International Food Research Journal 20(5):2035-2043 (2013)
Journal homepage: *http://www.ifrj.upm.edu.my*

MiniReview

Date seed and date seed oil

[1]Abdul Afiq, M.J., [1,2,3*]Abdul Rahman, R., [1,2,4]Che Man, Y.B., [4]AL-Kahtani, H.A. and [1]Mansor, T.S.T.

[1]Halal Products Research Institute, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia
[2]Faculty of Food Science and Technology, Department of Food Technology, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia
[3]Faculty of Engineering, Department of Process and Food Engineering, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia
[4]College of Food and Agriculture Sciences, Department of Food Science and Nutrition, King Saud University, P.O. Box 2460, Riyadh 11451, Saudi Arabia

Article history

Received: 24 December 2012
Received in revised form: 21 March 2013
Accepted: 28 March 2013

Keywords

Date seed
Date seed oil
Fatty acid composition
Date varieties
Antioxidant content
Dietary fiber

Abstract

Date palm is an important plant in arid regions with more than 20 varieties reported all over the world. Date seed is a byproduct of date fruit industry which is normally being discarded, used as animal feed ingredient or turned into non-caffeinated coffee by the Arabs. About 11-18% of date fruit weight is the seed which is composed of carbohydrates, dietary fiber, fat, ash and protein. In addition, the antioxidant content in date seed oil (DSO) was found to be comparable with olive oil, which can be as a good source of antioxidant in order to fulfill the consumers demand. Oleic acid is the major fatty acid found in DSO, followed by lauric, linoleic, palmitic and myristic acid. However, different varieties of date fruits have different fatty acid compositions. This paper reviewed the potential use of date seed and date seed oil in order to discover and develop its usage and find out the suitable application of these seed and oil.

Introduction

Date fruit (*Phoenix dactylifera* L) has become an important fruit in some countries as a source of nutrition and economics (Nancib *et al.*, 1997; Bendiab *et al.*, 1998; Al-Qarawi *et al.*, 2003; Awad 2007; Al-Farsi *et al*., 2007; Baliga *et al*., 2010; Briones *et al*., 2011). Date fruit consists of 73-79% carbohydrates, 14-18% total dietary fibers, 2.5% ash, 2.1-3.0 % protein (Elleuch *et al*., 2008), and 2.0-3.2% fat (Al-Farsi *et al*., 2007), depending on the variety of the date fruit. The Food and Agriculture Organization of the United Nations (FAO, 2010) reported that during 2010, the total world production of dates have exceeded 7 million tons, meaning that approximately more than 1 million tons of date seeds were produced during that year. The date seed (Figure 1(a)) have been used traditionally as the animal feed or grinded into smaller size and being roasted to turn it into caffeine-free coffee substitute, which have been commercialized by the Arabs in two types, whether plain or mixed with coffee (Rahman *et al.*, 2007; Al-Farsi and Lee, 2011).

Generally the date fruit can be categorized into several maturity stages. The first stage known as the "hababouk" stage (the fruits are fully layered by the calyx leaves and only pea-sized). The second stage known as the "kimri" stage (the color of the fruit is green and the shape changes from small berry to oblong). The third stage called as the "khalal" or "besser" stage (the color of the fruit changes from green to yellow to red and reaches its maximum weight and size). The fourth stage known as the "rutab" stage (the date flesh become softer, the color of the fruit turns darker in color and decreases weight due to loss of water) and the fifth stage, the "tamar" stage (known as the final and full ripe stage, the color of the fruit changes into darker color and looks dehydrated) (Al-Shahib and Marshall, 2003a; Baliga *et al.*, 2010; Amira *et al.*, 2011). The weight of the four varieties of date fruit namely Allig, Degla, Deglet Nour and Gosbi and it's seeds decrease as the maturation process takes place from the besser stage through the tamar stage except for the Horra variety, in which the seed weight increases although the fruit weight decreases (Amira *et al*., 2011). This paper will review some of the characteristics of the date seed and date seed oil as well as some comparison of this oil with other vegetable oils such as olive oil, canola oil, virgin coconut oil and palm oil.

*Corresponding author.
Email: *russly@food.upm.edu.my*
Tel.: +603-89430405; Fax: +603-89439745

Table 1. Date flesh and seed composition (%)

Component	Date Flesh *[1,2,3]	Fresh Date pits *[4]	Date pits (dry basis) *[5]	Roasted date pits (dry basis) *[6]
Moisture	9.7-17.7	8.6-12.5	-	-
Protein	1.1-3.0	4.8-6.9	5.2-5.6	7.1
Fat	0.5-3.3	5.7-8.8	10.2-12.7	8.1
Ash	1.4-2.6	0.8-1.1	1.1-1.2	1.0
Dietary fiber	5.9-18.4	67.6-74.2	-	-
Carbohydrate	72.8-85.0	2.4-4.7	81.0-83.1	62.3

*[1] Al-Farsi *et al*., 2007; [2] Elleuch *et al*., 2008; [3] Besbes *et al*., 2010; [4] Habib and Ibrahim, 2009; [5] Nancib *et al*., 1997; [6] Rahman *et al*., 2007

Date seed composition

Seed play an important part for certain plants in production of the new plant generation. Normally a seed is composed of proteins, carbohydrates and lipids, which is either in wax, fat or oil form. Among these three components, the oil content is the most important for seed germination as the oil can supply twice the energy needed for the germination process compared to proteins and carbohydrates (Baud and Lepiniec, 2010).

About 11-18% of the date fruit weight comes from the seed (Besbes *et al*., 2004a; Nehdi *et al*., 2010; Amira *et al.*, 2011). Table 1 shows the compositions of date flesh, fresh date pit, dry date pit and roast date pit that were determined by several studies. The fat content in the date seed obtained from several studies were range from 5.7 to 12.7% (Besbes *et al.*, 2004a; Besbes, 2005; Rahman *et al.*, 2007; Habib and Ibrahim, 2009; Nehdi *et al*., 2010). They stated that the difference may occur due to different date varieties, different origin, different harvesting time, and the use of fertilizer which could affect the nutrient content of the date. Other than oil, protein, carbohydrate, moisture and ash, the date seed is also composed of several important minerals, namely potassium, magnesium, calcium, phosphorus, sodium and iron (Hamada *et al*., 2002; Ali-Mohamed and Khamis, 2004; Besbes *et al*., 2004a; Al-Farsi *et al*., 2007; Habib and Ibrahim, 2009; Nehdi *et al.*, 2010).

Various studies regarding the date seed have been carried out in order to determine the functional properties of the date seed in food and non-food usage such as thermal properties (Rahman *et al*., 2007), dietary treatment (Hussein *et al.*, 1998; Aldhaheri *et al.*, 2004), macro- and micronutrient composition (Habib and Ibrahim, 2009), phenolic acid composition (Al-Farsi and Lee, 2008b), as a bread ingredient (Almana and Mahmoud, 1994) as well as protein solubility (Hamada *et al*., 2002). These studies shows that date seed can be as a good source of dietary fiber, phenolic component and natural antioxidant, which can be further developed into new products or already existing products. The use of date seed in fiber-based foods and dietary supplements are suggested due to the excellent content of dietary fiber in the seed (Al-Farsi and Lee, 2008b). Sodium, potassium, calcium, iron, copper, magnesium, manganese, zinc, phosphorus, lead, cadmium and chromium are the minerals that are found in date seed. Table 2 shows the minerals content in date seed obtained from several studies. The total mineral content that was found in date seed was comparable with the mineral content in barley, shows that the date seed can be as a good source of minerals, and can also be used to substitute the usage of barley in food products for the same purpose (Ali-Mohamed and Khamis, 2004).

The total dietary fiber found in date seed was 58%, with 53% of it was insoluble dietary fiber namely as hemicelluloses, cellulose and lignin (Alhdaheri *et al.*, 2004; Al-Farsi and Lee, 2008b). In comparison, higher dietary fiber was detected in another study that was carried out on three different date varieties, which range from 65% to 69% of date seed, indicate the high content of lignin and resistant starch (Hamada *et al.*, 2002). On the other hand, protein also had been detected to be present in date seed in considerable amount. Albumin, globulin, prolamin and glutelin are among the soluble protein that was detected in date seed, with 5-6% of total protein content (Hamada *et al*., 2002). The total phenolic content found in date seed was 48.64 mg/100 g. The phenolic acids detected in date seed were gallic acid, protocatechuic acid, *p*-hydroxybenzoic acid, vanillic acid, caffeic acid, *p*-coumaric acid, ferulic acid, *m*-coumaric acid and *o*-coumaric acid (Al-Farsi and Lee, 2008b).

However, besides all of the benefits of date seed, Bokhari (2010) reported that the seeds of six types of date varieties known as Sukhari, Saggae, Rotana, Kholasi, Rashoodia and Nabtat Ali have potential for the growth of seed-borne fungi. Eleven species of seed-borne fungi have been isolated from the date seeds, namely *Alternaria alternate*, *A. chlamydospora*, *Aspergillus flavus*, *Curvularia lunata*, *Drechslera hawaiiensis*, *Eurotium* sp., *Fusarium oxysporum*, *Fusarium solani*, *Monilia* sp., *Penicillium chrysogenum* and *Rhizopus oryzae*.

Fatty acid composition of date seed oil

Date seed oil (Figure 1 (b)) is obtained from date seed through Soxhlet extraction technique. In date seed oil, oleic acid (C18:1) comprises over 50% of the fatty acid content and represents the main fatty acid in the oil, followed by 19% linoleic acid (C18:2), 10% lauric acid (C12:0) and 10% palmitic acid (C16:0) (Nehdi *et al.*, 2010). As shown in Table 3, the oleic, linoleic, lauric and palmitic acid that occurred in Deglet Nour seed oil were 41%, 12%, 18% and 11%, respectively, while in Allig seed oil,

Table 2. Mineral contents in various date seeds

Minerals	Concentration (mg/100 g sample)					
	Roasted date pits *(1)	Deglet Nour seed *(2)	Allig seed *(2)	*P. canariensis* seed *(3)	18 date pit varieties *(4)	Bahraini dates seed *(5)
Sodium (Na)	16.5	10.4	10.25	8.8	7.2-15.4	21.7-26.1
Potassium (K)	254.1	229.0	293.0	255.4	175.0-240.5	459.9-542.2
Calcium (Ca)	19.2	38.8	28.9	48.6	13.4-34.0	6.5-11.3
Iron (Fe)	2.13	2.3	2.21	3.2	1.3-5.0	2.9-6.0
Copper (Cu)	0.5	-	-	-	0.1-0.6	0.4-0.6
Magnesium (Mg)	78.9	51.7	58.4	62.8	58.8-89.7	61.3-69.6
Manganese (Mn)	0.6	-	-	-	0.6-1.3	1.3-1.7
Zinc (Zn)	0.2	-	-	-	1.0-1.6	1.0-1.5
Phosphorus (P)	130.0	68.3	83.6	41.3	110.1-146.8	-

*1) Rahman *et al.*, 2007; 2) Besbes *et al.*, 2004a; 3) Nehdi *et al.*, 2010; 4) Habib and Ibrahim, 2009; 5) Ali-Mohamed and Khamis, 2004

Table 3. Fatty acid composition of date seed oil (% of total fatty acid)

Fatty acid	Date seed oil						
	Deglet Nour *(1)	Heat treated Deglet Nour *(2)	Allig *(1)	Heat treated Allig *(2)	Tamirraq *(3)	*Phoenix canariensis* *(4)	Roasted date seed *(5)
Capric (C10:0)	0.8	0.7	0.1	0.8	0.0	0.1	0.35
Lauric (C12:0)	17.8	31.7	5.8	34.2	13.1	10.2	38.8
Myristic (C14:0)	9.8	14.0	3.1	15.7	11.0	7.5	-
Palmitic (16:0)	10.9	10.6	15.0	13.8	11.8	9.8	15.1
Stearic (18:0)	5.7	3.9	3.0	4.24	2.8	1.7	-
Oleic (18:1)	41.3	34.5	47.7	26.3	52.2	50.1	36.5
Linoleic (18:2)	12.2	3.3	21.0	0.3	7.1	19.2	9.2
Linolenic (18:3)	1.7	0.7	0.8	1.9	-	0.1	-

*1) Besbes *et al.*, 2004a; 2) Besbes *et al.*, 2005; 3) Al-Shahib and Marshall, 2003b 4) Nehdi *et al.*, 2010; 5) Rahman *et al.*, 2007

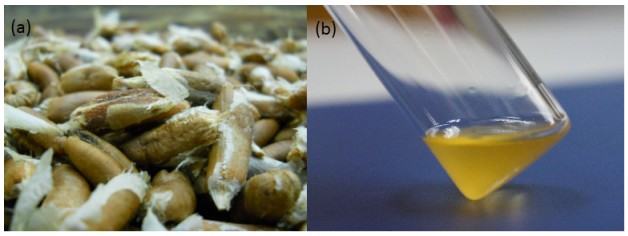

Figure 1. Date seed (a) and date seed oil (b).

the oleic, linoleic, lauric and palmitic acid content were 48%, 21%, 6% and 15%, respectively (Besbes *et al.*, 2004a). Al-Shahib and Marshall (2003a) found that the oleic acid content of 24 cultivars of the date seed oil ranges from 41 to 59%, which could be a good source of C18:1 fatty acid. To conclude, the date seed oil is mainly composed of the four fatty acid namely oleic, linoleic, lauric and palmitic acid.

In comparison, it is found that the canola oil has 54% oleic acid (Marikkar *et al.*, 2002). This composition is almost similar with the oleic acid content found in date seed oil reported above. The linoleic acid (27%), which is the second highest fatty acid found in canola oil is in comparison with the linoleic acid obtained in date seed oil from Allig variety (21%) (Besbes *et al.*, 2004a). Canola oil have been used in food as salad oils, tablespreads and shortening for baking and frying (Vaisey-Genser *et al.*, 1994). Other than that, canola oil have been mixed with used cooking oil in order to improve biodiesel production (Issariyakul *et al.*, 2008). They found that the mixtures of these canola and used cooking oils at certain ratio could also reduce the feedstock and operating cost which will result in lower total production cost of biodiesel. But this similarity does not confirm the suitability of the date seed oil to be used in biodiesel production. More studies on biodiesel and date seed oil compatibility will be discussed in later part of this article.

The thermal profile of date seed oil was affected by the application of heating treatment to the date seed. Besbes *et al.* (2005) found that the heating treatment on the date seed could also affect the extracted oil in terms of the fatty acid composition. The fatty acid composition of date seed oil from Deglet Nour and Allig variety showed some changes in their values when treated in a Rancimat test at 100 °C for 48 hours (Besbes *et al.*, 2005). The oleic and linoleic acid composition of both seed oils decreased after being treated with heat (100°C). The oleic acid of Deglet Nour and Allig seed oils have decreased by 7% and 21%, respectively, while the linoleic acid decreased by 9% and 21%, respectively. In Deglet Nour seed oil, an increase observed for lauric and myristic acid content with an increase of 14% and 4%, respectively. In Allig seed oil, lauric and myristic acids increased

by 28% and 13%, respectively. Significant changes on the fatty acid compositions were observed in Allig seed oil compared to Deglet Nour seed oil. These changes indicate the stability of the seed oil content of Deglet Nour variety over Allig variety to heating treatment, which due to the saturated and unsaturated fatty acid content of both oils. Hence, heating treatment is a method that might be used to increase the medium chain fatty acid (MCFA) content in date seed oil. In another study, a high lauric and palmitic acid contents was found in date seed oil extracted from roasted date seed, with value of 38.8% and 15.1%, respectively (Rahman *et al.*, 2007). They stated that the date varieties, pollination and roasting process influenced the fatty acid composition of the date seed oil.

Chemical and physical properties of date seed oil

Literally, the iodine value (IV) of date seed oil is 76.7 g/100 g of oil, the saponification value (SV) is 191.3, the free fatty acid as oleic acid percentage is 0.6, the *p*-anisidine value is 3.7 and the peroxide value (PV) is 3.6 meq O_2/kg of oil (Nehdi *et al*., 2010). The study also found that the safety of this oil as an edible oil is supported by the low total oxidation value (totox) and acid value of the oil. However, Besbes *et al.* (2004b) found that the IV of another variety of date seed oil namely Deglet Nour and Allig seed oil are 44.1 g/100 g and 45.5 g/100 g of oil, respectively, which are lower than obtained by study mentioned previously (Nehdi *et al*., 2010). These could be due to the difference in oleic and linoleic acid content of the oils.

The thermal profile of date seed oil could be evaluated using the differential scanning calorimetry (DSC). In a study on virgin coconut oil (Marina, 2009), DSC technique was used to determine the quality of the samples, for example to check the crystallization and melting properties of oil. On the other hand, the melting peak, melting enthalpy and onset temperature of date seed oil reported by Nehdi *et al*. (2010) is 3.7°C, 62.1 J/g and -13.6°C, respectively. The thermal profile of date seed oil is different from one variety to another. The differences in the thermal profile of date seed oils is due to differences in fatty acid (Nehdi *et al.*, 2010) and triacylglycerol compositions (Besbes *et al.*, 2005) between different varieties. Besbes *et al*. (2004a) found that the melting peak (-3.3°C), the melting enthalpy (71.9 J/g) and onset temperature (-21.7°C) of Allig seed oil is higher than the Deglet Nour seed oil (-2.66°C, 67.5 J/g and -19.0°C respectively). The higher content of monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) in Allig seed oil than the Deglet Nour seed oil had caused the difference of their thermal profiles.

The thermal profile of date seed oil was affected as the date seeds were treated with heat. Besbes *et al.* (2005) have determined that the total melting enthalpy of both Allig and Deglet Nour seed oil decreased as the time of heating treatment is lengthened. The longer the seed is treated by the heat, the lower the melting enthalpy of the seed oil (Besbes *et al.*, 2005). This phenomenon was obtained because heating degraded the oil's fatty acid composition over time. The composition of saturated fatty acid (SAFA) was increase while unsaturated fatty acid (USFA) was decrease in date seed oil as heating treatment was applied to the date seed. In addition, it was found that the amount of SAFA present in the oil influences the properties of solid fat content of the oil (Besbes *et al*., 2004a).

Antioxidant content

Antioxidant can be classified into synthetic and natural. Synthetic antioxidant such as butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) is purposely added to preserve flavor, color, and to avoid vitamin destruction of the food or any related products (Moure *et al.*, 2001). Natural antioxidant could be obtained from plant. It is normally extracted in the form of phenolic compounds (flavonoids, phenolic acids and alcohols, stilbenes, tocopherols, tocotrienols), ascorbic acid and carotenoids (Ali *et al.*, 2008). All of these antioxidants are different in their effectiveness. The tocopherol's strength arranged as δ> γ> β> α (Moure *et al*., 2001). Both tocopherols and tocotrienols with these eight vitamers (α-, β-, γ-, and δ-tocopherols and tocotrienols, respectively) are also known collectively as vitamin E (Adhikari *et al*., 2008).

Nehdi *et al.* (2010) found that 66% of α-tocotrienol posses the highest tocols content found in a variety of date seed oil from Tunisia with content value of 34.0 mg/100 g oil. The other tocols found in this date seed oil were γ-tocopherol, γ-tocotrienol, δ-tocopherol, β-tocopherol and α-tocopherol with content value of 10.3 mg/100 g, 4.6 mg/100 g, 1.0 mg/100 g, 0.9 mg/100 g and 0.6 mg/100 g, respectively. The total content of tocols in date seed oil reported by Nehdi *et al.* (2010) is in the range of total tocols content found in palm oil reported by Sundram *et al.* (2003) and Cornelius (1977). Tocopherols have been recognized as very effective natural antioxidants. However the antioxidants activities depend on the structure of isomers. Marinova *et al.* (2008) discovered that the combination of α-tocopherol with myricetin has increased the effectiveness of

Table 4. Tocols contents of date seed oil and other vegetable oil (mg/100 g oil)

Samples	Total tocols (mg/100 g)
Date seed oil (*P. Canariensis*) *(1)	51.5
Black raspberry seed oil *(2)	166.0
Soybean oil *(2)	99.9
Corn oil *(2)	61.1
Olive oil *(2)	28.0
Canola oil *(2)	27.0
Perilla oil *(2)	45.4
Grape seed oil *(2)	52.2

*1) Nehdi *et al.*, 2010; 2) Adhikari *et al.*, 2008

these antioxidants protection effect. In comparison, tocotrienols are capable in reducing the risk of breast cancer compared to tocopherols (Schwenke, 2002). In addition, the intake of tocotrienols capsules could reduce the cholesterol and low density lipoprotein (LDL) cholesterol in human (Yuen *et al.*, 2011).

A study have been conducted regarding the antioxidant content in two types of date seed oil, namely Deglet Nour seed oil and Allig seed oil (Besbes *et al.*, 2004c). The total number of phenolic compounds that were detected in both seed oils was different. Hydroxytyrosol, protocatechuic acid, tyrosol, gallic acid, caffeic acid, *p*-Coumaric and and oleuropein were identified to occur in Deglet Nour seed oil. The same phenolic compounds were also detected in Allig seed oil but at different level, with additional of 3,4-dihyroxyphenylacetic acid detected in that oil. They concluded that better oxidative stability of Deglet Nour seed oil over the Allig seed oil was due to the high amount of total phenols that is present in the oil (Besbes *et al*., 2004a; Besbes *et al.*, 2004c). The phenols content in date seed oil were also found to be higher than the olive oil and can be a good source for natural phenolic compounds (Besbes *et al*., 2004c). In another study, 2015 µg Gallic acid/g of phenolic content have been directly extracted from the seed of a variety of date fruit (Amany *et al.*, 2012).

Compared to other commercial vegetable oil (Table 4), grape seed oil is the most similar oil with date seed oil in terms of total tocols content (Adhikari *et al.*, 2008). Although olive oil is one of the edible oil that contains high phenolic contents (Marina *et al*., 2009a), review had shown that the total tocols content of date seed oil found by Nehdi *et al.* (2010) is higher than that of olive oil. The review also shown that the antioxidant content in date seed oil is higher than commercial virgin coconut oil (Marina *et al*., 2009b). However, the amount of antioxidant that occurs in vegetable oil depends on the condition of oil extraction process. Extraction process that is carried out at high temperature will increase the amount of antioxidant present in the extracted oil (Seneviratne *et al*., 2009).

Animal feed and health aspects

The date seed that is rich in protein, fat and dietary fiber (Besbes *et al*., 2004a; Al-Farsi and Lee, 2008a) is normally discarded after being separated from the flesh, however there are reports that it has been used in animal feed (Aldhaheri *et al*., 2004; Besbes *et al.*, 2004a; Besbes *et al*., 2005; Rahman *et al*., 2007; Habib and Ibrahim, 2009) as well as caffeine-free coffee, substitute, prepared by the Arabs for years (Ali-Mohamed and Khamis, 2004; Rahman *et al.*, 2007; Habib and Ibrahim, 2009). The proteins, mineral ions and fat contents in date seeds make it as a valuable ingredient in animal feed production (Ali-Mohamed and Khamis, 2004). A study conducted by Hussein *et al.* (1998) on chicks diet had shown that the body weight and feed utilization of the chicks improved as the chicks were fed on diet that had been enriched with date seed. Aldhaheri *et al*. (2004) found that the feeding studies using date seed as a part of the diet of Winstar rats gave no effect to the testosterone level of male rats, while the increase in date seed intake by the female Winstar rats caused the oestradiol in the rat's serum level to decrease. However, the results of the study showed a disagreement with Hussein *et al.* (1998), where the addition of date seed into the Winstar rats diet had no effect on the rats total body weight gain. Another study that have been carried out on Awassi lambs found that the additional of date's by products (date seed and flesh) in the diets have increased the average daily gain (ADG), weight gain and back fat deposition of the lambs, which can be due to the presence of natural anabolic agents in date's by products (Elgasim *et al*., 1995). In addition, the nickel which is toxic to plants and animals have been found to occur in low amount in date seed compared to coffee and barley, which indicate the safety level of the date seed to be used as a food or animal feed ingredient (Ali-Mohamed and Khamis, 2004).

Other than the date seed, the date seed oil also found to be beneficial to be used for the health purpose. *P. canariensis* seed oil which is also known as the oleic-linoleic oil is due to the high content of both oleic and linoleic acid (Nehdi *et al.*, 2010). They found that the oleic and linoleic acid content in the date seed oil are 50% and 19% of the total fatty acid composition. The oleic acid plays an important role for the prevention of the cardiovascular disease. Oleic acid which categorized as long chain fatty acid that is taken in diet is increased the high density lipoprotein (HDL) content in blood, and at the same time lowering the low density lipoprotein (LDL) content (Gilmore *et al*., 2011). This condition could prevent

cardiovascular diseases. The linoleic acid which is also known as the omega-6 fatty acid, can also be found highly and as the major fatty acid in sunflower oil, soy bean oil (Lautenschlager, 2003; Schardt, 2005), corn oil, sesame oil (Schardt, 2005), grape seed oil, wheatgerm oil, black caraway oil (Lautenschlager, 2003), red flesh pitaya (*Hylocereus polyrhizus*) seed oil and white flesh pitaya (*Hylocereus undatus*) seed oil (Ariffin *et al.*, 2009). Therefore, the idea of application of the date seed oil can be developed based on the application of the oils mentioned above such as biodiesel, soap, and cooking oil as well as nutritional food and supplement.

A study had been conducted on the effect of sperm quality after supplemented with date seed oil (Fatma *et al.*, 2009). The study that have been carried out on 16 men aged from 25 to 45 years old found that the level of lipid peroxidation of spermatozoa added with date seed oil decreased significantly. They also found that the ability of sperms to initiate the acrosome reaction (when the sperm cells meet the oocyte) have also improved. As a result, the capability of the sperm to fertilize the oocyte is increase. They concluded that the protection against the lipid peroxidation was due to the presence of natural antioxidants in date seed oil. In another study, the male mice that have been injected with isotonic saline solution containing date seed oil were found to increase in sperm count, motility and viability, while decrease in percentage of abnormal sperm (Abdallah *et al*., 2009).

Cosmetic applications

In recent days, the interest in natural and/or organic cosmetics has increased among the consumers. This is due to the increase in wariness of the consumer to the chemical usage in cosmetic products. As the industry seeks for the natural alternatives, the demand for seed oil has increased dramatically. However, not all of the substances existing in plant are good. There are also plant constituents that could result in detrimental effect to the users such as capsaicinoids in cayenne peppers, phototoxic psoralen in oranges, urushiols in poison ivy and poison oak (Bertram, 2009).

The beneficial effect of the oil used in cosmetics and other personal care products is due to the fatty acids composition of the oil (Vermaak *et al*., 2011). The deficiency of linoleic acid, which cannot be produced by human body will result in dry and scaly skin, nails crack, hair loss and increase transepidermal water loss. The linoleic acid is widely used in cosmetic products as it helps to heal dermatoses, sun burns and effectively treat acne vulgaris (Lautenschlager, 2003). The high oleic acid content in date seed oil can be a good source of effective percutaneous absorption enhancer by enhancing the penetration of tenoxicam. Tenoxicam is a non-steroidal anti-inflammatory drug (NSAID), an effective anti-inflammatory and analgesics, which has been widely used in conditions such as chronic rheumatic disorders treatment (Larrucea *et al*., 2001).

Date seed oil has an absorbance in the range of ultraviolet (UV)-C (100-290 nm) and UV-B (290-320 nm). As a result, the date seed oil can be used as an ingredient of UV protector products which could give protection from both UV-B and UV-A (Nehdi *et al*., 2010). The application of date seed oil on the skin has approved the protective effects against the damage due to the exposure to UV-B irradiation when it was compared with skin that was applied with the date seed oil (Dammak *et al*., 2010a). Other than that, study found that the date seed oil could repair the human skin which could be due to the antioxidant activity. The presence of natural antioxidants such as phenols and tocopherols in date seed oil was capable to prevent keratinocytes oxidative damage caused by the exposure of hydrogen peroxide (H_2O_2) on the skin (Ines *et al*., 2010). In addition, they also found that date seed oil could protect the skin from the oxidative stress damage caused by hydrogen peroxide (H_2O_2) through the lipid peroxidation process that is better than olive oil (Dammak *et al.*, 2007a; Dammak *et al*., 2007b). Another study had determined the effectiveness of date seed oil against the oxidative damage due to the H_2O_2 exposure to the normal human epidermal melanocytes (Dammak *et al.*, 2009) and keratinocytes (Dammak *et al*., 2010b).

Date seed oil as biodiesel?

Biodiesel is assumed as an alternative to conventional diesel. Normally biodiesel is made from vegetable oil, which have few advantages than the diesel in terms of chemical and physical properties such as being biodegradable, non-toxic, its renewability, better gas release, and it yields particles, smoke and carbon monoxide at lower level (Phan and Phan, 2008; Sousa *et al*., 2010). In biodiesel production, the oil will react with alcohol such as methanol to produce methyl ester, which is known as biodiesel (Van Gerpen, 2005).

The free fatty acid content of the oil that is used in biodiesel production plays as an important factor for cost saving. Previous studies shows that oil with high free fatty acid content will result in more catalyst needed (potassium hydroxide (KOH) or sodium hydroxide (NaOH)) in order to balance the acidity of the oil (Phan and Phan, 2008; Qiu *et al*., 2011). This would become as an advantage for the date seed oil as the free fatty acid content in this oil is very low,

which was range between 0.53% to 1.05% (Besbes *et al.*, 2004b ; Nehdi *et al.*, 2010).

Biodiesel has been produced from many types of oil such as soybean oil, rapeseed oil (Qiu *et al.*, 2011), canola oil (Issariyakul *et al*., 2008), jatropha oil (Banerji *et al.*, 1985; Lu *et al*., 2009; Jain and Sharma, 2010) and waste cooking oil (Issariyakul *et al*., 2008; Phan and Phan, 2008). However there is no study that has been conducted yet on biodiesel production using date seed oil as well as the industries. In term of cost, date seed oil could be of relevance as the oil is obtained from a waste product (date seed). As mentioned earlier, the estimation of more than 1 million tons of date seed produced can be as another factor for the production of date seed oil to be commercialized, as the same oil extraction process of palm kernel oil can be applied for this oil (Tang and Teoh, 1985).

Conclusion

Date seed is a byproduct of date fruit industry. Various studies that have been conducted on date seed found that it can be as an excellent source of dietary fiber. In addition, the other component such as protein and minerals also present in considerable amount in the seed. Based on the fatty acid composition of date seed oil, it is suggested the use of this oil for nutritional purpose, as edible cooking oil and also for the production of margarine due to the high stability and resistance of date seed oil to thermal treatment which indicate the good shelf life and storability of this oil even for a long period of time. Moreover, different degree of unsaturation of date seed oil compared to other vegetable oil make it as potential oil that can be developed for different uses, than the already existing commercial vegetable oil. As there are scarce info on date seed oil, perhaps more research should be conducted, not only to identify its characteristics and its various differences that would occur either inter or intra species, but also for development of edible and non-edible products.

Acknowledgements

We are grateful that our work on date seed oil is supported by grants from Universiti Putra Malaysia (UPM) awarded to Prof. Dr. Yaakob Bin Che Man through RUGS 9199937 grant.

References

Abdallah, F. B., Dammak, I., Mallek, H., Hentati, B. and Keskes, L. A. 2009. Effects of date seed oil on testicular antioxidant enzymes and epididymal sperm characteristics in male mice. First International Journal of Andrology 41: 229-234.

Adhikari, P., Hwang, K. T., Shin, M. K., Lee, B. K., Kim, S. K., Kim, S. Y., Lee, K. T. and Kim, S. Z. 2008. Tocols in caneberry seed oils. Food Chemistry 111: 687-690.

Al-Farsi, M., Alasalvar, C., Al-Abid, M., Al-Shoaily, K., Al-Amry, M. and Al-Rawahy, F. 2007. Compositional and functional characteristics of dates, syrups, and their by-products. Food Chemistry 104: 943-947.

Al-Farsi, M. A. and Lee, C. Y. 2008a. Nutritional and functional properties of dates: a review. Critical Reviews in Food Science and Nutrition 48: 877-887.

Al-Farsi, M. A. and Lee, C. Y. 2008b. Optimization of phenolics and dietary fibre extraction from date seeds. Food Chemistry 108: 977-985.

Al-Farsi, M. A. and Lee, C. Y. 2011. Usage of date (Phoenix Dactylifera L.) seeds in human health and animal feed. In Preedy, V.R., Watson, R.R.; Patel, V.B. (eds). Nuts and Seeds in Health and Disease Prevention. p 447-452. USA: Elsevier.

Al-Qarawi, A. A., Ali, B. H., Mougy, S. A. and Mousa, H. M. 2003. Gastrointestinal transit in mice treated with various extracts of date (Phoenix dactylifera L.). Food and Chemical Toxicology 41: 37-39.

Al-Shahib, W. and Marshall, R. J. 2003a. The fruit of the date palm: its possible use as the best food for the future? International Journal of Food Science and Nutrition 54: 247-259.

Al-Shahib, W. and Marshall, R. J. 2003b. Fatty acid content of the seeds from 14 varieties of date palm Pheonix dactylifera L.. International Journal of Food Science and Technology 38: 709-712.

Aldhaheri, A., Alhadrami, G., Aboalnaga, N., Wasfi, I. and Elridi, M. 2004. Chemical composition of date pits and reproductive hormonal status of rats fed date pits. Food Chemistry 86: 93-97.

Ali, S. S., Kasoju, N., Luthra, A., Singh, A., Sharanabasava, H., Sahu, A. and Bora, U. 2008. Indian medicinal herbs as sources of antioxidants. Food Research International 41: 1-15.

Ali-Mohamed, A. Y. and Khamis, A. S. H. 2004. Mineral ion content of the seeds of six cultivars of Bahraini date palm (*Phoenix dactylfera*). Journal of Agriculture and Food Chemistry 52: 6522-6525.

Almana, H. A. and Mahmoud, R. M. 1994. Palm date seeds as an alternative source of dietary fiber in Saudi bread. Ecology of Food and Nutrition 32: 261-270.

Amany, M. M. B., Shaker, M. A. and Abeer, A. K. 2012. Antioxidant activities of date pits in a model meat system. International Food Research Journal 19: 223-227.

Amira, E. A., Guido, F., Behija, S. E., Manel, I., Nesrine, Z., Ali, F., Mohamed, H., Noureddine, H. A. and Lotfi, A. 2011. Chemical and aroma volatile compositions of date palm (*Phoenix dactylifera* L.) fruits at three maturation stages. Food Chemistry 127: 1744-1754.

Ariffin, A. A., Bakar, J., Tan, C. P., Rahman, R. A.,

Karim, R. and Loi, C. C. 2009. Essential fatty acids of pitaya (dragon fruit) seed oil. Food Chemistry 114: 561-564.

Awad, M. A. 2007. Increasing the rate of ripening of date palm fruit (*Phoenix dactylifera* L.) cv. Helali by preharvest and postharvest treatments. Postharvest Biology and Technology 43: 121-127.

Baliga, M. S., Baliga, B. R. V., Kandathil, S. M., Bhat, H. P. and Vayalil, P. K. 2010. A review of the chemistry and pharmacology of the date fruits (*Phoenix dactylifera* L.). Food Research International doi: 10.1016/j. foodres.2010.07.004

Baud, S. and Lepiniec, L. 2010. Physiological and development regulation of seed oil production. Progress in Lipid Research 49: 235-249.

Banerji, R., Chowdhury, A. R., Misra, G., Sudarsanam, G., Verma, S. C. and Srivastava, G. S. 1985. Jatropha seed oils for energy. Biomass 8: 277-282.

Bendiab, K., Baaziz, M. and Majourhat, K. 1998. Preliminary date palm cultivar composition of Moroccan palm groves as revealed by leaf isoenzyme phenotypes. Biochemical Systematics and Ecology 26: 71-82.

Bertram, C. "26 allergens" in cosmetics: a challenge for all stakeholders in Lintner K. (ed.). Global Regulatory Issues for the Cosmetics Industry. p 55-78. Chanac, France: Wiliam Andrew Inc., Crodarom S.A.S.

Besbes, S., Blecker, C., Deroanne, C., Bahloul, N., Lognay, G., Drira, N. E. and Attia, H. 2004c. Date seed oil: Phenolic, tocopherol and sterol profiles. Journal of Food Lipids 11: 251-265.

Besbes, S., Blecker, C., Deroanne, C., Drira, N. E and Attia, H. 2004a. Date seeds: chemical composition and characteristic profiles of the lipid fraction. Food Chemistry 84: 577-584.

Besbes, S., Blecker, C., Deroanne, C., Lognay, G., Drira, N. E. and Attia, H. 2004b. Quality characteristics and oxidative stability of date seed oil during storage. Food Science and Technology International 10: 333-338.

Besbes, S., Blecker, C., Deroanne, C., Lognay, G., Drira, N. E. and Attia, H. 2005. Heating effects on some quality characteristics of date seed oil. Food Chemistry 91: 469-476.

Besbes, S., Ghorbel, R., Ben Salah, R., Masmoudi, M., Jedidi, F., Attia, H. and Blecker, C. 2010. Date fiber concentrate: Chemical compositions, functional properties and effect on quality characteristics of beef burgers. Journal of Food and Drug Analysis 18: 8-14.

Bokhari, H. A. 2010. Seed-borne fungi of date-palm, *Phoenix dactylifera* L. from Saudi Arabia. Saudi Journal of Biological Sciences 17: 327-329.

Briones, R., Serrano, L., Younes, R. B., Mondragon, I. and Labidi, J. 2011. Polyol production by chemical modification of date seeds. Industrial Crops and Products 34: 1035-1040.

Cornelius, R. J. 1977. Palm oil and palm kernel oil. Progress in the Chemistry of Fats and Other Lipids 15: 5-27.

Dammak, I., Abdallah, F. B., Boudaya, S., Besbes, S., Keskes, L., El Gaied, A., Turki, H. and Hentati, B. 2007a. Date seed oil limit oxidative injuries induced by hydrogen peroxide in human skin organ culture. Biofactors 29: 137-145.

Dammak, I., Abdallah, F. B., Boudaya, S., Keskes, L., Besbes, S., El Gaied, A., Attia, H., Turki, H. and Hentati, B. 2007b. Effects of date seed oil on normal human skin *in vitro*. European Journal of Dermatology 17: 516-519.

Dammak, I., Boudaya, S., Abdallah, F. B., Besbes, S., Attia, H., Turki, H. and Hentati, B. 2010b. Date seed oil inhibits hydrogen peroxide-induced oxidative stress in human epidermal keratinocytes. International Journal of Dermatology 49: 262-268.

Dammak, I., Boudaya, S., Abdallah, F. B., Hamida, T. and Attia, H. 2009. Date seed oil inhibits hydrogen peroxide-induced exidative stress in normal human epidermal melanocytes. Connective Tissue Research 50: 330-335.

Dammak, I., Boudaya, S., Abdallah, F. B., Turki, H. and Attia, H. 2010a. Effect of date seed oil on p53 expression in normal human skin. Connecticve Tissue Research 51: 55-58.

Elgasim, E. A., Alyousef, Y. A. and Humeida, A. M. 1995. Possible hormonal activity of date pits and flesh fed to meat animals. Food Chemistry 52:, 149-152.

Elleuch, M., Besbes, S., Roiseux, O., Blecker, C., Deroanne, C., Drira, N. E. and Attia, H. 2008. Date flesh: chemical composition and characteristics of the dietary fibre. Food Chemistry 111: 676-682.

FAO (Food and Agriculture Organization of the United Nations). 2010. Statistical Databases. Downloaded from *http://faostat.fao.org* on April 24, 2012.

Fatma, B. A., Nozha, C. F., Ines, D., Hamadi, A., Basma, H. and Leila, A. K. 2009. Sperm quality improvement after date seed oil *in vitro* supplementation in spontaneous and induced oxidative stress. Asian Journal of Andrology 11: 393-398.

Gilmore, L. A., Walzem, R. L., Crouse, S. F., Smith, D. R., Adams, T. H., Vaidyanathan, V., Cao, X. and Smith, S. B. 2011. Consumption of high-oleic acid ground beef increases HDL-cholesterol concentration but both high- and low-oleic acid ground beef decrease HDL particle diameter in normocholesterolemic men. The Journal of Nutrition 141: 1188-1194.

Habib, H. M. and Ibrahim, W. H. 2009. Nutritional quality evaluation of eighteen date pits varieties. International Journal of Food Sciences and Nutrition 60:99-111.

Hamada, J. S., Hashim, I. B. and Sharif, F. A. 2002. Preliminary analysis and potential uses of date pits in foods. Food Chemistry 76: 135-137.

Hussein, A. S., Alhadrami, G. A. and Khalil, Y. H. 1998. The use of dates and date pits in broiler starter and finisher diets. Bioresource Technology 66: 219-223.

Ines, D., Sonia, B., Fatma, B. A., Souhail, B., Hamadi, A., Hamida, T. and Basma, H. 2010. Date seed oil inhibits hydrogen peroxide-induced oxidative stress in human epidermal keratinocytes. International Journal of Dermatology 49: 262-268.

Issariyakul, T., Kulkarni, M. G., Meher, L. C., Dalai, A. K. and Bakhshi, N. N. 2008. Biodiesel production from

mixtures of canola oil and used cooking oil. Chemical Engineering Journal 140: 77-85.

Jain, S. and Sharma, M. P. 2010. Biodiesel production from Jatropha curcas oil. Renewable and Sustainable Energy Reviews 14: 3140-3147.

Larrucea, E., Arellano, A., Santoyo, S. and Ygartua, P. 2001. Combined effect of oleic acid and propylene glycol on the percutaneous penetration of tenoxicam and its retention in the skin. European Journal of Pharmaceutics and Biopharmaceutics 52: 113-119.

Lautenschläger, H. 2003. Essential fatty acids- cosmetic from inside and outside. Beauty Forum 4: 54-56.

Lu, H., Liu, Y., Zhou, H., Yang, Y., Chen, M. and Liang, B. 2009. Production of biodiesel from Jatropha curcas L. oil. Computers and Chemical Engineering 33: 1091-1096.

Marikkar, J. M. N., Ghazali, H. M., Che Man, Y. B. and Lai, O. M. 2002. The use of cooling and heating thermograms for monitoring of tallow, lard and chicken fat adulterations in canola oil. Food Research International 35: 1007-1014.

Marina, A. M. 2009. Characterization, antioxidant properties and authentication of virgin coconut oil. Serdang, Malaysia: Universiti Putra Malaysia. DPhil thesis.

Marina, A. M., Che Man, Y. B. and Amin, I. 2009a. Virgin coconut oil: emerging functional food oil. Trends in Food Science & Technology 20: 481-487.

Marina, A. M., Che Man, Y. B., Nazimah, S. A. H. and Amin, I. 2009b. Chemical properties of virgin coconut oil. Journal of the American Oil Chemists' Society 86: 301-307.

Marinova, E., Toneva, A. and Yanieslieva, N. 2008. Synergistic antioxidant effect of α-tocopherol and myricetin on the autoxidation of triacylglycerols of sunflower oil. Food Chemistry 106: 628-633.

Moure, A., Cruz, J. M., Franco, D., Manuel Dominguez, J., Sineiro, J., Dominguez, H., Jose Nunez, M. and Carlos Parajo, J. 2001. Natural antioxidants from residual sources. Food Chemistry 72: 145-171.

Nancib, N., Nancib, A. and Boudrant, J. 1997. Use of waste date products in the fermentative formation of baker's yeast biomass by *Saccharomyces serevisiae.* Bioresource Technology 60: 67-71.

Nehdi, I., Omri, S., Khalil, M. I. and Al-Resayes, S.I. 2010. Characteristics and chemical composition of date palm (*Pheonix canariensis*) seeds and seeds oil. Industrial Crops and Products 32: 360-365.

Phan, A. N. and Phan, T. M. 2008. Biodiesel production from waste cooking oil. Fuel 87: 3490-3496.

Przybylski, R. (Dr.). Canola oil: Physical and chemical properties. Canola Council of Canada. Downloaded from *http://www.canolacouncil.org/uploads/Chemical1-6.pdf* on 8/9/2011

Qiu, F., Li, Y., Yang, D., Li, X. and Sun, P. 2011. Biodiesel production from mixed soybean oil and rapeseed oil. Applied Energy 88: 2050-2055.

Rahman, M. S., Kasapis, S., Al-Kharusi, N. S. Z., Al-Marhubi, I. M. and Khan, A. J. 2007. Composition characterization and thermal transition of date pits powders. Journal of Food Engineering 80: 1-10.

Schardt, D. 2005. An article of Just the flax, a "miracle" seed comes down to earth. Nutrition Action Healthletter 7-9.

Schwenke, D. C. 2002. Does lack of tocopherols and tocotrienols put women at increased risk of breast cancer? Journal of Nutritional Biochemistry 13: 2-20.

Seneviratne, K. N., Hapuarachchl, C. D. and Ekanayake, S. 2009. Comparison of the phenolic-dependent antioxidant properties of coconut oil extracted under cold and hot conditions. Food Chemistry 114: 1444-1449.

Sousa, L. L., Lucena, I. L. and Fernandes, F. A. N. 2010. Transesterification of castor oil: Effect of the acid value and neutralization of the oil with glycerol. Fuel Processing Technology 91: 194-196.

Sundram, K., Sambanthamurthi, R. and Tan, Y-A. 2003. Palm fruit chemistry and nutrition. Asia Pacific Journal of Clinical Nutrition 12: 355-362.

Tang, T. S. and Teoh, P. K. 1985. Palm kernel oil extraction-the Malaysian experience. Journal of the American Oil Chemists' Society 62: 254-258.

Vaisey-Genser, M., Malcolmson, L. J., Ryland, D., Eskin, N. A. M. and Armstrong, L. 1994. Consumer acceptance of canola oil during temperature-accelerated storage. Food Quality and Preference 5: 237-243.

Van Gerpen, J. 2005. Biodiesel processing and production. Fuel Processing Technology 86: 1097-1107.

Vermaak, I., Kamatou, G. P. P., Komane-Mofokeng, B., Viljoen, A. M. and Beckett, K. 2011. African seed oils of commercial importance-cosmetic applications. South African Journal of Botany doi: 10.1016/j.sajb.2011.07.003

Yuen, K. H., Wong, J. W., Lim, A. B., Ng, B. H. and Choy, W. P. 2011. Effect of mixed-tocotrienols in hypercholesterolemic subjects. Functional Foods in Health and Disease 1: 106-117.