

Chemical Composition and Functional Properties of Date Press Cake, an Agro-Industrial Waste

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ABSTRACT

Date press cake is a by-product of date fruit juicing that has remained underutilized in the food industry. This is mostly due to the lack of information and technical knowledge about its chemical composition, nutritional value, health benefits and possible effects on the quality of food products upon inclusion. The main aim of this research was to determine the chemical composition, bioactive compounds and functional properties of date press cake to promote its food applications as an economical and available functional ingredient. The research was carried out on ground date press cake obtained from Shahani dates with two particle sizes of 355 µm (coarse) and 167 µm (fine). On average, Shahani date press cake contained 13.37% moisture, 4.92% fat, 6.35% protein, 11.74% crude fiber and 79.06% carbohydrate. Fructose was the main simple sugar, magnesium was the major mineral, oleic acid was the predominant fatty acid, and phenolic compounds were the main antioxidant. The chemical composition and functional properties of the date press cake were affected by its particle size. The coarse sample had lower fibre, oleic acid, total phenolic and flavonoid content and antioxidant activity than the fine sample. However, the fine sample had higher sugar and fat content and exhibited higher water holding capacity and solubility than the coarse sample.

Keywords: Date by-product, Food waste management, Functional ingredient, Particle size, Value addition.

INTRODUCTION

Industrial fruit processing is accompanied by production of large quantities of by-products including seeds, skin and press cake, which is the fibrous material remains after juice filtration. These agro-industrial wastes contribute to a great loss of raw materials and cause disposal problems and environmental issues due to their bulky nature and high carbohydrate and moisture content (Al-Farsi and Lee, 2008; Ashraf and Hamidi-Esfahani, 2011). However, recent studies on some fruit press cakes have revealed their immense scope as functional ingredient in development of value-added and healthy foods (Sudha *et al.*,

2007; O'Shea *et al.*, 2015; Kosmala *et al.*, 2017). Fruit press cake offers an available, low cost and natural component suitable for production of many types of foods including allergy-free (e.g. gluten and lactose free) products.

Date fruit (*Phoenix dactylifera* L.) with world production of about 7 million tons is an important global industry (FAOSTAT, 2010). The world producers of date fruits are Egypt, Iran, and Saudi Arabia. Date fruit is known as "emerging healthy foods" with documented anti-cancer, anti-inflammatory, anti-mutagenic and hepato-protective effects (Ashraf and Hamidi-Esfahani, 2011; Vayalil, 2012) and hence consumption of date and its processed products such as juice is booming around the

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world. Date juicing results in about 17-28% date press cake, which is mostly used as stock feed or dumped into open lands and drains (Heidarinejad *et al.*, 2018) posing great economic and environmental issues. The underutilization of the date press cake is mainly due to the lack of information about its chemical composition, health benefits and food and non-food applications. Although recent studies have shown its great potential as a cheap, renewable, and abundant precursor for production of activated carbon (Heidarinejad *et al.*, 2018), other applications of date press cake have not been acknowledged.

While the chemical, nutritional and functional properties of press cakes obtained from some common fruits including apple, pineapple, orange, blackberry and strawberry have been investigated, such information are limited for date press cake. One of the few studies on press cake indicates the higher nutritional value and bioactive compounds of date press cake than their corresponding syrups (Al-Farsi *et al.*, 2007).

The main objectives of this research were to determine chemical composition, functional properties and bioactive compounds of date press cake of Iranian Shahani dates. This cultivar is one of the most famous and popular date fruits in Iran and is exported to other countries around the world due to its high customer preference, economic price and availability throughout the year. The results of this research may be useful to extend the applications of date press cake into human foods for value addition and reducing food waste. Milling of food by-products is a common practice to make them suitable for inclusion into other food products. In this research, the effects of two particle sizes on the composition and functional properties of date press cake were also investigated.

MATERIALS AND METHODS

Date press cake remained after juicing of fully matured Shahani dates was produced in one of the largest date processing factories called Minoos Date Factory, Shiraz Grand

Industrial Estate Zone, Shiraz, Iran. The press cake was provided as a dry powder containing a mixture of fibrous material from date flesh and smashed pieces of date seed. It was packed in air tight polyethylene bags and frozen at -18 °C for further tests. Folin-Ciocalteu reagent and the 2, 2-DiPhenyl-1-PicrylHydrazyl (DPPH) were purchased from Sigma-Aldrich Company (St. Louis, MO, USA). Other chemicals were of analytical grade and purchased from Merck Company (Darmstadt, Germany).

Preparation of Date Press Cake with Different Particle Sizes

To investigate the effects of different particle sizes on the composition and functional properties of date press cake, it was ground using an electrical mill (Moulinex, Model 320, France) and sieved manually using a set of stainless steel sieves (ASTME:11, Iran) to obtain average particle sizes of 355 µm (coarse) and 167 µm (fine). Then, they were packed in polyethylene bags, sealed and kept at -18°C for further experiments.

Determination of Chemical Composition, Sugars and Mineral Content

Chemical compositions of the samples including moisture, protein, fat, ash and crude fiber were measured according to the approved methods of Association of Official Analytical Chemists (AOAC, 2000) and total carbohydrate content was calculated by subtracting the sum of moisture, protein, fat and ash content from 100.

Sugars (glucose, fructose, sucrose and total sugar) were determined using the Fehling test. The content (mg kg⁻¹) of Calcium (Ca), Zinc (Zn), Copper (Cu), iron (Fe), Manganese (Mn) and Magnesium (Mg) were measured by using an atomic absorption spectrophotometer (Shimadzu, Model AA670G, Japan) (AOAC, 2002). Sodium (Na) and potassium (K) contents (mg kg⁻¹)

were determined by a flame photometer (Model 405 Corning, Cambridge, UK).

Determination of Bioactive Compounds

Extraction of Bioactive Compounds

Each sample (5 g) was extracted three times with 30 mL methanol (99.5%, v/v). In each step, the mixture of sample and methanol was shaken over a vortex mixer at medium speed for 5 min and then centrifuged (Froilabo SW14Rmodel, France) at $5,000\times g$ for 10 minutes. The combined supernatants were centrifuged at 5000g for 10 min. The supernatant was made up to 100 mL with 99.5% methanol. The extract was kept in a dark container at 4°C prior to further analysis (Habibi *et al.*, 2015; Farahnaky *et al.*, 2016).

Determination of Total Phenolic Content (TPC)

To measure TPC of the date press cake extracts, Folin–Ciocalteu method was used (Othman *et al.*, 2009). Date press cake extract (0.1 mL) was added to 900 mL distilled water, along with 1 mL of Folin–Ciocalteu reagent and 0.75 mL of 2% sodium carbonate solution (w/v), mixed with a glass bar and incubated for 1 hour at 20°C. A control sample was prepared in the same method with 0.1 mL methanol instead of date press cake extract. The absorbance of the samples was measured at 765 nm using a UV–Visible spectrophotometer (Unico, China). TPC values were determined from a calibration curve prepared with a series of gallic acid standards (25, 50, and 100 $\mu\text{g mL}^{-1}$) and the results were reported as mg of gallic acid equivalents g^{-1} of date press cake.

Determination of Total Flavonoid Content (TFC)

To measure TFC, 0.5 mL of date press cake extract was mixed with 0.1 mL of 1M $\text{CH}_3\text{CO}_2\text{K}$, 2.8 mL of distilled water and 0.1

mL of 10% AlCl_3 and incubated at 20°C for 30 minutes. A control sample was prepared in the same method but 0.5 mL ethanol was added instead of date press cake extract. Then, the absorbance of the samples at 415 nm was measured using a spectrophotometer (Unico, China). Quercetin solutions with concentrations of 6.25, 12.00 and 25.00 $\mu\text{g mL}^{-1}$ in methanol were used to obtain a standard curve. The TFC was recorded as mg of the quercetin equivalent per g of sample weight (Habibi *et al.*, 2015).

Determination of Radical Scavenging Activity (RSA)

To measure RSA, the 2,2-DiPhenyl-1-PicrylHydrazyl free radical (DPPH°) scavenging assay was used. The methanolic extract (0.1 mL) of the samples was mixed with 2 mL of methanolic DPPH° solution (0.25 mM), shaken vigorously and left for 1 hour in a dark cabinet before reading the absorbance at 517 nm.

The amount of antioxidant required for a 50% loss of the DPPH° activity is defined as DPPH° scavenging activity (IC_{50}). Using Equation (1), the percentage of inhibition of DPPH° by the methanolic extract was calculated.

$$\text{Inhibition (\%)} = [(A_c - A_s)/A_c] \times 100 \quad (1)$$

Where, A_c is the Absorbance of the control reaction and A_s is the Absorbance of the methanolic date press cake extract after 1 hour. IC_{50} of the extracts was measured from the percentage of the remaining DPPH° against methanolic extract concentrations (Mazidi *et al.*, 2012).

Ferrous Ion Reducing Antioxidant Power (FRAP)

To measure FRAP of the samples, 1 mL of the methanolic extract was mixed with 1 mL of potassium ferricyanide [$\text{K}_3\text{Fe}(\text{CN})_6$] (1%) and 1 mL of phosphate buffer (0.2M, pH 6.6) and then placed in a water bath at 50°C for 20 minutes. Then, they were cooled rapidly



under running water and mixed with 0.2 mL of 0.1% ferric chloride and 1 mL of 10% trichloroacetic acid. After 10 minutes shaking, the absorbance was measured at 700 nm. The increased absorbance of the reaction mixture indicated the FRAP. A series of vitamin C concentrations (0.001, 0.01 and 1 $\mu\text{g mL}^{-1}$) were used as standard (Farahmand et al., 2017).

Cupric Ion Reducing Antioxidant Capacity (CUPRAC)

One mL of CuCl_2 solution ($1.0 \times 10^{-2}\text{M}$), 1 mL of neocuproine alcoholic solution ($7.5 \times 10^{-3}\text{M}$) and 1 mL ammonium acetate buffer solution were added in a test tube and mixed. Then, 0.5 mL of extract (1 mg mL^{-1}) followed by 0.6 mL of distilled water were added to the tube and mixed well. After 30 minutes, the absorbance of the samples against a blank was measured at 450 nm. Vitamin C with concentrations of 0.001, 0.01 and 0.1 $\mu\text{g mL}^{-1}$ was used as standard (Farahmand et al., 2017).

Chelating Power

To measure chelation of ferrous ion of the samples, 2 mL of the date press cake extract was mixed with 3.7 mL of deionized water and then reacted with ferrous chloride (2 mmol L^{-1} , 0.1 mL) and ferrozine (5 mmol L^{-1} , 0.2 mL) for 20 minutes. The absorbance was measured at 562 nm. EDTA was used as a positive control. Chelating activity was calculated using Equation (2)

$$\text{Chelating effect (\%)} = [(A_b - A_s)/A_b] \times 100 \quad (2)$$

Where, A_b is the Absorbance of the blank without extract or EDTA and A_s is the Absorbance in the presence of extract or EDTA (Farahmand et al., 2017).

Fatty Acid (FA) Analysis

The FA composition of the date press cake samples was determined using a gas

chromatography method (Golmakani et al., 2012).

Color Evaluation

Color parameters of the date press cakes with different particle sizes were measured by digital image analysis method (Afshari-Jouybari and Farahnaky, 2011). A digital camera (Canon, Model PowerShot SX270 HS, 12.1 Megapixels, Malaysia) was used to take pictures with resolution of 300 dots per inch (dpi), contrast of 62% and lightness of 62%. The angle between sample surface and camera lens and between the sample surface and the light source was 90° and 45° , respectively. The JPEG pictures were analyzed using Adobe Photoshop CS 5 Software (Adobe Systems Inc., Beijing, China) to obtain color parameters including L -value (lightness), a -value (redness–greenness) and b -value (yellowness–blueness).

Determination of Water Holding Capacity (WHC) and Solubility

WHC of date press cake with different particle sizes were measured using the method of Tang (2007), with slight modification. Date press cake (1 g, dry basis) was mixed with 50 mL distilled water in a centrifuge tubes, mixed well with a glass rod and then stirred overnight at ambient temperature. The sample was centrifuged at $6,000 \times g$ for 20 minutes at 20°C . WHC was calculated using Equation (3).

$$\text{WHC} = \frac{\text{Weight of the pellet} - \text{Dry weight of the sample}}{\text{Dry weight of the sample}} \quad (3)$$

The supernatant from the previous experiment was weighed and dried at 110°C until constant weight (4 hours). Solubility was calculated according to Equation (4).

$$\text{Solubility (\%)} = \frac{\text{Weight of dried supernatant}}{\text{dry weight of the sample}} \times 100 \quad (4)$$

pH Measurement

Suspension of date press cake in distilled water (10%, W/W) was prepared by shaking the samples for 1 minute over a medium speed vortex mixer. Then the pH was measured at 20°C using a calibrated pH meter (Model SK-632PH; Metrohm, Herisau, Switzerland) (AOAC, 2002).

Statistical Analysis

All experiments were performed in triplicates. Mean and standard values of the samples were obtained using Excel 2007 and reported in this paper. Analysis of variance (ANOVA) was performed to determine significant differences ($P < 0.05$) between the means. The Duncan's multiple range test was applied to compare the means using SPSS (version 16.0, Team EQX, USA).

RESULTS AND DISCUSSION

Chemical Composition

Table 1 shows the chemical composition of the fine and coarse date press cakes. On average, Shahani date press cake contained 13.37% moisture, 4.92% fat, 6.35% protein, 11.74% crude fiber and 79.06% carbohydrate. The protein, ash, and carbohydrate content of the samples were close to the values reported for seedless date press cake (Al-Farsi *et al.*, 2007). However, they reported a lower fat content (~1.8%), which can be related to the fact that the seeds are rich in fat (Chandrasekaran and Bahkali, 2013) and hence seed removal resulted in a press cake with a lower fat content.

Compared to the press cakes from some common fruits, it was found that the date press cake had higher fat, ash and protein content than apple, orange and pineapple

Table 1. Chemical composition (dry basis) and mineral content of coarse and fine date press cake.^a

	Coarse (355 μm)	Fine (167 μm)	Average
Moisture (%)	6.67 ± 0.38 ^a	6.70 ± 0.31 ^a	13.37 ± 0.34
Fat (%)	4.48 ± 0.29 ^a	5.37 ± 0.22 ^b	4.92 ± 0.25
Protein ^b (%)	6.30 ± 0.35 ^a	6.41 ± 0.79 ^a	6.35 ± 0.75
Crude fibre (%)	14.35 ± 0.17 ^b	9.13 ± 0.10 ^a	11.74 ± 0.13
Total carbohydrate content ^c (%)	79.09 ± 0.32 ^a	79.04 ± 1.07 ^a	79.06 ± 0.69
Total sugar (%)	16.00 ± 0.21 ^a	16.51 ± 0.10 ^b	16.25 ± 0.11
Glucose (%)	4.84 ± 0.06 ^a	4.84 ± 0.14 ^a	4.84 ± 0.10
Fructose (%)	11.02 ± 0.22 ^a	11.09 ± 0.22 ^a	11.05 ± 0.22
Sucrose (%)	0.24 ± 0.04 ^a	0.58 ± 0.03 ^b	0.41 ± 0.35
Ash (%)	2.65 ± 0.05 ^a	2.48 ± 0.14 ^a	2.56 ± 0.09
Minerals (mg kg ⁻¹)			
Fe	71.40 ± 0.46 ^a	90.10 ± 0.30 ^b	80.75 ± 0.38
Zn	17.53 ± 0.25 ^a	21.92 ± 0.18 ^b	19.72 ± 0.21
Cu	10.47 ± 0.25 ^b	7.65 ± 0.17 ^a	9.06 ± 0.21
Mn	9.63 ± 0.21 ^a	12.43 ± 0.15 ^b	11.03 ± 0.18
Ca	503.53 ± 0.65 ^b	417.40 ± 2.65 ^a	460.46 ± 1.65
Mg	825.67 ± 8.74 ^a	1093.33 ± 3.81 ^b	959.50 ± 6.27
P	541.67 ± 8.50 ^a	1165.07 ± 8.06 ^b	853.37 ± 8.28
Na	1.57 ± 0.21 ^a	2.53 ± 0.15 ^b	2.05 ± 0.18
K	20.53 ± 0.35 ^a	39.33 ± 1.16 ^b	29.93 ± 0.75

^a Values are average of triplicates ± standard deviation. Different letters in each row show significant statistical difference ($P < 0.05$). ^b $N \times 6.25$, ^c Including crude fiber.



press cakes but lower fat, protein and ash content than strawberry and blackberry press cakes (Sudha *et al.*, 2007; O'Shea *et al.*, 2015; Kosmala *et al.*, 2017). Moreover, the glucose (1.4%) and fructose (1.8%) content of strawberry press cake reported by Sójka *et al.* (2013) were lower than the date press cake measured in this research.

Fine and coarse samples had similar moisture, ash, carbohydrate and protein content. However, the coarse sample had significantly ($P < 0.05$) higher fiber but lower sugar and fat content than the fine sample. The higher fiber content of the coarse sample can be related to its higher content of date seed, which is a rich source of fiber (Hamada *et al.*, 2002). On the other hand, the fine sample contained more date flesh, which is high in sugar. In addition, the larger surface area of the fine sample could assist with the extraction of more fat and sugars resulting in the higher content of these materials being determined in the fine sample.

Analysis of nine minerals in the samples (Table 1) showed that Mg had the highest content followed by P, while Na had the lowest content in both samples. Date press cake with fine particle size, had significantly ($P < 0.05$) higher mineral content than the coarse sample, except for the Cu and Ca. This may indicate that some minerals were more extractable from the fine samples due to its larger surface area as well as different concentrations of various minerals in the date seed and flesh, which requires further investigation. Date press cake had higher micro minerals (Fe, Mn, and Zn) while lower macro minerals (Na, K, Ca, and Mg) content than Shahani date fruit reported by Rastegar and Raahemi (2016). This is mainly related to the juicing process, which could wash out some minerals. Furthermore, another reason may be due to the different mineral concentrations in the date flesh and seeds, which requires further studies. On average, date press cake had higher Zn and Fe content but lower Ca, P, Mn content than those of apple and orange press cakes reported by O'Shea *et al.* (2015).

FA Profile of Date Press Cake

Both samples had higher amounts of mono unsaturated fatty acids than polyunsaturated fatty acids (Table 2). The main FA of both samples was oleic acid (C 18:1), which is also the predominant FA in the Shahani seed oil according to Biglari *et al.* (2008) as well as other date fruits (Al-shahib and Marshall, 2003). Myristic acid was the major unsaturated fatty acid while behenic, luric and capric acids were the minor unsaturated fatty acids in both samples. Changing the particle size of the date press cake significantly influenced the fatty acid composition of the samples. The coarse sample had lower ratio of saturated to unsaturated FA (0.93 vs 1.07) and higher content of oleic acid than the fine sample. Date seed is a rich source of fatty acids and hence its higher content in the coarse sample would result in higher fatty acids, particularly oleic acid (Al-shahib and Marshall, 2003). No data on the fatty acid content and composition of date press cake was found for comparison.

Antioxidant Activity

On average, date press cake contained 17.79 mg g⁻¹ phenolic content and 1.89 mg g⁻¹ flavonoid content (Table 3). The phenolic content was close to the value reported for Shahani date fruit (18 mg g⁻¹), while the flavonoid content was considerably lower than the reported values (35 mg g⁻¹) (Rastegar and Raahemi, 2016). Thus, it is possible to conclude that the date antioxidants, particularly flavonoids, are extracted into the date juice leading to lower flavonoid content of the press cake. It is likely that the phenolic and flavonoid compounds have different concentrations in different parts of the date fruit including seeds, flesh, and skin, and hence the juicing process may change their concentration in the press cake, which requires further studies. This is further supported by Al-Farsi *et al.* (2007) who reported that date seeds had higher phenolic

Table 2. Fatty Acid (FA) composition (%) of different particle sizes of date press cake. ^a

	Coarse (355 μm)	Fine (167 μm)	Average
Saturated FA	48.42 ± 2.28 ^a	52.46 ± 1.56 ^b	50.44 ± 1.92
Unsaturated FA	51.98 ± 2.31 ^b	48.65 ± 1.60 ^b	50.31 ± 1.95
Mono unsaturated FA	42.25 ± 1.42 ^a	39.89 ± 1.37 ^a	41.07 ± 1.39
Poly unsaturated FA	9.73 ± 0.99 ^a	8.76 ± 0.25 ^a	9.24 ± 0.62
Oleic acid (C18:1)	42.25 ± 1.42 ^b	39.89 ± 1.37 ^a	41.07 ± 1.39
Myristic acid (C14:0)	21.37 ± 3.14 ^a	26.17 ± 1.63 ^b	23.77 ± 2.25
Stearic acid (C18:0)	13.43 ± 1.07 ^b	11.42 ± 0.34 ^a	12.42 ± 0.70
Palmitic acid (C16:0)	12.52 ± 0.21 ^a	12.65 ± 0.26 ^a	12.58 ± 0.23
Linoleic acid (C18:2)	9.73 ± 0.99 ^a	8.76 ± 0.25 ^a	9.24 ± 0.62
Lauric acid (C12:0)	0.44 ± 0.09 ^a	0.78 ± 0.11 ^b	0.61 ± 0.10
Behenic acid (C22:0)	0.42 ± 0.11 ^a	0.64 ± 0.10 ^b	0.53 ± 0.10
Capric acid (C10:0)	0.24 ± 0.00 ^a	0.80 ± 0.11 ^b	0.52 ± 0.05

^a Values are the average of triplicates ± standard deviation. Different letters in each row show significant statistical difference (P < 0.05).

Table 3. Bioactive compounds and antioxidant activity of coarse and fine date press cake. ^a

	Coarse (355 μm)	Fine (167 μm)	Average
Total phenolic content (mg of gallic acid equivalents g ⁻¹ sample)	16.18 ± 0.03 ^a	18.78 ± 0.04 ^b	17.79 ± 0.03
Total flavonoid content (mg of quercetin g ⁻¹ sample)	1.84 ± 0.05 ^a	1.95 ± 0.04 ^b	1.89 ± 0.04
IC50 (mg mL ⁻¹)	1.46 ± 0.69 ^b	1.39 ± 0.60 ^a	1.42 ± 0.79
Cupric reducing antioxidant capacity (mg Vit C g ⁻¹ sample)	1.27 ± 0.02 ^a	1.88 ± 0.04 ^b	1.57 ± 0.03
Ferric reducing antioxidant potential (mg Vit C g ⁻¹ sample)	9.12 ± 0.30 ^a	9.53 ± 0.15 ^a	9.32 ± 0.22
Chelating effect (%)	5.37 ± 0.45 ^a	10.37 ± 0.60 ^b	7.87 ± 0.52

^a Values are the average of triplicates ± standard deviation. Different letters in each row show significant statistical difference (P < 0.05).

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). Sójka *et al.* (2013) also indicated that the flavonols are strongly bond to the strawberry cell walls, which remains in the press cake while their presence in the juice is very limited.

Compared to other fruit press cakes, date press cake (current research) had higher phenolic and flavonoid content than those of 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) (Viskeliš *et al.*, 2017), and lower flavonoid content than strawberry press cake (18.84 mg g⁻¹) (Sójka *et al.*, 2013).

The fine sample had significantly (P < 0.05) higher total phenolic and flavonoid content, cupric reducing antioxidant capacity and chelating effect, but lower IC50 (meaning higher antioxidant activity) than the coarse particles. The coarse sample contains more seed particles of higher antioxidant compounds but they remain mostly intact (Al-farsi and Lee, 2008).

Color of the Date Press Cake Samples

Figure 1 shows the appearance of the date press cake before and after milling. Both samples exhibited light brown color due to the natural pigments from the date flesh and



seed mainly carotenoids and anthocyanins (Baliga *et al.*, 2011; Fadel *et al.*, 2006).

Color analysis of the samples (Table 4) showed that the fine sample was lighter, more reddish and yellowish than the coarse sample. Similar findings have been reported for wheat bran with different particle sizes (Majzoubi *et al.*, 2013; Onipe *et al.*, 2017). The brighter color of the fine sample can be attributed to the smoother surface of the sample, which allows more light reflection on the surface. The differences in the chemical composition also affect the color of the samples (Onipe *et al.*, 2017).

Hydration Properties of the Date Press Cake with Different Particle Sizes

Fine sample showed higher WHC and solubility than the coarse sample (Table 4). WHC could be affected by size, shape, hydrophilic and hydrophobic interactions and

the presence of lipids, carbohydrates and amino acid residues on the surface (Moure *et al.*, 2001). The higher WHC of the fine sample compared to the coarse sample (4.55 vs 3.57) can be due to its larger surface area, more porous structure, and different chemical composition, which allowed more water interactions. This could also allow more materials (e.g. simple sugars and proteins) to become soluble in water resulting in higher water solubility.

The WHC value of date press cake in this research (average of 4.06) was lower than peach (10.60), pineapple (5.32), orange (12.25), and apple (8.54) press cake (Grigelmo-Miguel *et al.*, 1999; Selani *et al.*, 2014; Figuerola *et al.*, 2005; O'Shea *et al.*, 2015), which is attributed to their different chemical composition and processing conditions affecting their ability to interact with water.

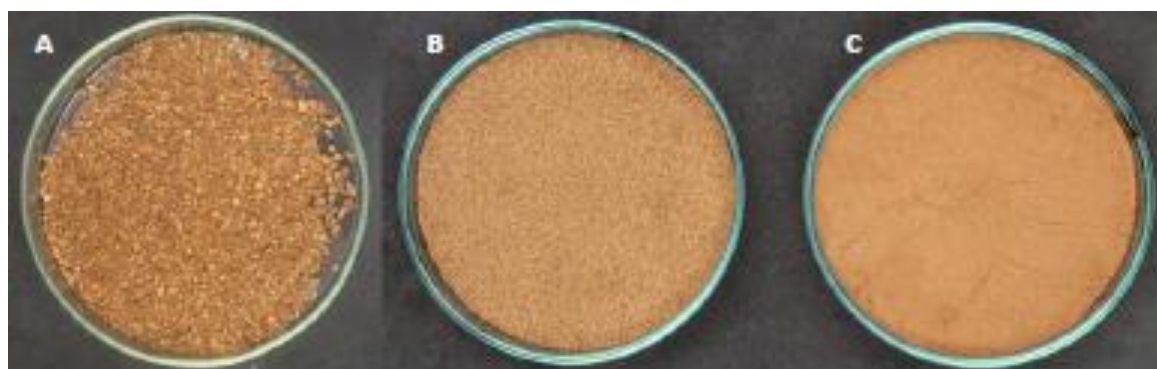


Figure 1. The appearance of date press cake before milling (A) and after milling with particle size of 355 (B) and 167 μm (C).

Table 4. Color parameters, Water Holding Capacity (WHC), solubility and pH of coarse and fine date press cake powder.^a

	Coarse (355 μm)	Fine (167 μm)	Average
L-Value	68.00 \pm 1.41 ^a	73.25 \pm 3.20 ^b	70.62 \pm 0.23
a-Value	13.00 \pm 0.82 ^a	15.50 \pm 0.58 ^b	14.25 \pm 0.70
b-Value	35.25 \pm 0.96 ^a	37.75 \pm 0.96 ^b	36.5 \pm 0.96
WHC	3.57 \pm 0.36 ^a	4.55 \pm 0.39 ^b	4.06 \pm 0.37
Solubility (%)	16.38 \pm 0.19 ^a	18.17 \pm 0.31 ^b	17.27 \pm 0.25
pH	5.26 \pm 0.02 ^b	5.19 \pm 0.02 ^a	5.22 \pm 0.02

^a Values are the average of triplicates \pm standard deviation. Different letters in each row show significant statistical difference ($P < 0.05$).

pH of the Date Press Cake

Both samples were mildly acidic with pH values of 5.19 and 5.26, respectively. The acidic nature of date press cake is because of the natural organic acids originating from date fruit including acetic, succinic, maleic, and tartaric acid (Mortazavi *et al.*, 2010; Ghnimi *et al.* 2017). Slightly lower pH of the fine sample could be related to the extraction of more acids from the fine sample during pH measurement due to its larger surface area. The pH value of date press cake (5.22) was higher than the pH of date juice (4.24) reported by Farahnaky *et al.* (2016) but lower than the value of Shahani date fruits (6.3) as reported by Rastegar and Raahemi (2016). This may indicate that the soluble organic acids of the date fruits were mostly extracted in the juice resulting in higher pH of the date press cake.

CONCLUSIONS

Determination of the physicochemical and antioxidant properties of the date press cake as carried out in this research revealed that date press cake can be considered as a valuable functional ingredient high in dietary fiber and antioxidants in development of novel and healthy foods. Due to its natural brown color, date press cake may be a suitable choice in dark color foods such as bakery products. The moderate water holding capacity of date press cake may be advantageous in products such as salad dressing, instant soups and desserts in which improved hydration and viscosity are desirable.

Particle size of the date press cake should be considered for its applications as it affects the chemical composition, nutritional value, and functional properties. Further works are required to study the applications of date press cake with different particle sizes in production of value added food products.

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ترکیبات شیمیایی و ویژگیهای عملکردی کنجاله ی خرما به عنوان محصول جانبی فراوری محصولات کشاورزی

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چکیده

کنجاله ی خرما یک محصول جانبی حاصل از آبنگیری میوه خرما است که بدون استفاده در محصولات غذایی باقی مانده است. دلیل اصلی این امر مربوط به کمبود اطلاعات و دانش فنی در مورد ترکیبات شیمیایی، ارزش غذایی، اثرات سلامت بخشی و تاثیرات احتمالی آن بر کیفیت مواد غذایی می باشد. هدف اصلی از این پژوهش تعیین ترکیبات شیمیایی، ترکیبات زیست فعال و ویژگی های عملکردی کنجاله ی خرما به منظور افزایش کاربردهای غذایی آن به عنوان یک ترکیب عملگرا، اقتصادی و در دسترس بود. این پژوهش بر روی کنجاله ی حاصل از خرما ی شاهانی با اندازه ی ذرات ۳۵۵ میکرومتر (زبر) و ۱۶۷ میکرومتر (نرم) انجام شد. به طور کلی کنجاله ی خرما ی شاهانی دارای ۱۳/۳۷٪ رطوبت، ۴/۹۲٪ چربی، ۶/۳۵٪ پروتئین، ۱۱/۷۴٪ فیبر خام و ۷۹/۰۶٪ کربوهیدرات بود. فروکتوز قند ساده ی اصلی، منیزیم ماده معدنی عمده، اولیک اسید به عنوان اسید چرب غالب، و ترکیبات فنولی مهمترین آنتی اکسیدان موجود در کنجاله ی خرما بود. ترکیبات شیمیایی و ویژگی های عملکردی کنجاله ی خرما تحت تاثیر اندازه ی ذرات آن قرار گرفت. نمونه ی زبر دارای فیبر، اولیک اسید، فنول و فلاونوئید کل و فعالیت آنتی اکسیدانی کمتری نسبت به نمونه ی نرم بود. نمونه ی نرم دارای مقدار بیشتری قند و چربی بود و ظرفیت نگهداری آب و حلالیت آن بیشتر از نمونه ریز بود.