ELSEVIER

Food Chemistry 84 (2004) 577–584

Food Chemistry

www.elsevier.com/locate/foodchem

Date seeds: chemical composition and characteristic profiles of the lipid fraction

Souhail Besbes[a,*], Christophe Blecker[b], Claude Deroanne[b], Nour-Eddine Drira[c], Hamadi Attia[a]

[a] *Unité Analyses Alimentaires, Ecole Nationale d'Ingénieurs de Sfax, Route de Soukra 3038 Sfax, Tunisia*
[b] *Unité de Technologie des Industries Agro-alimentaires, Faculté Universitaire des Sciences Agronomiques de Gembloux, passage des Déportés 2, 5030 Gembloux, Belgium*
[c] *Laboratoire de biotechnologie végétale, Faculté des Sciences de Sfax, Route de Soukra 5038 Sfax, Tunisia*

Received 18 February 2003; received in revised form 22 May 2003; accepted 22 May 2003

Abstract

The seeds of two date palm (*Phoenix dactylifera* L.) cultivars, Deglet Nour and Allig, from the Degach region—Tunisia, were analysed for their main chemical composition. Studies were also conducted on properties of oil extracted from date pits. The following values (on a dry-weight basis) were obtained for Deglet Nour and Allig cultivars, respectively: protein 5.56 and 5.17%, oil 10.19 and 12.67%, Ash 1.15 and 1.12% and total carbohydrate 83.1 and 81.0%. Gas–liquid chromatography revealed that the major unsaturated fatty acid was oleic acid (41.3–47.7%), while the main saturated fatty acid was lauric acid (17.8%) for the Deglet Nour cultivar and palmitic acid for the Allig cultivar (15.0%). Capric, myristic, myristoleic, palmitoleic, stearic, linoleic and linolenic acids were also found. Thermal profiles of both date seed oils, determined by their DSC melting curves, revealed simple thermograms. Sensorial and physical profiles of Deglet Nour and Allig seed oil were based on studies of the CieLab (L^*, a^*, b^*) colour, oxidative stability, viscosity and microstructure. Results showed that date seed oil could be used in cosmetic, pharmaceutical and food products.

Keywords: Date seeds; Oil; Fatty acids; Thermal profile; Sensorial profile

1. Introduction

The date (*Phoenix dactylifera* L.) has been an important crop in arid and semiarid regions of the world. It has always played an important part in the economic and social lives of the people of these regions. The fruit of the date palm is well known as a staple food. It is composed of a fleshy pericarp and seed.

The chemical composition and nutritional value of date flesh have been reported (Al-Hooti, Jiuan, & Qabazard, 1995; Fayadh & Al-Showiman, 1990; Hussein, Mustafa, & Al-Zeid, 1976; Mohamed, Shabana, & Mawlod, 1983; Rygg, 1946; Salem & Hegazi, 1971; Vandercook, Hasegawa, & Maier, 1977; Youssif, Benjamin, Idin, & Ali, 1976). Few works have been published on date palm seeds (Al-Hooti, Sidhu, & Qabazard, 1998; Al-Showiman, 1990; Devshony, Eteshola, & Shani, 1992; El-Shurafa, Ahmed, & Abou-Naji, 1982; Hamada, Hashim, & Sharif, 2002). However, these were focused on their chemical composition only and not their thermal and sensorial properties. Pits of date palm (seed) are a waste product of many industries, after technological transformation of the date fruits (Al-Hooti, Sidhu, Al-Otaibi, Al-Ameeri, & Qabazard, 1997; Hobani, 1998; Khatchadourian, Sawaya, Khalil, & Mashadi, 1983; Youssif, Abou Ali, & Bou Idreese, 1990; Youssif & Al-Ghamdi, 1999; Youssif, Alghamdi, Hamad, & Mustafa, 1996) or their biological transformation (Abou Zied, Abderrahman, & Baghlef, 1991; Abou Zied & Baghlef, 1983; Abou Zied & Khoja, 1993; Al-Obaidi & Berry, 1976; Nacib, Nacib, & Bourdant, 1997; Nacib et al., 1999).

In some date-processing countries, such as Tunisia, date seeds are discarded or used as fodder for domestic farm animals. In Tunisia, the mean annual yield of date fruits is about 100,000 tons. From this, around 1000

* Corresponding author. Fax: +216-74-275-595.
E-mail address: besbes.s@voila.fr (S. Besbes).

0308-8146/$ - see front matter © 2003 Elsevier Ltd. All rights reserved.
doi:10.1016/S0308-8146(03)00281-4

tons of date seeds oils would be extracted. The aim of this study was to evaluate the chemical composition of date seeds from two important cultivars grown in Tunisia and to determine fatty acid profiles, thermal profiles and sensorial profiles of their lipid fraction.

2. Materials and methods

2.1. Seed material

Date palm fruits were obtained from the National Institute of Arid Zone (Degach, Tunisia). The seeds of the two cultivars under investigation (Deglet Nour and Allig) were directly isolated from 50 kg of date fruit having the same origin, collected at the "Tamr stage" (full ripeness) and kept at 10 °C for a week. The seeds were soaked in water, washed to get rid of any adhering date flesh, and then air-dried. Their relative percentage weight compared with the weight of the fresh fruits was about 11.32% for the Deglet Nour variety and about 10.7% for the Allig variety. Then, they were further dried at about 50 °C. Date pits, of each variety, were separately milled in a heavy-duty grinder to pass 1–2 mm screens and then preserved at −20 °C until analyses. One day after the lipid extraction, an appropriate quantity of powdered date seed was kept at 5 °C.

2.2. Lipid extraction and preservation

Lipid extraction was carried out with a SER 148 Solvent Extractor (Velp Scientifica, Europe) equipped with 6 Soxhlet posts. About 15 g of powdered date seeds were used for oil extraction, with petroleum ether, 40–60 °C (Merck, for analysis), in each Soxhlet post. The extraction was repeated at least 12 times for each variety. The operational conditions were:

- immersion time: 30 min with thimble immersed in boiling solvent; and
- washing time: 60 min of reflux washing.

After removing solvent, using a Rotavapor apparatus, the seed oil obtained was drained under a stream of nitrogen and then stored in a freezer (−20 °C) for subsequent physico chemical analyses.

2.3. Analytical methods

All analytical determinations were performed at least in triplicate. Values of different parameters were expressed as the mean ± standard deviation ($\overline{x} \pm$ S.D.).

2.3.1. Chemical analysis of powdered seeds

2.3.1.1. Dry matter. This was determined according to the Association of Official Analytical Chemists (AOAC, 1990).

2.3.1.2. Fat content. The weight of fat extracted from 15 g of seed powder was determined to calculate the lipid content. Result was expressed as the percentage of lipids in the dry matter of seed powder.

2.3.1.3. Protein content. Total protein was determined by the Kjeldahl method. Protein was calculated using the general factor (6.25) (El-Shurafa et al., 1982). Data were expressed as per cent of dry weight.

2.3.1.4. Ash and mineral contents. To remove carbon, about 2 g (powdered) of each cultivar, in a porcelain container, was ignited and incinerated in the muffle furnace at about 550 °C for 8 h. The total ash was expressed as per cent of dry weight. The mineral constituents (Ca, Na, K, Fe and Mg) present in the date seeds of each cultivar were analysed separately, using an atomic absorption spectrophotometer (Hitachi Z6100, Japan). The samples were prepared for analyses as described by Al-Showiman (1990). Phosphorus content (P) was determined by the phosphomolybdovanate method (AOAC, 1990).

2.3.1.5. Carbohydrate content. Carbohydrate content was estimated by difference of mean values, i.e., 100−(Sum of percentages of moisture, ash, protein and lipids) (Al-Hooti et al., 1998; Barminas, James, & Abubakar, 1999).

2.3.2. Analysis of oil extract

2.3.2.1. Fatty acid composition. The oils were converted to methyl esters using a boron trifluoride methanol complex (14% w/v). The mixture was maintained at 100 °C during 1 h. The reaction was stopped with 0.5 ml of distilled water. Then, the extracted fatty acid methyl esters (FAMES) were dissolved in pure heptane (Merck) for GC analyses.

GC analyses were performed on a Hewlett-Packard 5890 Series II gas chromatograph (H.P. Co., Amsterdam, The Netherlands) equipped with a flame hydrogen ionization detector and a capillary column (HP Inovax cross-linked PEG, 30 m × 0.32 mm × 0.25 μm film). The column temperature was programmed from 180 to 240 °C at 5 °C/min and the injector and detector temperature were set at 250 °C. Nitrogen was the carrier gas. The identification of the peaks was achieved by retention times and by comparing them with authentic standards analysed under the same conditions. Peak areas of triplicate injections were measured with a HP computing integrator.

2.3.2.2. Differential scanning calorimetry (DSC). Thermal properties were determined with a differential scanning calorimeter (DSC 2920 Modulated DSC-TA Instruments, Newcastle, DE, USA). Oil (2 ± 0.10 mg) was weighed into a DSC-pan (SFI—Aluminium, TA Instrument T11024). The sample was quickly cooled to −50 °C with a speed of 15 °C/min, maintained at this

temperature for 15 min, and heated to 90 °C with a heating speed of 15 °C/min. The same operation (cooling and heating) was repeated and the DSC thermographs were recorded during the second melting. An empty DSC-pan was used as an inert reference to balance heat capacity of the sample pan. The DSC was calibrated for temperature and heat flow using eicosane ($T_p = 36.80$ °C, $H = 247.70$ J/g) and dodecane ($T_p = -9.65$ °C, H = 216.73 J/g). Solid fat contents were determined from the DSC melting curves according to Deroanne (1977).

2.3.2.3. Oxidation induction time. Oxidative stability was evaluated by the Rancimat method. Stability was expressed as the oxidation induction time (h), measured with the Rancimat 679 apparatus (Metrohm AG, Herison, Switzerland) using an oil sample of 2.5 g, warmed to 100 °C and a purified air flow rate of 15 l/h. In the Rancimat method, the volatile degradation products were trapped in distilled water and determined conductometrically. The induction time was defined as the time necessary to reach the inflection point of the conductivity curve (Halbault, Barbé, Aroztegui, & De La Torre, 1997).

2.3.2.4. Colour. The CieLab coordinates (L^*, a^*, b^*) were directly read with a spectrophotocolorimeter MS/Y-2500 (Hunterlab, In., Reston, VA, USA), calibrated with a white tile. In this coordinate system, the L^* value is a measure of lightness, ranging from 0 (black) to 100 (white), the a^* value ranges from—100 (greenness) to + 100 (redness) and the b^* value ranges from—100 (blueness) to + 100 (yellowness). Twelve readings were taken on each sample.

Absorbance of oil solutions in hexane were measured with a spectrophotometer UV-240 (Shimmadzu Corporation, Kyoto, Japan).

2.3.2.5. Viscosity determination. Viscosity was followed at 25 °C with a Stress Tech Rheologica Rheometer (Rheologica Instruments AB, Lund, Sweden) conducted with a steel cone-plate (C40/4) under a constant shear rate of 100 s^{-1}.

2.3.2.6. Microscopic study. Microscopic analyses were carried out according to Attia, Bennasar, Lagaude, Hugodo, Rouvière, and Tarodo De La Fuente (1993). The observations were performed with scanning electron microscope (SEM) Philips XL 30 (Philips, Leimeil-Brevannes, France).

3. Results and discussion

3.1. Chemical composition of date seed

Table 1 presents the average compositions of *Phoenix dactylifera* L. date seed of the two studied cultivars.

Table 1
Chemical composition (dry basis) of date seeds from the two studied cultivars. All values given are means of three determinations

Component	Cultivar	
	Deglet Nour	Allig
Dry matter (%)	90.60±0.18	91.40±0.09
Fat[a]	10.19±0.11	12.67±0.26
Protein[a]	5.56±0.02	5.17±0.78
Ash[a]	1.15±0.02	1.12±0.05
Potassium[b]	229±9.57	293±21.42
Magnesium[b]	51.7±2.40	58.4±1.33
Calcium[b]	38.8±0.22	28.9±0.39
Phosphorus[b]	68.3±1.84	83.6±2.44
Sodium[b]	10.4±0.60	10.25±0.57
Iron[b]	2.30±0.21	2.21±0.26
Total carbohydrate[a]	83.1±0.33	81.0±0.91

[a] In %, dry matter basis.
[b] In mg/100 g of dry matter.

Date pits from Deglet-Nour and Allig cultivars contained 9.4 and 8.6% moisture, respectively. The ash, protein and fat contents (dry weight basis) in Deglet-Nour and Allig seeds were 1.15 and 1.12%; 5.56 and 5.17% and 10.19 and 12.67%, respectively. Accordingly, total carbohydrate content of date pits ranged from 83.1% for Deglet-Nour to 81.0% for Allig. These results were in general agreement with those reported by Hamada et al. (2002), Al-Hooti et al. (1998) and El-Shurafa et al. (1982), but higher than those reported by Hussein and El-Zeid (1975) and Devshony et al. (1992). Those differences may be attributed to the variability of the studied cultivars.

The date seeds also contained significant amount of important minerals (Table 1). The potassium concentration was the highest, followed in descending order by phosphorus, magnesium, calcium, sodium and iron. This order has already been reported by Al-Hooti et al. (1998), Devshony et al. (1992) and El-Shurafa et al. (1982). However, Al-Showiman (1990) found that the calcium content is highly significant, while potassium, sodium and magnesium come into second place.

Chemical composition of date seeds revealed that this by-product could be valuable. In order to justify the extraction of date seed fat, it is necessary to study its functional properties.

3.2. Profiles of the date seed oil

In order to seek added value of the lipid fraction of date seeds, we were interested in determining fatty acid composition, thermal, sensorial and physical profiles of date seed oil from Deglet-Nour and Allig cultivars.

3.2.1. Fatty acid composition

Fatty acid composition of the two studied seed oils is shown in Table 2. In all ten fatty acids were present,

Table 2
Fatty acid composition of date seed oil (g/100 g of total fatty acid). All values given are means of three determinations

Fatty acid	Cultivars	
	Deglet Nour	Allig
Capric $C_{10:0}$	0.80±0.13	0.07±0.01
Lauric $C_{12:0}$	17.8±0.60	5.81±0.25
Myristic $C_{14:0}$	9.84±0.09	3.12±0.06
Myristoleic $C_{14:1}$	0.09±0.15	0.04±0.03
Palmitic $C_{16:0}$	10.9±0.17	15.0±0.31
Palmitoleic $C_{16:1}$	0.11±0.19	1.52±0.01
Stearic $C_{18:0}$	5.67±0.20	3.00±0.03
Oleic $C_{18:1}$	41.3±0.76	47.7±1.11
Linoleic $C_{18:2}$	12.2±0.5	21.0±0.29
Linolenic $C_{18:3}$	1.68±0.71	0.81±0.38
SAFA	44.3±0.96	27.0±0.66
MUFA	41.45±1.10	49.2±1.15
PUFA	14.0±1.62	21.8±0.68

SAFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acid.

four of which were unsaturated. The most abundant fatty acids of date seed oil were oleic ($C_{18:1}$), linoleic ($C_{18:2}$), palmitic ($C_{16:0}$), myristic ($C_{14:0}$), and lauric ($C_{12:0}$) which together composed about 92% of the total fatty acids. The major fatty acid found in those cultivars was oleic acid, ranging from 41.3% for Deglet Nour seed oil to 47.7% for Allig seed oil. This is in agreement with previous reports (Al-Hooti et al., 1998; Al-Showiman, 1990; Devshony et al., 1992). However, Al-Hooti et al. (1998) found a higher content of oleic acid (53.3–58.8%) in date seed oil extracted from United Arab Emirates varieties. Fatty acid composition of date seed oil seems to vary slightly with cultivars.

Devshony et al. (1992) reported that date seed oil may be regarded as an oleic–lauric oil because oleic acid was most abundant, followed by lauric acid. Al-Hooti et al. (1998) showed also that date seed oils were oleic–linoleic or oleic–palmitic types. In this study, Deglet Nour seed oil was regarded as an oleic–lauric oil, while Allig seed oil was an oleic –linoleic oil. In general, date seed oil is characterized by the presence of five major fatty acids ($C_{18:1}$, $C_{18:2}$, $C_{16:0}$, $C_{14:0}$ and $C_{12:0}$); oleic fatty acid ($C_{18:1}$) was always most abundant in date seed oil.

Deglet Nour seed oil showed a higher saturated fatty acid content (SAFA: 44.3%) than Allig seed oil (SAFA: 26.3%) (Table 1). This can be explained by the presence of more lauric acid and myristic acid in Deglet Nour Cultivar. Allig seed oil contained higher amounts of linoleic and oleic acids and, in general, more UFA (unsaturated fatty acids), which makes it more sensitive to oxidation.

The degree of unsaturation of these date seed oils was lower than that of common vegetable oils, since date seed fat had a much lower linoleic acid content. In spite of this low level of unsaturation, date seed oil may have interesting potential for different uses.

3.2.2. Thermal profile

DSC is a fast and direct way to assess the quality of oil (Gloria & Aguilera, 1998). Using this method, various physical properties of date seed oil can be studied.

Date seed oil exhibited a simple thermogram after melting in the DSC (Fig. 1). The obtained peaks were asymmetric and may indicate the presence of four components, having different weights, in Deglet Nour seed oil or with the presence of two components having different weights in Allig seed oil. The fact that thermograms seemed to correspond to a number of compounds higher than those clearly shown, suggests the presence of mixed triglyceride groups with different melting points in the used conditions (Herrera & Anon, 1991). After total solidification, mixed glyceride crystals could be formed by intersolubility. They are associated into different crystalline groups with different melting points.

Deglet Nour seed oil exhibited a melting peak (−2.66 °C), a melting enthalpy (67.50 J/g) and an onset temperature (−19.01 °C) slightly different from those of Allig seed oil (−3.29 °C, 71.87 J/g and −21.72 °C respectively) (Table 3). This was due to the higher level of MUFA and PUFA in Allig seed oil (Section 3.2.1.).

Fig. 2 illustrates that solid fat content decreases when temperature increases. It was constant for temperatures above 15 °C. This corresponds to an entire liquefaction of date seed oil. At lower temperatures, solid fat content was relatively higher in Deglet Nour seed oil than in Allig seed oil. This can be explained by the fact that Deglet Nour seed oil had a higher SAFA content (Section 3.2.1).

3.2.3. Sensorial and physical profiles

To determine sensorial profile of date seed oil, colour, oxidative stability, viscosity and microstructure were studied.

3.2.3.1. Colour. Many different techniques were used to evaluate colour of frying oil objectively, including colorimetric kits (Croon, Rogsted, Leth, & Kiutamo, 1986) and colorimeters, such as the Lovibond (Al-Kahtani, 1991) and Agtron (Warner, Orr, Parrot, & Glynn, 1994). UV absorption, although outside the visible spectrum, was also related to colour changes (Mazza & Qi, 1992; Melton, Jafar, Sykes, & Trigiano, 1994). In this study, we compared L^*, a^* and b^* parameters of Deglet Nour and Allig seed oils. CieLab coordinates (L^*, a^*, b^*) of seed oil from the two studied date cultivars are shown in Fig. 3. Deglet Nour cultivar showed a higher $L*$ value and lower a^* and b^* values. This means that Deglet Nour seed oil was lighter-coloured than Allig seed oil. Such a colour seems to attract consumers (Hsu & Chung, 1998).

The CieLab (L^*, a^*, b^*) values of other vegetable oils, such as palm, soybean, sunflower, olive, and corn ranged from 63.4 to 69.5, 3.8 to 4.4 and 9.2 to 10.4,

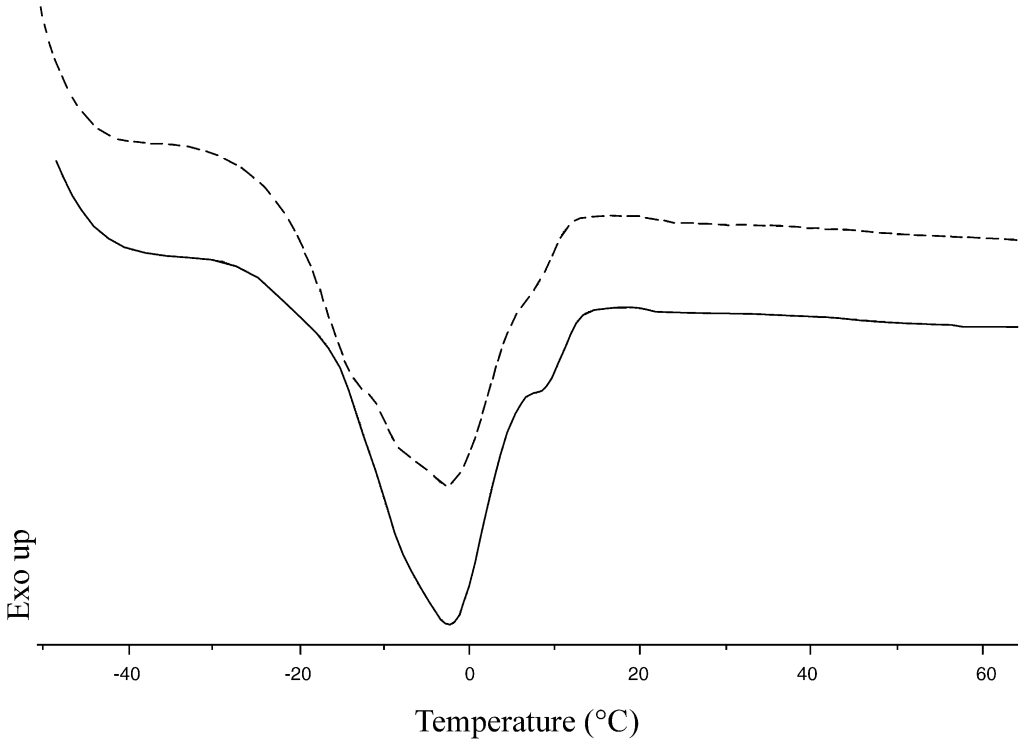

Fig. 1. Melting thermograms of seed oils from the two studied date cultivars (— Deglet Nour, - - - Allig).

Table 3
Thermal parameters, from DSC melting curves, of seed oil from the two studied date cultivars. All values given are means of three determinations

Parameter	Cultivar	
	Deglet Nour	Allig
Transition temperatures (°C)		
T_1	–	−15.23±1.53
T_2	–	−8.74±0.32
T_3	−2.66±0.53	−3.29±0.14
T_4	8.41±0.01	7.20±0.14
Onset temperature (°C)	−19.01±0.42	−21.72±1.45
Pick temperature (°C)	−2.66±0.53	−3.29±0.14
Melting enthalpy (J/g)	67.50±0.72	71.87±0.08

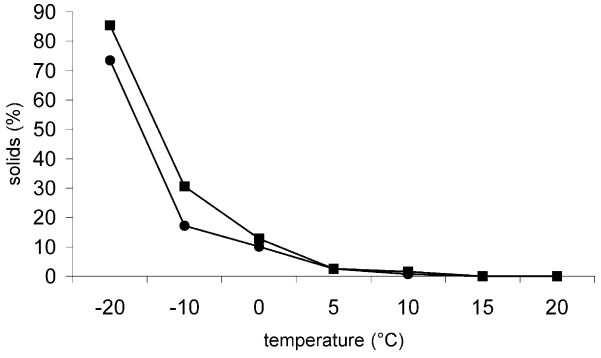

Fig. 2. Solids–temperature curves, determined with DSC method, for seed oil from the two studied cultivars (■ Deglet Nour, ● Allig).

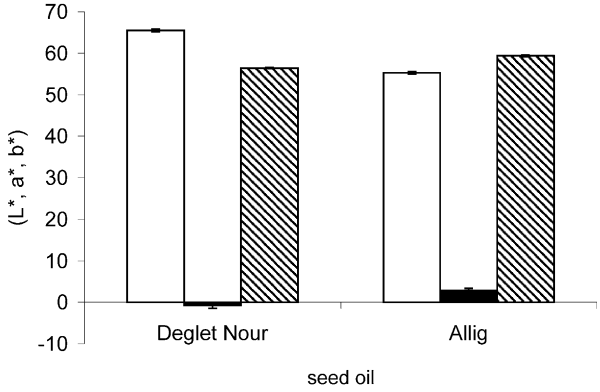

Fig. 3. CieLab coordinates (L^*, a^*, b^*) of seed oil from the two studied date cultivars (□ : L^*, ■: a^*, ▨: b^*).

respectively (Hsu & Yu, 2002). This shows that the date seed oil b^* values were higher than those of other vegetable oils. Date seed oils were more yellow-coloured than vegetable oils studied by Hsu and Yu (2002). This may suggest the presence of more yellow pigments (carotenoids) in date seed oils. Deglet Nour seed oil showed another colour particularity: Hunter a^* negative value (−0.81) was markedly lower than the Hunter a^* of common vegetable oils.

Allig seed oil showed some absorbance in the UV-C (100–290 nm), UV-B (290–320 nm) and UV-A (320–400 nm) range, whereas Deglet Nour seed oil showed absorbance only in the UV-C and UV-B range (Fig. 4). In the UV-B and UV-A ranges, the wavelengths of

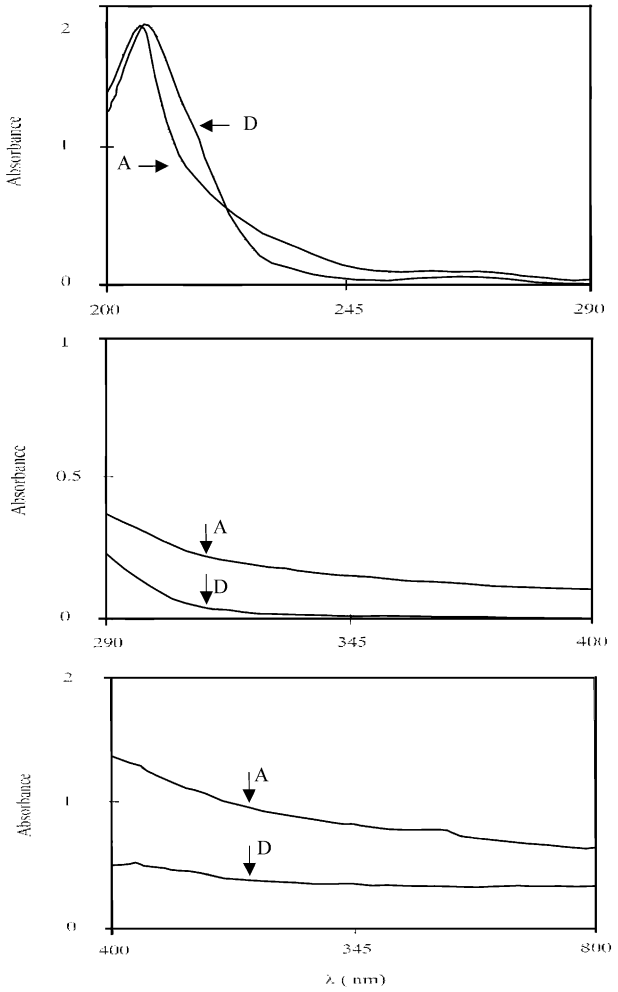

Fig. 4. Ultra violet visible spectra of date seed oils. Figure derived from scan ($\lambda = 200$–290) of oil diluted 1:800; from scans ($\lambda = 290$–400) of oil diluted 1:100 and from scans ($\lambda = 400$–800) of oil diluted 1:10, all in hexane. A: Allig, D: Deglet Nour.

ultraviolet light responsible for most cellular damage, date seed oil can shield against UV-B and UV-A radiation. Thus, date seed oil may be used in formulation of UV protectors that provide protection against both UV-A and UV-B. The optical transmission of date seed oil was comparable to that of raspberry seed oil, especially in the UV range (290–400 nm). This is comparable to titanium dioxide preparations as sun protection factors for UV-B (SPF) and UV-A (PFA) (Oomah, Ladet, Godfrey, Liang, & Girard, 2000).

Allig seed oil contained more yellow colouring than Deglet Nour seed oil, as indicated by the absorbance (1.20 against 0.45) at 440–460 nm for 1% oil in hexane. Date seed oil also contained more yellow colouring than raspberry seed oil which is characterized by an absorbance ranging from 0.08 to 0.11 at 440–460 nm, studied by Oomah et al. (2002) under the same conditions. This confirms the results obtained with the CieLab Miniscan instrument. This yellow colour, which include carotenoids, is beneficial, since it stimulates the appearance of butter without the use of primary colorants, such as carotenes and annattos, commonly used in the oil and fat industry (Oomah et al., 2000).

3.2.4. Oxidative stability

The results of the Rancimat test are shown in Table 4. Stability, expressed as the oxidation induction time (h), was about 45 h for Deglet Nour seed oil and about 33 h for Allig seed oil. This difference may be explained by the fact that Allig seed oil contained more MUFA and PUFA than Deglet Nour seed oil. The latter may also have a higher antioxidant content, e.g. α-tocophérol and phenolic compounds, which are well known as food lipid anti-oxidants. A linear regression based on the oleic/linoleic ratio and the contents of phenols and tocopherols, in virgin olive oil, showed a good correlation with the oxidative stability measured by Rancimat (Aparicio, Roda, Albi, & Guttiérez, 1999). A strong negative correlation was also observed between linoleic acid and oil stability measured by Rancimat (Salvador, Aranda, Gomez-Alonso, & Fregapane, 2001). A high correlation was observed between total polyphenol content and oxidative stability of olive oil by Rancimat (Caponio, Alloggio, & Gomez, 1999; Montedero, Servilli, Baldioli, Selvaggini, Miniati, & Macchioni, 1993; Papadoupoulus & Boskow, 1991; Salvador et al., 2001). The contribution of phenolic and orthophenolic compounds to the oxidation stability was about 51%; the contribution of fatty acids was 24%, and those α-tocopherols, carotenoids and chlorophylls even less (Aparicio et al., 1999).

The oxidative stability of date seed oil was higher than that of most vegetable oils and comparable to that of olive oil. This may be explained by the low content of PUFA in date seed oil and in olive oil compared to the common vegetable oil.

3.2.5. Viscosity

Table 4 shows that the viscosity of Deglet Nour seed oil was lower than that of Allig seed oil (18.30 mPa.s against 49.00 mPa.s) in spite of the fact that the latter contained more UFA (Section 3.2.1). This difference is likely due to Deglet Nour seed oil's high medium- and short- chain fatty acid contents (such as $C_{12:0}$ and $C_{14:0}$) compared to Deglet Nour seed oil. An obvious trend in the relationship between fatty acid chain length

Table 4
Oxidation induction time and viscosity of seed oil from the two studied date cultivars

	Cultivars	
	Deglet Nour	Allig
Induction time (h)	44.80±0.43	33.26±0.46
Viscosity (mPa.s)	18.30±0.40	49.00±0.50

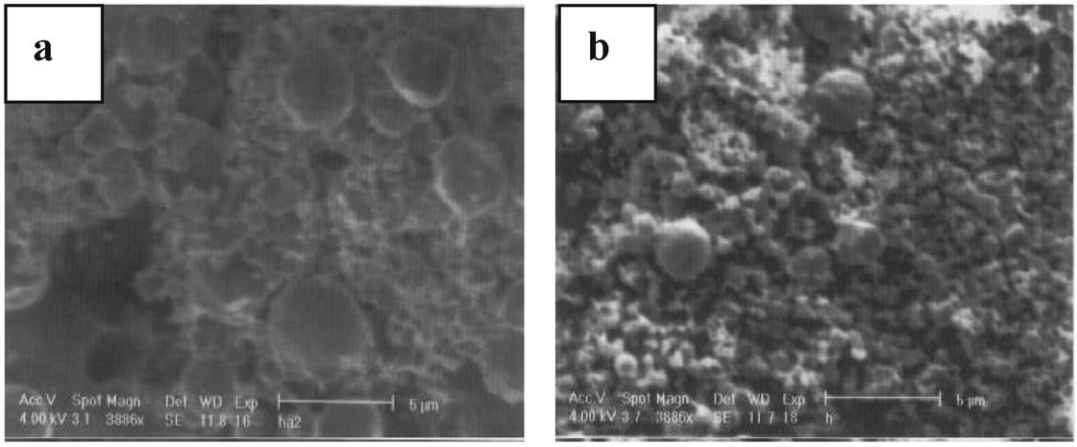

Fig. 5. SEM (scanning electron microscopy) observation of seed oil from the two studied date cultivars (a: Deglet Nour, b: Allig).

and viscosity was observed (Geller & Goodrum, 2000; Gustone, Harwood, & Padley, 1986). The presence of double bonds also influences oil viscosity.

It is worth noting that the viscosity of Deglet Nour seed oil is lower than that of most vegetable oils and similar to the oleic acid and raspberry seed oil studied by Oomah et al. (2000).

3.2.6. Microstructure

Scanning electron micrographs of the oil samples showed similar structures (Fig. 5). Light areas are seen, corresponding to individual structures and dark areas corresponding to diffuse structures. The average size of an individual structure is about 0.5–5 μm. Allig seed oil presented a denser structure which may also be related to the higher viscosity observed for this oil. In the food industry, the texture of fat-containing products strongly depends on macroscopic properties of fat network formed within the finished product (Narine & Marangoni, 1999). The macroscopic properties are also influenced by the particularity of the microstructure. Therefore, there is a need to consider the microstructural effect on macroscopic properties.

4. Conclusion

Considering the protein, fat, mineral and carbohydrate contents of date seed, we can conclude that date pits could be used to meet part of the nutritional requirements of animal feeds. This by-product of date processing industries could be regarded as an excellent source of food ingredients with interesting technological functionality that could also be used in food as an important source of dietary fibre.

This preliminary study shows that date seed oils contain high relative percentages of oleic acid. They are also more yellow-coloured than other vegetable oils and they can protect against UV light responsible for much cellular damage. Date seed oils could easily be conserved due to their high oxidative stability. Regarding these specificities, the value of this by-product in cosmetic and food industries may be justified. However, the safety of date seed oil must be tested before using it as an ingredient in the food or cosmetic industries.

Acknowledgements

We thank Mr. Fakhfakh Zouheir responsible for U.S.C.R. Microscopy for observations in S.E.M. and Mr. Hammami Mohamed, responsible for U.S.C.R. spectrometry, for chromatographic analysis.

References

Abou Zied, A. A., Abderrahman, N., & Baghlef, A. O. (1991). The formation of oxytetracycline in date-coat medium. *Bioresource Technology*, *37*, 179–184.

Abou Zied, A. A., & Baghlef, A. O. (1983). Utilization of date seeds and cheese whey in production of citric acid by *Candida lipolytica*. *Agricultural Wastes*, *8*, 131–142.

Abou Zied, A. A., & Khoja, S. M. (1993). Utilization of dates in the fermentative formation of citric acid by *Candida lipolytica*. *Zentral Microbiology*, *148*, 213–221.

Al-Hootii, S., Jiuan, S., & Quabazard, H. (1995). Studies on the physico-chemical characteristics of date fruits of five UAE cultivars at different stages of maturity. *Arab Gulf Journal*, *13*, 553–569.

Al-Hooti, S., Sidhu, J. S., Al-Otaibi, J., Al-Ameeri, H., & Qabazard, H. (1997). Processing quality of important date cultivars grown in the United Arab Emirates for jam, butter and dates-in-syrup. *Adv. Food. Sci.*, *19*, 35–40.

Al-Hooti, S., Sidhu, J. S., & Qabazard, H. (1998). Chemical composition of seeds date fruit cultivars of United Arab Emirates. *Journal of Food Science & Technology*, *35*, 44–46.

Al-Kahtani, H. A. (1991). Survey of quality of used frying oils from restaurants. *Journal of the American Oil Chemists Society*, *68*, 857–862.

Al-Obaidi, Z. S., & Berry, D. R. (1976). Saling up of citric acid fermentation using fermenters. *Date Palm Journal*, *2*, 19–33.

Al-Showiman, S. S. (1990). Chemical Composition of date palm seeds (*Phoenix dactylifera L.*) in Saudi Arabia. *J. Chem. Soc.*, *12*, 15–24.

AOAC. (1990). *Official methods of analyses*. Washington, DC: Association of Official Analytical Chemist.

Aparicio, R., Roda, L., Albi, M. A., & Gutiérrez, F. (1999). Effect of various compounds on virgin olive oil stability measured by Rancimat. *Journal of Agricultural & Food Chemistry*, *47*, 4150–4155.

Attia, H., Bennasar, M., Lagaude, A., Hugodo, B., Rouviere, J., & Tarodo De La Fuente, B. (1993). Ultrafiltration with microfiltration membrane of acid skimmed and fat-enriched milk coagula: hydrodynamic, microscope and rheological approaches. *Journal of Dairy Research*, *60*, 161–174.

Barminas, J. T., James, M. K., & Abubakar, U. M. (1999). Chemical composition of seeds and oil of *Xylopia aethiopica* grown in Nigeria. *Plant Foods for Human Nutrition*, *53*, 193–198.

Caponio, F., Alloggio, V., & Gomes, T. (1999). Phenolic compounds of virgin olive oil: influence of paste preparation techniques. *Food Chemistry*, *64*, 203–209.

Croon, L. B., Rogstad, A., Leth, T., & Kiutamo, T. (1986). A comparative study of the analytical methods for quality evaluation of frying fat. *Fette. Anstrichm*, *88*, 87–91.

Deroanne, C. (1977). L'analyse calorimétrique différentielle, son intérêt pratique pour le fractionnement de l'huile de palme et la détermination de la teneur en phase solide. *Lebensm.-Wiss. U.-Technol.*, *10*, 251–255.

Devshony, S., Eteshola, A., & Shani, A. (1992). Characterisation and some potential application of date palm (Phoenix dactylifera L.) seeds and seeds oil. *JAOCS*, *69*, 595–597.

El-Shurafa, M. Y., Ahmed, H. S., & Abou-Naji, S. E. (1982). Organic and inorganic constituent of dates palm pit (seeds). *J. Date Palm*, *2*, 275–284.

Fayadh, J. M., & Al-Showiman, S. S. (1990). Chemical composition of date palm (*Phoenix dactylifera* L.). *J. Chem. Sos. Pak.*, *12*, 84–103.

Geller, D. P., & Goodrum, J. W. (2000). Rheology of vegetable oil anlogs and triglycerids. *JAOCS*, *77*, 111–114.

Gloria, H., & Aguilera, J. M. (1998). Assessment of the quality of heated oils by differential scanning calorimetry. *Journal of Agricultural & Food Chemistry*, *46*, 1363–1368.

Gustone, F. D., Harwood, J. L., Padley, F. B. (Eds.). (1986). *The lipid handbook*. London: Chapman and Hall.

Halbault, L., Barbé, C., Aroztegui, M., & De La Torre, C. (1997). Oxidative stability of semi-solid excipient mixtures with corn oil and its implication in the degradation of vitamin A. *International Journal of Pharmaceutics*, *147*, 31–41.

Hamada, J. S., Hashim, I. B., & Sharif, A. F. (2002). Preliminary analysis and potential uses of date pits in foods. *Food Chemistry*, *76*, 135–137.

Herrara, M. L., & Anon, M. C. (1991). Crystalline fractionation of hydrogenated sunflowerseed oil. Differential scanning calorimetry (DSC). *JAOCS*, *68*, 799–803.

Hobani, A. I. (1998). Rheological behaviour of date–water concentrates. *Journal of Food Engineering*, *36*, 349–357.

Hsu, S. Y., & Chung, H. Y. (1998). Effects of processing factors on qualities of emulsified meatball. *Journal of Food Engineering*, *36*, 337–347.

Hsu, S. Y., & Yu, S. H. (2002). Comparisons on 11 plant oil fat substitutes for low-fat kung-wans. *Journal of Food Engineering*, *51*, 215–220.

Hussein, F., & El-Zeid, A. (1975). Chemical composition of Khalas dates grown in Saudi Arabia. *Egypt. J. Hort.*, *2*, 209–214.

Hussein, F., Mustafa, S., & Al-Zeid, A. (1976). Studies on physical and chemical characteristics of eighteen date cultivars grown in Saudi Arabia. *Indian J. Hort.*, *33*, 107–113.

Khatchadourian, H. A., Sawaya, W. N., Khalil, J., & Mashadi, A. S. (1983). Processing of five major Saudi Arabian date varieties into Dates butter and dates in syrup. *Date Palm Journal*, *1*, 103–119.

Mazza, G., & Qi, H. (1992). Effect after-cooking darkening inhibitors on stability of frying oil and quality of French fries. *Journal of the American Oil Chemists' Society*, *69*, 847–853.

Melton, S. L., Jafar, S., Sykes, D., & Trigiano, M. K. (1994). Review of stability measurements for frying oils and fried food flavor. *Journal of American Oil Chemists' Society*, *71*, 1301–1308.

Mohamed, S., Shabana, H. R., & Mawlod, E. A. (1983). Evaluation and identification of Iraqi date cultivars: fruits Characteristics of fifty cultivars. *Date Palm Journal*, *2*, 27–55.

Montedoro, G., Servilli, M., Baldioli, M., Selvaggini, R., Miniati, E., & Macchioni, A. (1993). Simple and hydrolyzable compounds in virgin olive oil. Spectroscopic characterizations of the secoiridoid derivatives. *Journal of Agricultural & Food Chemistry*, *41*, 2228–2234.

Nacib, N., Nacib, A., & Bourdant, J. (1997). Use of waste products in the fermentative formation of Baker's yeast biomass by *Saccharomyces Cervisiae*. *Bioresource Technology*, *60*, 67–71.

Nacib, N., Nacib, A., Mostefa, G., Larbi, L., Adimi, L., Remmal, M., & Bourdant, J. (1999). Use of date products in production of thermophilic dairy starters strain *Streptococcus thermophilus*. *Bioresource Technology*, *67*, 291–295.

Narine, S. S., & Marangoni, A. G. (1999). Microscopic and rheological studies of fat crystal networks. *Journal of Crystal Growth*, *199*, 1315–1319.

Oomah, B. D., Ladet, S., Godfrey, D. V., Liang, J., & Girard, B. (2000). Characteristics of raspberry (*Rubus idaeus* L.) seed oil. *Food Chemistry*, *69*, 187–193.

Papadopoulus, G., & Boskow, D. (1991). Antioxidant effect of natural phenols on olive oil. *Journal of the American Oil Chemists' Society*, *68*, 669–671.

Rygg, G.L. (1946). *Compositional changes in the date fruit during growth and ripening*. USDA, Technical Bulletin No 910, Washington, DC.

Salem, S. A., & Hegazi, S. M. (1971). Chemical composition of the Egyptian dry dates. *J. Sci. Food Agric.*, *22*, 632–634.

Salvador, M. D., Aranda, F., Gomez-Alonso, S., & Fregapane, G. (2001). Cornicabra virgin olive oil: a study of five crop seasons. Composition, quality and oxidative stability. *Food Chemistry*, *74*, 267–274.

Vandercook, C. E., Hasegawa, S., & Maier, V. P. (1977). Quality and nutritive value of dates as influenced by their chemical composition. *Date Grower's Iinst. Rep.*, *54*, 3–11.

Warner, K., Orr, P., Parrot, L., & Glynn, M. (1994). Effects of frying oil composition on potato chip stability. *Journal of the American Oil Chemists' Society*, *71*, 1117–1121.

Youssif, A. K., Abou Ali, M., & Bou Idreese, A. (1990). Processing, evaluation and storability of date Jelly. *Journal of Food Science & Technology*, *27*, 264–267.

Youssif, A. K., Alghamdi, A. S., Hamad, A., & Mustafa, A. I. (1996). Processing and evaluation of a date juice–milk drink. *Egyptian Journal of Dairy Science*, *24*, 277–288.

Youssif, A. K., Benjamin, N. D., Idin, S. M. A., & Ali, S. M. (1976). *Nutritive value of commercial Iraqi date cultivars*. Palm and Date Research Center, Technical Bulletin No. 7, Mimeographed, Baghdad, Iraq.

Youssif, A. K., & Alghamdi, A. S. (1999). Suitability of some date cultivars for jelly macking. *Journal of Food Science & Technology*, *36*, 515–518.