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Physicochemical Properties of Seeds and Seeds Oil Extracted from Iranian Date Palm Cultivars

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ABSTRACT: In the present study, the seeds of two date palm (*Phoenix dactylifera* L.) cultivars, Mazafati (Jiroft & Bam) and Kalutah were analyzed for their physical properties and chemical composition. Studies were also conducted on properties of oil extracted from the seeds and its fatty acid composition. The seeds constitute about 6-10% of the fruit weight. The seeds weight ranged from 0.73-0.84g, the length from 19.4-21.0mm, and the diameter from7.3-8.5mm. They, on the average, contained 4.84% protein, 12.22% fat, 27.58% fiber, 80.76% carbohydrates, 1.18% ash, and 1.72% moisture. Mineral analysis showed higher concentration of Fe followed by Ca, Cu, Na, Zn, and Mn. The seeds were also a rich source of phenolics, which ranged from 1840.93 to 1952.93mg GAE/100g. The date seed oils were a yellow semi-liquid having refractive index of 1.459. The average chemical characteristics of the date seed oils were: iodine value 55.153g/100g oil, saponification value 228.067mg KOH/g oil, and peroxide value 15.537mg O_2/1000g oil. The main fatty acids of the seed oils were oleic (48.10-50.50%), lauric (14.00-15.80%), palmitic (10.80-11.70%), myristic (10.60-10.90%), linoleic (7.70-8.20%), and stearic acids (3.00-3.40%). Linolenic, palmitoleic, arachidonic, caprylic, and capric acids were also found in negligible amounts, average values being 0.5%, 0.3%, 0.3%, 0.5%, and 0.3%, respectively. The fatty acid profiles of Mazafati Jiroft and Mazafati Bam seed oils were similar with minor differences. Kalutah seed oil contained higher amounts of saturated fatty acids (caprilic, capric, lauric) than Mazafati seed oil.

Keywords: Arecaceae, date palm, Kalutah, Mazafati, *Phoenix dactylifera* L., seed oil.

INTRODUCTION

The date palm (*Phoenix dactylifera* L.) grows in the arid and semi-arid regions of the world especially in most of the Middle Eastern countries. It has played an effective role in survival of many old civilizations. As a valuable nutrient, the date palm dated back to 6000 BC (Dowson, 1982). Dates have also an important role in economics of the date producing countries (Gurevich *et al*, 2005). Iran is one of the main date producing countries with the annual production of about 1 million tons of date and 100000-150000 tons exportation. Date fruit composed of a seed with a hard endocarp and a thin epicarp which constitutes 10-46% of date fruit weight (Sotolu *et al*, 2011). The seeds are oblong with an abdominal groove, a small embryo and a hard endosperm placed inside a cellulose wall (Al-Farsi and Lee, 2011). Date seeds are odorless with a dark brown color and bitter taste (Hamada *et al*, 2002). Recent studies show that date seed contains 77.52% carbohydrate (Besbes *et al*, 2004; Nehdi *et al*, 2010; Rahman *et al*, 2007; Sawaya *et al*, 1984), 5.77% protein and 10.62% fat (Sawaya *et al*, 1984; Saafi *et al*, 2008; Besbes *et al*, 2004; Nehdi *et al*, 2010; Hamada *et al*, 2002; Rahman *et al*, 2007), 9.375% moisture (Nehdi *et al*, 2010; Hamada *et al*, 2002) and 1.294% ash (Besbes *et al*, 2004; Hamada *et al*, 2002). Many minerals such as sodium, potassium, calcium, iron, copper, magnesium, zinc, phosphorus, lead, cadmium and chromium are reported in date seeds (Abdul Afigh *et al*, 2013). Date seeds are an excellent source of dietary fiber (64.5-80.15 g/ 100 g fresh weight) (Al-Farsi and Lee, 2011) and also rich in phenolic compounds (3102-4430 mg GAE/100 g) and antioxidants (580-929µmol trolox equivalents/g fresh weight) (Al-Farsi *et al*, 2007). The oil of date seed contains high percentage of oleic and lauric acids. Natural antioxidants such as tocopherol and polyphenols are found in date seed oil. The oil has high oxidative stability due to low content of polyunsaturated fatty acids (Amany *et al*, 2012).

Kerman is the widest province in Iran and it is in the first rank for producing date in the country. Different date cultivars are cultivated in this region which among them Mazafati date and Kalutah date are considered the main cultivars and they are popular for their high quality. Mazafati date is the best date for export and domestic market. To best of our knowledge, no work has been carried out on the physicochemical properties of the seed and seed oil in these cultivars. The aim of this research was to study physicochemical properties and fatty acid profile of date seeds from two important date cultivars, Mazafati and Kalutah, grown in Kerman, Iran.

MATERIALS AND METHODS

Date cultivars, Mazafati and Kalutah, were obtained from the Agricultural Research Stations located in Bam and Jiroft areas of Kerman province, Iran. The seeds were separated manually and soaked in water and washed to remove any adhering date flesh and then air-dried. They were further dried in oven at 60°C. The seeds were ground in a hammer millto 1 mm particle size. The seed powders were stored under refrigeration in polyethylene bags until analysis. Twenty date fruits from each cultivar were selected randomly. The weight of the fruits and seeds was determined and the percentage of the seeds was calculated. The length and diameter of the date seeds were measured using a micrometer and the volume was determined by water displacement (Habib and Ibrahim, 2009). Chemical analysis was performed according to the Association of Official Analytical Chemists (AOAC, 1990). Date seed oil was extracted using n-hexane solvent. Moisture content and protein content were determined by air oven and the Kjeldahl method, respectively. Protein was calculated by multiplying the total nitrogen content by a factor of 6.25 (El-Shurafa *et al*, 1982). To determine ash, about 2g of date seed powder was ignited and incinerated in a furnace at 550°C for 8 h (Besbes *et al*, 2004). It was expressed as a percent of dry weight. The minerals (Ca, Na, K, Fe, Cu, Mn, and Zn) were analyzed using an atomic absorption (Thermo Elmentar AA, England). Phosphorus content was determined by the phosphor molybdovanate method. Carbohydrate content was calculated in accordance to the following formula: 100 - (%moisture + % ash+% protein +% oil) (Nehdi *et al*, 2010). Total phenolics were measured by colorimetric method using Folin-Ciocateaure agent (Velioglu *et al*, 1998). 1,1-Diphenyl-2-Picryl-hydrazyl (DPPH) was used to determine antioxidants (Tadhani *et al*, 2007). The refractive index of date seed oil was measured using a refractometer (Atago, Japan). The iodine and saponification values were determined according to the American Oil Chemists Society method (AOCS, 1993). The peroxide value was measured in accordance to thiocyanate method. Fatty acids of date seed oil were determined by the preparation of fatty acid methyl esters and use of a GC-FID equipped with a capillary column (BPX70, 10 m, 0.1 mm film thickness). The detector temperature was 280°C and the column temperature was set on 50-250°C.The run time was 45 min. The fatty acid methyl esters peaks were recognized comparing their retention times with standard FAMEs. All tests were performed in triplicate. Statistical analysis was carried out using SAS software (version 9.1). Data were analyzed using a completely randomized block design method. Data were compared using analyses of variance and by the Duncan's multiple range tests with a probability of $p < 0.05$.

RESULTS AND DISCUSSION

Table 1 presents the average physical characteristics of date seed of the studied cultivars. Date seeds from Mazafati and Kalutah cultivars included about 6-10% of the fruit weight. The seed weight of date cultivars was in the range of 0.73-0.84g. The average length and diameter values for the seeds were 19.40-21.05mm and 7.38-8.37mm, respectively. However, there were differences in physical properties among the date seeds. According to Habib and Ibrahim (2009), environmental factors, irrigation, soil fertilization and post-harvest treatments can affect the physical properties of date fruits and also likely those of date seeds.

Date seeds from Mazafati and Kalutah cultivars contained 26.18- 28.56% crude fiber, 10.66-14% fat, 4.44-5.07% protein, 1.66-2.33% moisture, 1-1.52% ash and 79.32-82.97% total carbohydrate (Table 2). Kalutah date seeds had the lowest fat content (10.66%), whereas Mazafati Jiroft had the highest fat content (14%).

Table 1: Physical characteristic of date seeds of Mazafati and Kalutah cultivars.

Cultivar	Physical characteristic				
	Mass (g)	Length (mm)	Diameter (mm)	Volume (ml)	Percentage from fruit
Mazafati Bam	0.84 [a]	21.05 [a]	8.37 [a]	0.62 [a]	6.23
Mazafati Jiroft	0.78 [b]	20.82 [a]	8.58 [a]	0.58 [a]	6.69
Kalutah	0.73 [c]	19.40 [b]	7.38 [b]	0.57 [a]	9.80

Means with similar letters within the same columns are not significantly different ($p< 0.05$).

The amount of fat in date seeds was reported in the range of 7.7 to 12.7% (Al-Shahib and Marshall, 2003; Hamada *et al*, 2002; Al-Farsi and Lee, 2011). The seeds of Mazafati Jiroft and Kalutah date cultivars were significantly ($p < 0.05$) higher in crude fiber (28%) and protein (5%) compared to Mazafati Bam date seeds. As a result, there were differences in chemical composition of seeds between two date cultivars (Mazafati & Kalutah) and also the cultivar grown in different regions (Jiroft & Bam). It was reported that the dietary fiber content of seeds of the 18 date cultivars grown in the United Arab Emirates was different. The observed differences were probably due to maturation stage (Habib and Ibrahim, 2009). In general, our results were in agreement with those reported by Hamada *et al*, 2002 and Besbes *et al*, 2004. Saafi *et al*, 2008 reported that the differences in chemical composition of the flesh and seed might be due to the variability of the cultivars and also climatic conditions. However, carbohydrates and fats are more important than proteins in date seeds because the protein content in date seeds is low and it may not be very digestible (Hamada *et al*, 2002).

Table 2: Chemical composition and mineral content of the date seeds.

Component	Cultivar		
	Mazafati Bam	**Mazafati Jiroft**	**Kalutah**
Composition (%)			
Moisture	2.33^{a}	1.66^{a}	1.66^{a}
Fat	12^{a}	14^{a}	10.66^{a}
Protein	4.44^{b}	5.01^{a}	5.07^{a}
Ash	1.52^{a}	1.00^{b}	1.01^{b}
Total Carbohydrate	79.32^{c}	79.97^{b}	82.97^{a}
Crude Fiber	26.18^{b}	28.07^{a}	28.56^{a}
Minerals (meq/L)			
Sodium	25.33^{b}	25^{b}	29.667^{a}
Calcium	25.33^{b}	25^{b}	29.66^{a}
Potassium	0.6^{a}	0.4^{a}	0.47^{a}
Manganese	4.5^{b}	7.6^{a}	7.9^{a}
Phosphorus	0.06^{b}	0.08^{a}	0.06^{b}
Cupper	25.32^{b}	25.14^{b}	29.64^{a}
Zinc	6.23^{c}	11.0^{b}	153.33^{a}
Iron	43.76^{b}	106.66^{a}	42.90^{c}

Means with similar letters within the same rows are not significantly different ($p< 0.05$).

Table 2 shows the mineral content of date seeds for the cultivars. The seeds contained significant level of minerals such as iron, calcium, copper, sodium, zinc and manganese. Mineral analysis showed that iron concentration was the highest in both seeds. Phosphorus and potassium were present in the lowest level, ranging from 0.06-0.08meq/Land 0.40-0.60meq/L, respectively. Attalla and Harraz (1996) reported that the seeds of 11 date cultivars grown in Qassim region had 0.19-0.26% phosphorus. Sodium, calcium and cupper contents in Mazafati date seeds grown in different regions were similar. The level of zinc in Mazafati date seeds was in the range of 6.23-11meq/L and it had the highest content (153.33meq/L) in Kalutah date seeds. Minerals are important for the body. For example, iron is an essential trace element for all living organisms. Zinc participates in the structure of brain enzymes and it is essential for general growth of all tissues and also it ensures immune system of the body (Krebs, 2000). Potassium, phosphorus, magnesium, calcium and sodium had the highest levels in date seeds and Iron, manganese, zinc and copper contained the highest levels among the microelements (Ali-Mohamed and Khamis, 2004). Sawaya *et al* (1984) stated that potassium was the most abundant mineral in the seeds of Ruzeiz and Sifri date cultivars, whereas sodium had the lowest concentration. According to Ali-Mohamed and Khamis (2004), total content of minerals in date seeds is comparable to minerals in barley. However, there are differences in the contents of minerals and also their order among different date seeds. These variations may be due to differences in date cultivars (Sawaya *et al*, 1984), genetic and environmental factors, fertilizer, irrigation water and etc. (Habib and Ibrahim, 2009). Total phenolic contents and antioxidant activity of the date seeds are shown in Fig. 1. The date seeds had considerable antioxidant activity ranging from 194488mM ASA/100g to 248166mM ASA/100g. There were significant differences ($p<0.05$) in total phenolic contents among the studied date seeds.

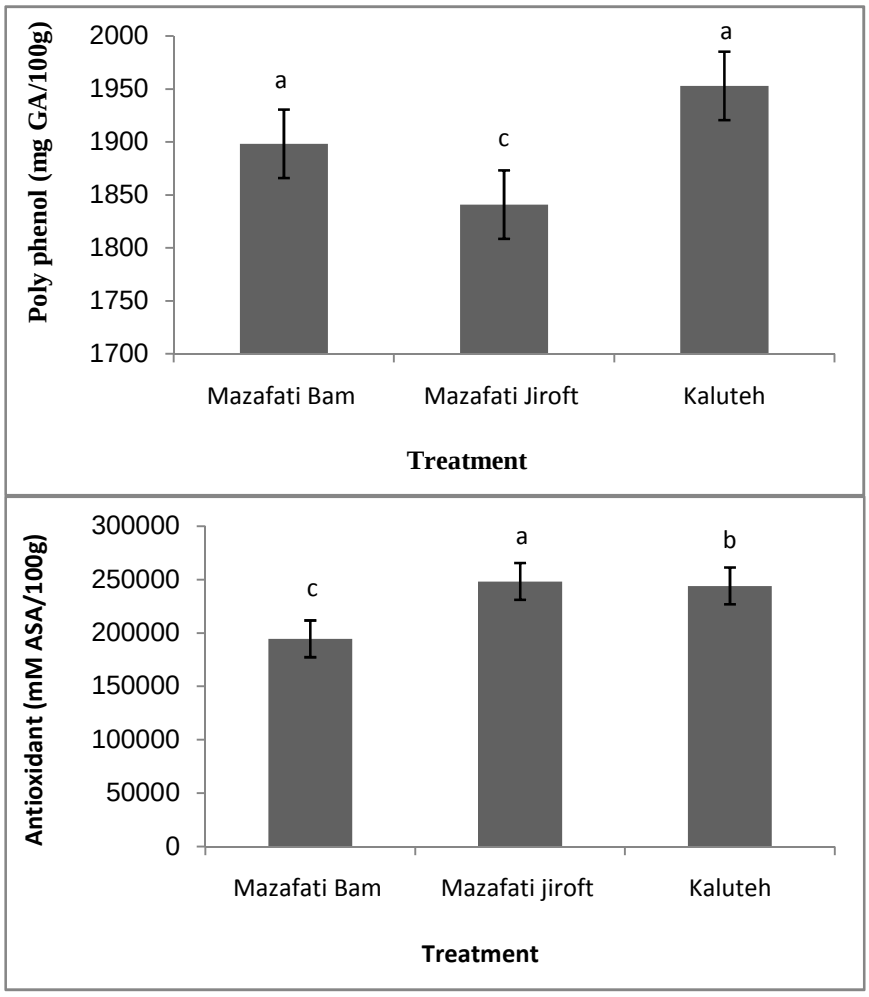

Fig. 1. Total phenolic contents and antioxidant activity of date seed cultivars.

On average, total phenolic contents in Mazafati date seeds (Bam & Jiroft) were 1870mg GAE/100g. Kalutah cultivar had the highest phenolic content (1952.93mg GAE/100g). However, the phenolic contents and antioxidant activity differed according to the cultivar. The phenolic contents and antioxidant activity of the seeds of three date cultivars (Mabseeli, Um-sellah, and Shahal) from Oman were 3102-4430mg GAE/100g and 580-929µmol of Trolox equivalent/g fresh weight, respectively (Al-Farsi *et al*, 2007). Abdul Afiq *et al* (2013) reported that the total phenolic content in date seeds was 48.64mg/ 100g. The amount of polyphenols and antioxidant activity in date seeds was reported to be higher than date fruit (up to 10 fold), grape seed and tea extract (Platat *et al*, 2013).

Dates were also found to be good sources of antioxidants in comparison with figs, prunes, and raisins (Al-Farsi *et al*, 2007). The date seed oils were yellow in color and semi-solid. Physicochemical characteristics of the extracted oil of the date cultivars (Mazafati & Kalutah) are presented in Table 3. The refractive index of Kalutah seed oil (1.4599) was higher than that of Mazafati seed oils (1.4580-1.4588). Refractive index was reported to be 1.456 in *P. canariensis* seed oil (Nehdi *et al*, 2010) and 1.458 in two date palm cultivars of Sudan (Mahmoud Abdalla *et al*, 2012). The iodine value of Mazafati Bam, Mazafati Jiroft, and Kalutah seed oils were 46.2, 54.1 and 65.16g/100g oil, respectively (Table 3).

Table 3: Characteristics and fatty acid composition (% of total fatty acid) of the date seed oils.

Analysis	Cultivar		
	Mazafati Bam	**Mazafati Jiroft**	**Kalutah**
Peroxide value (meq/kg)	15.36	14.65	16.59
Iodine value (gI_2/100g oil)	46.2	54.1	65.16
Saponification value (mgKOH/100g oil)	227.29	171.43	285.48
Refractive index	1.4580	1.4588	1.4599
Caprylic (C8:0)	0.1	0.3	1.2
Capric (C10:0)	0.2	0.2	0.5
Lauric (C12:0)	14	14.3	15.8
Myristic (C14:0)	10.8	10.9	10.6
Palmitic (C16:0)	11.7	11.8	10.8
Palmitoleic (C16:1)	0.3	0.2	0.4
Stearic (C18:0)	3.1	3.4	3
Elaidic (C18:1) Trans	0.1	0.1	-
Oleic (C18:1)Cis	50.5	49.7	48.1
Linoleic (C18:2)	8	7.7	8.2
Linolenic (C18:3)	0.5	0.4	0.7
Gondoic (C20:1)	0.4	0.3	0.2
Behenic (C22:0)	0.1	-	-

All values given are means of three determinations.

Besbesetal (2004) reported that the iodine value of date seed oil was in the range of 44-61g/100g oil and according to Abdul Afiq *et al* (2013), it was 76.7g/100g. The seed oil of Kalutahhad the highest peroxide value (16.598mg O_2/1000g oil) and on average, the peroxide value of Mazafati seed oil was 15mg O2/1000g oil. The average saponification value of the date seed oils was 228mg KOH/g oil. Our results were in agreement with those reported by Devshony *et al*, 1992; and Al-Farsi and Lee, 2011. As referred, date seeds from the cultivars contained 10.66-14% fat. Table 3 presents the fatty acid composition of the date seeds, which contain saturated, monounsaturated, and polyunsaturated fatty acids.

Fatty acid analysis showed that oleic acid (48.1-50.5%) and lauric acid (14-15.8%) were the main fatty acids followed by Palmitic acid (10.8-11.8), myristic acid (10.6-10.9%), linoleic acid (7.7-8.2%), and stearic acid (3-3.4%). Therefore, date seed oil can be considered as oleic-lauric oil. This result was in agreement with that reported by Devshony *et al*, 1992 and Saafi *et al*, 2008. Besbes *et al* (2004) stated that the seed oil of some date cultivars can be regarded as oleic-linoleic oil. Behenic acid, elaidic acid, gondoic acid, linolenic acid, palmitoleic acid, caprylic acid and capric acid were minor components in the seed oils. As indicated in Table 3, fatty acid composition of Mazafati Bam seed oil is similar to that of Mazafati Jiroft. Sawaya *et al* (1984) reported that oleic acid (44.25%), lauric acid (17.35%), Myristic acid (11.45%), Palmitic acid (10.30%) and linoleic acid (8.45%) were the major constituents in date seed oil.

Al-Shahib and Marshall (2003) reported that oleic acid was the major fatty acid in the seed oil of 14 date cultivars.

Besbes *et al* (2004) also reported that oleic, linoleic, palmitic, myristic and lauric acids together composed 92% of the total fatty acids in the seed oil of Allig and Deglet Noor dates. According to Nehdi *et al* (2010), oleic acid composed about 50% of the total fatty acid in *P. canariensis* seed oil followed by linoleic acid (19.23%), lauric acid (10.24%) and Palmitic acid (9.83%).

Analysis of the seeds from Iranian commercial dates (Mazafati and Kalutah) showed that they contained considerable amounts of fiber, fats, protein, some minerals, and total phenolics. It could be concluded that the date seeds are suitable for the preparation of fiber-based foods. The results also showed that chemical composition differed among the date seeds of different cultivars. The main fatty acids in both date seed oils were oleic acid and lauric acid, followed by palmitic acid, myristic acid and linoleic acid. The date seed oils were low in polyunsaturated fatty acids (8.1-8.9%). This characteristic is important in their stability during storage and they may have good shelf-life. Therefore, date seeds can be a useful source of edible oils for human consumption after testing their safety.

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