC210	0.644 ± 0.013 [Aa]	0.613 ± 0.023 [Aa]	0.604 ± 0.022 [Aa]	0.573 ± 0.015 [Aa]	0.519 ± 0.059 [Ab]

[a] For each characteristic, different capital letters in each column and small letters in each row (for each characteristic) indicate significant statistical difference ($P< 0.05$).

samples. According to Wilderjans *et al.* (2010), starch gel influences crumb firmness while protein aggregation in cake crumb is associated with springiness. Further research is necessary to confirm that DPC can promote starch retrogradation and protein aggregation as other possible reasons for the increased hardness and reduced springiness of the cakes. The increased hardness of the cakes can also be attributed to the dilution and weakness of the gluten network caused by DPC.

Sensory Properties of Cakes

Figure 1 shows the surface and cross-section of the cakes enriched with DPC. Based on the sensory evaluation results (Figures 2-A and -B), the cake color became darker with increasing DPC level, which had negative effects on the sensory scores given by the panelists. However, changes in the particle size of the DPC had no significant effects on the scores given to the crust and crumb color.

According to the panelists, the cake crumb became harder and more uneven with increasing the level of DPC and hence lower scores were given to these samples. However, the crumb texture of the samples produced with DPC210 was softer than those produced with DPC500 and, therefore, the latter samples received higher scores. These results are in line with the results of instrumental texture studies of the cakes (see Table 5). The scores given to the cake appearance decreased with increasing the level of DPC due to the formation of an uneven crust as the level of DPC increased. This was more obvious for the cakes prepared with DPC210. Incorporation of DPC had an adverse effect on the flavor of the cakes, however, increasing the level and changes in the particle size had no significant effect on this parameter. The overall acceptability of the cakes decreased with inclusion of the DPC, particularly when more than 20% DPC was added. The samples prepared with DPC210 received higher scores for general acceptability than those made with DPC500. The panelists indicated that the overall appearance and taste of the cakes containing DPC resembled a chocolate cake.

CONCLUSIONS

The results of this study showed that the DPC is a rich source of fiber and antioxidants and hence has a great potential to be utilized in value-added products. Inclusion of DPC in the cake recipe showed some adverse effects on the quality of the cakes including increased density and hardness, and development of an undesirable flavor. To compensate such effects, optimizing the concentration of the DPC is essential. In addition, controlling the particle size of the DPC is also important to support quality as well as nutritional value. Overall, in terms of physicochemical properties of cakes, the impact of DPC level was more

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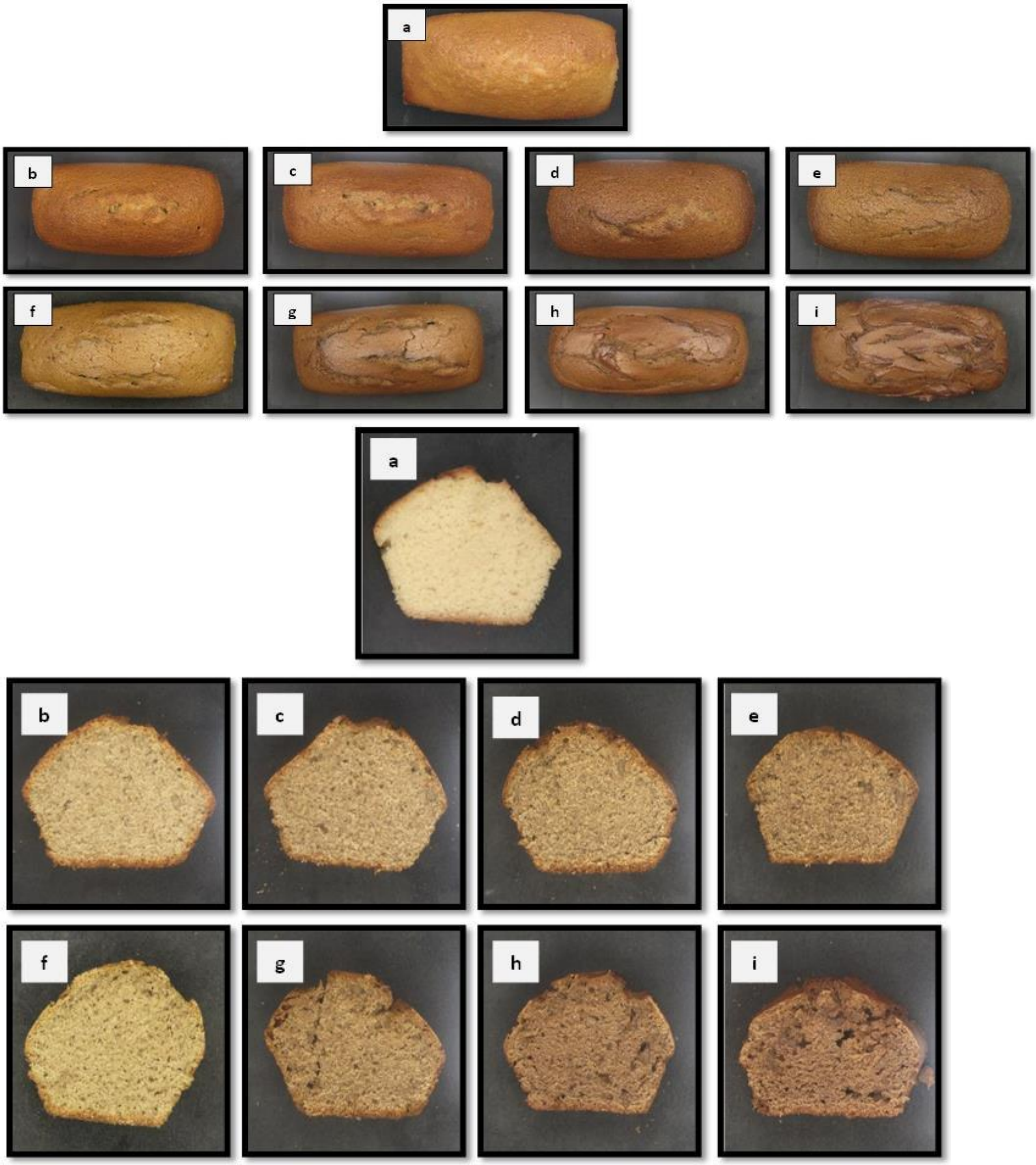
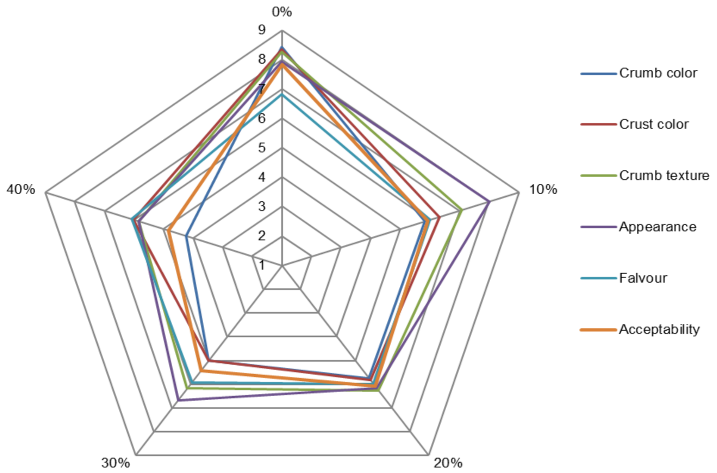


Figure 1. The crust and crumb color of cakes containing different levels (%) and particle sizes (µm) of date press cake: (**a)** Control; (**b)** 10%, 500 µm; (**c**) 20%, 500 µm; (**d**) 30%, 500 µm; (**e**) 40%, 500 µm; (**f**) 10%, 210 µm; (**g**) 20%, 210 µm; (**h**) 30%, 210 µm, and (**i**) 40%, 210 µm.

[DOR: 20.1001.1.16807073.2020.22.1.19.5]



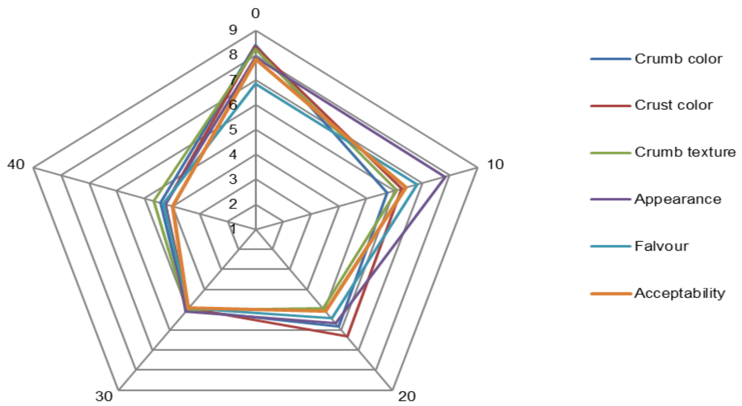


Figure 2. Sensory evaluation results of the cakes containing different levels (0-40%) of date press cake with particle sizes of 500 (DPC500) (A) and 210 µm (DPC210) (B).

profound than the particle size. In terms of appearance and sensory evaluation, the cakes containing DPC had a color and flavor close to a chocolate cake as indicated by the panelists. According to the results, cakes produced with 10% DPC210 resulted in higher antioxidant content and overall acceptability. Further works towards improving the quality and sensory attributes of DPC cakes are required.

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تاثیرات مقدار و اندازه ذرات کنجاله خرما بر ویژگی های رؤلوژیکی خمیر و خصوصیات فیزیکی و تغذیه ای کیک

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چکیده

کنجاله خرما یک محصول جانبی آبگیری میوه خرما می باشد که عمدتا بدون کاربرد در تولیدات غذایی باقی مانده است. هدف اصلی از این تحقیق بررسی امکان کاربرد مقادیر مختلف کنجاله خرما (۰، ۱۰، ۲۰، ۳۰ و ۴۰ ٪) و اندازه ذرات ۲۱۰ میکرومتر (ذرات ریز) و ۵۰۰ میکرومتر(ذرات درشت) در تهیه کیک بود. نتایج آزمایشات نشان داد که کنجاله خرما دارای فیبر، خاکستر و چربی بیشتری نسبت به آرد گندم بود. افزایش درصد و کاهش اندازه ذرات کنجاله باعث افزایش قوام، سفتی، چسبندگی، پیوستگی و ویسکوزیته خمیر کیک گردید. افزودن کنجاله خرما باعث کاهش دانسیته، پی اچ و رطوبت پوسته کیک گردید که این ویژگی ها تحت تاثیر مقدار کنجاله خرما قرار نگرفت. با افزایش مقدار کنجاله سفتی بافت کیک افزایش ولی به هم پیوستگی آن کاهش یافت. در مقایسه با کنجاله های دانه درشت، افزودن کنجاله های ریز منجر به تولید کیکی با بافت نرمتر و پیوستگی کمتر گردید. افزودن کنجاله ها به ویژه کنجاله های دانه ریز باعث افزایش مقدار ترکیبات آنتی اکسیدانی در کیک گردید/ در نهایت نمونه دارای ۱۰٪ کنجاله ریز از ویژگی های حسی-چشایی قابل قبولی برخوردار بود.

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