Date Seed Oil

Subjects: Food Science & Technology

Contributor: Abdessalem Mrabet , Ana Jiménez-Araujo , Rafael Guillén-Bejarano , Rocío Rodríguez-Arcos , Marianne Sindic

The date seed is an important by-product for date fruit manufacturers. Its use as source of different added-value compounds could be of great interest. Oil accounts for around 5-13% of the seed weight and its composition in phytochemicals makes it valuable for the food, cosmetic, pharmaceutical, and chemical industries.

date seed oil applications chemical composition phytochemicals fatty acids tocols sterols phenolics

1. Introduction

The date palm has long been one of the most important fruit crops for southern Mediterranean countries, where dates are the main income source and staple food for some local populations. In addition, this crop is not only a source of income from an economic point of view, but also a key for fixing populations and creating or maintaining centers of life. The cultivation of date fruit has been increasing in recent decades, from 1.05 million hectares of cultivated area and 6.44 million tons of production in 2000 to 1.09 Mha and 8.53 MT in 2018 [1]. These data also suggest an important increase in the crop yield since with a similar cultivated area, production has been raised by 25%. Egypt, Saudi Arabia, and Iran were the top three producers in 2018, with nearly half the global production. However, Tunisia is the biggest exporter, and is responsible for 17.6% of the worldwide trade (more than $300 million in 2018).

Date fruit production is not only devoted to its consumption as dried fruit (plain, pitted, or stuffed), but also to an increasing manufacturing industrial sector (puddings, bread, jellies, jams, syrups, etc.). Co-products from the date fruit industry (date flesh and seeds) have become an environmental problem for the growing and processing areas. In fact, tons of date seeds (around 10–15% of date fruit fresh weight) are daily discarded [2][3] as unwanted material or used mainly as animal feed for cattle, sheep, and camels [3]. The literature has reported several works devoted to searching for solutions to this problem.

The date seed is mainly composed of dietary fiber, protein, carbohydrates, phenols [4], and minerals (potassium, magnesium, calcium, phosphorus, sodium, and iron). Such substances perform several functions from a biological point of view, such as antioxidant, antibacterial, and antiviral activities [5].

Date seeds are also a good source of oil (5 to 13%), which is rich in phenolic compounds, tocopherols, and phytosterols [3][6][7][8][9]. Date seed oil has been studied by other authors, and its composition in vitamins, minerals,

and fatty acids makes it valuable for food formulations [9][10]. The literature data confirm that date seed oil is an interesting source of important nutrients that have a very positive effect on human health.

2. Chemical Composition of Date Seed Oil

2.1. Fatty Acid Composition

As shown in Table 1, the fatty acid profiles of several date seed oils are characterized by the presence of five major fatty acids, but in different amounts (oleic acid (C18:1), linoleic acid (C18:2), palmitic acid (C16:0), myristic acid (C14:0), and lauric acid (C12:0)),which together compose more than 90% of the total fatty acid contents [6][11][12]. Generally, oils with high oleic acid contents are of great interest due to their high stability and their nutritional importance. Oleic acid is recognized as one of the most important unsaturated fatty acids in human food because of its preventive effects on distinct heart vascular diseases, its low saturation level, and its potential for reducing cholesterol in the blood, as well as its high oxidative stability [12]. It is widely accepted that dietary oil which is rich in unsaturated fatty acids prevents cardiovascular and inflammatory diseases [13]. Moreover, various studies point out the preventive effect of lauric acid on prostatic hyperplasia development [14], its healthier characteristics compared to trans-fatty acids [15], and its antimicrobial properties, which inhibit the growth of microbes and their production of toxins [14][15][16].

Table 1. Fatty acid profiles of date seed oil expressed as percentage of total fatty acid quantified.

References	Besbes et al. (2004) [17]	Basuny et al. (2011) [18]	Dehdivan et al. (2017)[19]	Nehdi et al. (2018) [11]	Raza et al. (2019) [20]	Laghouiter et al. (2018)[21]	Akbari et al. (2012) [22]	Bouhlali et al. (2017) [23]
Saturated								
Capric acid (10:0)	0.80	0.25	0.2–0.5	0.71	0.48–0.55	nd [1]	0.47–0.50	nd
Lauric acid (12:0)	17.8	35.31	14–15.8	10.36	25.7–30.8	6.6–25.4	25.6–30.8	16.7–20.3
Myristic acid (14:0)	9.84	0.04	10.6–10.9	10.44	6.9–16.7	9.3–19.3	13.3–16.9	10.2–12.3

Palmitic acid (16:0)	10.9	12.58	10.8–11.8	12.83	11.9–13.1	9.6–17.6	11.9–13.1	9.8–10–9
Stearic acid (18:0)	5.67	3.3	3–3.4	5.56	1.8–2.3	0.8–3.4	1.8–2.3	2.9–3.7
Monounsaturated								
Palmitoleic acid (16:1)	0.11	nd	0.2–0.4	nd	nd	0.09–1.66	nd	0.05–0.09
Oleic acid (18:1)	41.3	39.5	48.1–50.5	51.45	31.5–37.6	37.8–52.5	31.5–37.6	44.9–48.4
Gadoleic acid (20:1)	nd	nd	0.2–0.4	0.37–0.52	nd	0.16–0.65	nd	0.26–0.40
Polyunsaturated								
Linoleic acid (18.2)	12.2	8.2	7.7–8.2	7.2	4.4–6.9	5.7–10.4	4.4–7.0	8.30–9.02
Linolenic acid (18:3)	1.68	0.81	0.4–0.7	nd	nd	0.10–0.59	nd	0.09–0.21

nd[1] not detected

2.2. Tocopherol and Tocotrienol Compositions

Tocols (tocopherols and tocotrienols) (Table 2) are present in the unsaponifiable fraction of vegetable oils [24]. Tocopherols and tocotrienols (commonly known as vitamin E) are important for human health due to their lipoperoxyl radical scavenging activities [25][26]. They are known to be very efficient natural antioxidants, which protect biological membrane components. Watson and Preedy [27] showed that the benefits of tocotrienols are significantly greater than α-tocopherol. In addition, tocols also protect oil from free radical damage, thus

contributing to their stability. They are more effective than the synthetic antioxidant butylated hydroxytoluene (BHT) [28]. Tocopherols exhibit biological functions such as neuro-protective, anticancer, anti-inflammatory, cardioprotective, immunostimulatory, antidiabetic, hepatoprotective, and nephroprotective activities [29][30].

Table 2. Unsaponifiable components of date seed oil.

	Content	Composition	References
Tocols (mg/100g)	32–74	α-tocopherol (74%), (β+γ)-tocopherol (40.56%), δ-tocopherol (28.41%)	Laghouiter et al. (2018) [21]
	54.65	α-tocotrienol (63.28%), γ-tocopherol (17.72%), γ-tocotrienol (11.84%), δ-tocotrienol (3.60%), α-tocopherol (1.85%), β-tocopherol (1.7%)	Al-Juhaimi et al. (2017) [31]
	0.053–0.143	α-tocopherol (51.02%), (β+γ)-tocopherol (30.61%), δ-tocopherol (12.24%)	Boukouada et al. (2014) [32]
	1.01–1.86	α-tocopherol (52.54%), α-tocopheryl acetate (27.68%), γ-tocopherol (19.76%)	Habib et al. (2013)[10]
	24.97–42.08	α-tocopherol (38.8%), γ-tocopherol (5.4%), δ-tocopherol (2.4%)	Besbes et al. (2004)[17]
	51.54	α-tocotrienol (66%), γ-tocopherol (10.3%), γ-tocotrienol (4.6%), δ-tocopherol (1%), β-tocopherol (0.9%), α-tocopherol (0.6%)	Nehdi et al. (2010)[9]
	70.75	α-tocotrienol (30.19%), γ-tocopherol (23.61%), γ-tocotrienol (19.07%), α-tocopherol (17.52%), δ-tocotrienol (5.89%), β-tocopherol (2.42%), δ-tocopherol (0.9%)	Nehdi et al. (2018)[11]

Sterols (mg/100g)	300–350	β-sitosterol (80%), campesterol (10%), Δ5-avenasterol (4.5%), stigmasterol (2.42%), cholesterol (0.96%), Δ5,24-stigmastadienol (0.41%)	Besbes et al. (2004)[17]
	470–845	ND [1]	Laghouiter et al. (2018)[21]
	336	β-sitosterol (76%), campesterol (8.89%), Δ5-avenesterol (8.79%), Δ5,24-stigmastadienol (2.73%), Δ7-avenasterol (1.18%), stigmasterol (1.09%), Δ7-stigmastenol (0.79%), cholesterol (0.42%)	Nehdi et al. (2010)[9]
Phenols (mg/kg)	220.3–520.8	Hydroxytyrosol (10.21%), protocatechuic acid (9.62%), tyrosol (8.10%), caffeic acid (4.95%), gallic acid (4.11%), p-coumaric acid (0.26%), oleuropein (0.18%)	Besbes et al. (2004)[17]
	640–1270	ND	Boukouada et al. (2014)[32]

ND[1] not determined

2.3. Sterol Composition

The level of phytosterols in vegetable oils is used for the determination of the oil quality and for detecting alterations [33][34]. In general, phytosterols are present in oils in their esterified forms. Sterols, along with tocols, have been shown to be major components of the unsaponifiable fraction. The literature reported that the major components of date seed oil sterols were β-sitosterol, campesterol, and Δ5-avenasterol [17]. Other minor sterols were cholesterol, stigmasterol, Δ5,24-stigmastadienol, Δ7-avenasterol, and Δ7-stigmastenol [9][17] (Table 2).

2.4. Phenolic Compounds

The antioxidant activity may be partly due to some compounds other than tocopherols and sterols, e.g., phenolics [35]. Phenolic compounds are also present in the unsaponifiable matter, or "minor constituents" of oils (Table 2). On average, the total phenolic content of date seed oil ranged from 0.64 to 1.27 mg/g. However, the phenolic content and antioxidant activity differed according to the cultivar [36]. A study was conducted by Besbes et al. [17] regarding

the phenolic compounds present in Tunisian date seed oil (Deglet Nour and Allig varieties). These results showed that the oils extracted from the seeds of Deglet Nour and Allig contained eight phenolic compounds in different amounts (hydroxytyrosol, protocatechuic acid, tyrosol, gallic acid, caffeic acid, p-coumaric, oleuropein, and 3,4-dihyroxyphenylacetic acid). They also concluded that the higher stability of Deglet Nour oil was related to the high amount of phenolics present in Deglet Nour oil [37]. Date seed oil showed a significantly higher concentration of phenolic compounds than olive oil and can be a good source of natural phenolic compounds [37]. Phenolic compounds play an important role in seed oils regarding flavor, shelf-life, and resistance to oxidation. Reduced oil stability could be caused by a higher peroxide content following the extended duration and temperature of extraction, but better oxidative stability could be related to an increase in phenolic compounds.

3. Potential Applications of Date Seed Oil

3.1. Culinary Uses

Date seed oil presents a valuable chemical composition and physicochemical characteristics for its use as edible oil. It is rich in oleic acid, which confers nutritional importance. Its content of saturated fatty acids and the presence of many other antioxidants (phenolic compounds, tocols, carotenoids, etc.) make it highly stable against oxidative rancidity [9] and thermal treatments [7], making date seed oil suitable as a cooking, frying, or seasoning oil, or even as an alternative to palm olein [11]. Its content of carotenoids is adequate for margarine production since they provide a natural yellowish butter-like color without the addition of synthetic colorants [9]. Basuny et al. [18] replaced conventional corn oil with date seed oil for producing mayonnaise, which had higher sensory characteristics than the control. However, any applications for human consumption must be investigated for their complete safety.

3.2. Health Beneficial Effects

Date seed oil has the potential to be used in cosmetic and pharmaceutical practices as well. Date seed oil can protect against UV-B and UV-A radiation due to its absorbance spectrum of UV radiation, which is responsible for most cellular damage to skin [37], so date seed oil may be used in the formulation of UV protectors [9]. Ines et al. [38] studied it as a chemopreventive agent using a normal human epidermal keratinocyte model, concluding that this oil was able to prevent oxidative damage caused by H_2O_2 exposure. Besides, it did not show any toxic effect on cells at a dose as high as 30 µg/mL. These same authors [39] irradiated human skin samples with UV-B and observed that skin cultures with date seed oil had four times lower DNA damage than those without it for the same irradiation level. The authors related these effects to the content of phenolics and tocols present in this photoprotective oil. In fact, Lecheb and Benamara [40] formulated a cosmetic cream containing date seed oil and an aqueous seed extract. The optimized cream had similar spreadability, viscosity, and rheological behavior to other commercial creams, with the advantage of the substitution of synthetic components with natural ones. These bio-creams could have a great acceptance by consumers, who are more and more concerned about the use of chemicals in cosmetics [36].

3.3. Feedstock for Industrial Processes

Date seed oil shows outstanding promise, not only in the production of some functional food products and pharmaceuticals, but also as a renewable resource. Azeem et al. [41] concluded that this oil is also adequate for the production of biodiesel because of its low content of free fatty acids. A study conducted by Al-Zuhair et al. [42] using different catalysts (NaOH and Novozym®435), concluded that the yields were similar for both catalysts. However, the selectivity of NaOH was high toward transesterifying trans-9-elaidic acids compared to other acids, whereas Novozym®435 equally transesterified most acids present in the oil sample. Another industrial application that has been explored is as feedstock for the synthesis of poly(3-hydroxybutyrate) (PHB), a biodegradable polyester that could replace contaminating plastics [43]. The microorganism *Cupriavidus necator* can use date seed oil instead of edible vegetable oils as a sole carbon source and produce PHB at a reasonably good concentration and accumulation. The PHB obtained from date seed oil demonstrated physicochemical characteristics similar to standard PHB. The use of oils which are not expensive and do not compete with food as feedstock for the production of biodiesel and other chemicals is highly recommended. This is the case of the date pit, an abundant agro-food waste product with the appropriate chemical composition for these purposes.

4. Conclusions

Date seed oil is remarkable for its content of monounsaturated fatty acids, especially oleic acid. It is an excellent source of important lipid-soluble antioxidant compounds, such as phenols, tocopherols, and phytosterols, which play an important role in reducing the risk of many diseases. With the increasing availability of date seeds, which constitutes a troublesome waste product, their oil extraction may be economically beneficial and should be considered an opportunity for future venture. Based on its chemical and functional composition, date seed oil can be presented as a novel oil with interesting and varied applications, from human food (cooking, frying, seasoning, or shortening oil) to pharmaceutical and cosmetic applications, and even biodiesel or bio-plastic production. Date seeds would evolve from waste to feedstock for several industrial activities, which would support the economic and social development of date fruit producing and manufacturing areas.

References

1. FAOSTAT . FAOSTAT. Retrieved 2020-10-27
2. M. Chandrasekaran; Ali H. Bahkali; Valorization of date palm (Phoenix dactylifera) fruit processing by-products and wastes using bioprocess technology – Review. *Saudi Journal of Biological Sciences* **2013**, *20*, 105-120, 10.1016/j.sjbs.2012.12.004.
3. M.S. Rahman; S. Kasapis; N.S.Z. Al-Kharusi; I.M. Al-Marhubi; A.J. Khan; Composition characterisation and thermal transition of date pits powders. *Journal of Food Engineering* **2007**, *80*, 1-10, 10.1016/j.jfoodeng.2006.04.030.
4. Abdessalem Mrabet; Guillermo Rodríguez-Gutiérrez; Rafael Guillén-Bejarano; Rocío Rodríguez-Arcos; Ali Ferchichi; Marianne Sindic; Ana Jiménez-Araujo; Valorization of Tunisian secondary

date varieties (Phoenix dactylifera L.) by hydrothermal treatments: New fiber concentrates with antioxidant properties. *LWT - Food Science and Technology* **2015**, *60*, 518-524, 10.1016/j.lwt.2014.09.055.

5. O.D. Ekpa; R.U.B. Ebana; Comparative Studies of Manyanga, Palm and Coconut Oils: Anti-microbial effects of the oils and their metallic soaps on some bacteria and fungi. *Global Journal of Pure and Applied Sciences* **1996**, *1*, 155-163.
6. Souhail Besbes; Christophe Blecker; Claude Deroanne; Nour-Eddine Drira; HamadI Attia; Date seeds: chemical composition and characteristic profiles of the lipid fraction. *Food Chemistry* **2004**, *84*, 577-584, 10.1016/s0308-8146(03)00281-4.
7. Souhail Besbes; Christophe Blecker; Claude Deroanne; Georges Lognay; Nour-Eddine Drira; HamadI Attia; Heating effects on some quality characteristics of date seed oil. *Food Chemistry* **2005**, *91*, 469-476, 10.1016/j.foodchem.2004.04.037.
8. Hosam M. Habib; Wissam H. Ibrahim; Nutritional quality evaluation of eighteen date pit varieties. *International Journal of Food Sciences and Nutrition* **2009**, *60*, 99-111, 10.1080/09637480802314639.
9. Imededdine Arbi Nehdi; S. Omri; M.I. Khalil; S.I. Al-Resayes; Characteristics and chemical composition of date palm (Phoenix canariensis) seeds and seed oil. *Industrial Crops and Products* **2010**, *32*, 360-365, 10.1016/j.indcrop.2010.05.016.
10. Hosam M. Habib; Hina Kamal; Wissam H. Ibrahim; Ayesha S. Al Dhaheri; Carotenoids, fat soluble vitamins and fatty acid profiles of 18 varieties of date seed oil. *Industrial Crops and Products* **2013**, *42*, 567-572, 10.1016/j.indcrop.2012.06.039.
11. Imeddedine Arbi Nehdi; Hassen Mohamed Sbihi; Chin Ping Tan; Umer Rashid; Saud Ibrahim Al-Resayes; Chemical Composition of Date Palm (Phoenix dactylifera L .) Seed Oil from Six Saudi Arabian Cultivars. *Journal of Food Science* **2018**, *83*, 624-630, 10.1111/1750-3841.14033.
12. M. Kirthy Reddy; H. Durga Rani; Ch. Naga Deepika; Suraj Samrawat; V. Akshara; K. B. Rajesh; Study on Physico-chemical Properties of Oil and Powder of Date Palm Seeds (Phoenix dactylifera). *International Journal of Current Microbiology and Applied Sciences* **2017**, *6*, 486-492, 10.20546/ijcmas.2017.612.059.
13. Mohamed Fawzy Ramadan; G. Sharanabasappa; S. Parmjyothi; M. Seshagiri; Joerg-Thomas Moersel; Profile and levels of fatty acids and bioactive constituents in mahua butter from fruit-seeds of buttercup tree [Madhuca longifolia (Koenig)]. *European Food Research and Technology* **2005**, *222*, 710-718, 10.1007/s00217-005-0155-2.
14. S.V. Veeresh Babu; B. Veeresh; Anup A. Patil; Y.B. Warke; Lauric acid and myristic acid prevent testosterone induced prostatic hyperplasia in rats. *European Journal of Pharmacology* **2010**, *626*, 262-265, 10.1016/j.ejphar.2009.09.037.

15. Nicole M De Roos; Evert G. Schouten; Martijn B. Katan; Consumption of a solid fat rich in lauric acid results in a more favorable serum lipid profile in healthy men and women than consumption of a solid fat rich in trans-fatty acids.. *The Journal of Nutrition* **2001**, *131*, 242-245, 10.1093/jn/131.2.242.
16. Andrew P. Desbois; Potential Applications of Antimicrobial Fatty Acids in Medicine, Agriculture and Other Industries. *Recent Patents on Anti-Infective Drug Discovery* **2012**, *7*, 111-122, 10.2174/157489112801619728.
17. Souhail Besbes; Christophe Blecker; Claude Deroanne; Neila Bahloul; Georges Lognay; Nour-Eddine Drira; HamadI Attia; DATE SEED OIL: PHENOLIC, TOCOPHEROL AND STEROL PROFILES. *Journal of Food Lipids* **2004**, *11*, 251-265, 10.1111/j.1745-4522.2004.01141.x.
18. Amany Mohamed Mohamed Basuny; Maliha Ali Al-Marzooq; Basuny Amany Mohamed Mohamed; Al-Marzooq Maliha Ali; Production of Mayonnaise from Date Pit Oil. *Food and Nutrition Sciences* **2011**, *2*, 938-943, 10.4236/fns.2011.29128.
19. N.S. Dehdivan; B. Panahi; Physicochemical Properties of Seeds and Seeds Oil Extracted from Iranian Date Palm Cultivars. *Biological Forum – An International Journal* **2017**, *9*, 139-144.
20. M.Q. Raza; M.U. Arshad; M.S. Arshad; F.M. Anjum; Characterization of compositional and functional characteristics of date seeds and oil (Phoenix dactylifera L.) from three varieties. *International Journal of Biosciences* **2019**, *15*, 1-4.
21. Oum Kelthoum Laghouiter; Mohamed Benalia; Nadhir Gourine; Amar Djeridane; Isabelle Bombarda; Mohamed Yousfi; Chemical characterization and in vitro antioxidant capacity of nine Algerian date palm cultivars (Phoenix dactylifera L.) seed oil. *Mediterranean Journal of Nutrition and Metabolism* **2018**, *11*, 103-117, 10.3233/mnm-17185.
22. M. Akbari; Oil characteristics and fatty acid profile of seeds from three varieties of date palm (Phoenix dactylifera) cultivars in Bushehr-Iran. *African Journal of Biotechnology* **2012**, *11*, 12088-12093, 10.5897/ajb12.1084.
23. Eimad Dine Tariq Bouhlali; Chakib Alem; Jamal Ennassir; Mohamed Benlyas; Addi Nait Mbark; Younes Filali Zegzouti; Phytochemical compositions and antioxidant capacity of three date (Phoenix dactylifera L.) seeds varieties grown in the South East Morocco. *Journal of the Saudi Society of Agricultural Sciences* **2017**, *16*, 350-357, 10.1016/j.jssas.2015.11.002.
24. Shahin Sharif Ali; Naresh Kasoju; Abhinav Luthra; Angad Singh; Hallihosur Sharanabasava; Abhishek Sahu; Utpal Bora; Indian medicinal herbs as sources of antioxidants. *Food Research International* **2008**, *41*, 1-15, 10.1016/j.foodres.2007.10.001.
25. Imededdine Arbi Nehdi; Hassen Sbihi; Chin Ping Tan; Saud Ibrahim Al-Resayes; Evaluation and characterisation of Citrullus colocynthis (L.) Schrad seed oil: Comparison with Helianthus annuus (sunflower) seed oil. *Food Chemistry* **2013**, *136*, 348-353, 10.1016/j.foodchem.2012.09.009.

26. Prakash Adhikari; Keum Taek Hwang; Min Kyung Shin; Bo Kyung Lee; Sung Kyu Kim; Sun Young Kim; Ki-Teak Lee; Sung Zu Kim; Tocols in caneberry seed oils. *Food Chemistry* **2008**, *111*, 687-690, 10.1016/j.foodchem.2008.04.038.
27. R.W. Watson; V.R. Preedy. Tocotrienols vitamin E beyond tocopherols; CRC Press: Boca Raton, Florida, 2009; pp. 124-158.
28. F.D. Gunstone. Vegetable Oils in Food Technology; Blackwell publishing, CRC Press: Boca Raton, Florida, 2002; pp. 501.
29. Haseeb Ahsan; Amjid Ahad; Jahangir Iqbal; Waseem A Siddiqui; Pharmacological potential of tocotrienols: a review. *Nutrition & Metabolism* **2014**, *11*, 1-22, 10.1186/1743-7075-11-52.
30. Chandan K. Sen; Savita Khanna; Sashwati Roy; Tocotrienols: Vitamin E beyond tocopherols. *Life Sciences* **2006**, *78*, 2088-2098, 10.1016/j.lfs.2005.12.001.
31. Fahad Al-Juhaimi; Mehmet Musa Özcan; Oladipupo Adiamo; Omer N. Alsawmahi; Kashif Ghafoor; Elfadil E. Babiker; Effect of date varieties on physico-chemical properties, fatty acid composition, tocopherol contents, and phenolic compounds of some date seed and oils. *Journal of Food Processing and Preservation* **2018**, *42*, e13584, 10.1111/jfpp.13584.
32. Mustapha Boukouada; Zineb Ghiaba; Nadhir Gourine; Isabelle Bombarda; Mokhtar Saidi; Mohamed Yousfi; Chemical composition and antioxidant activity of seed oil of two Algerian date palm cultivars (Phoenix dactylifera).. *Natural Product Communications* **2014**, *9*, 1777-1780, 10.1177/1934578x1400901230.
33. K. Warner; S. Knowlton; Frying quality and oxidative stability of high-oleic corn oils. *Journal of the American Oil Chemists' Society* **1997**, *74*, 1317-1322, 10.1007/s11746-997-0063-7.
34. G Lercker; Maria Teresa Rodriguez-Estrada; Chromatographic analysis of unsaponifiable compounds of olive oils and fat-containing foods.. *Journal of Chromatography A* **2000**, *881*, 105-129, 10.1016/s0021-9673(00)00455-6.
35. M. Tasioula-Margari; O. Okogeri; Isolation and Characterization of Virgin Olive Oil Phenolic Compounds by HPLC/UV and GC-MS. *Journal of Food Science* **2001**, *66*, 530-534, 10.1111/j.1365-2621.2001.tb04597.x.
36. M.J. Abdul Afiq; R. Abdul Rahman; Y.B. Che Man; H.A. Al- Kahtani; T.S.T. Mansor; Date seed and date seed oil. *International Food Research Journal* **2013**, *20*, 2035-2043.
37. Souhail Besbes; C. Blecker; C. Deroanne; G. Lognay; Nour-Eddine Drira; H. Attia; Quality Characteristics and Oxidative Stability of Date Seed Oil During Storage. *Food Science and Technology International* **2004**, *10*, 333-338, 10.1177/1082013204047777.
38. Dammak Ines; Boudaya Sonia; Ben Abdallah Fatma; Besbes Souhail; Attia Hamadi; Turki Hamida; Hentati Basma; Date seed oil inhibits Hydrogen peroxide-induced oxidative stress in

human epidermal keratinocytes. *International Journal of Dermatology* **2010**, *49*, 262-268, 10.1111/j.1365-4632.2009.04237.x.

39. Dammak Ines; Sonia Boudaya; Fatma Ben Abdallah; Hamida Turki; HamadI Attia; Effect of Date Seed Oil on p53 Expression in Normal Human Skin. *Connective Tissue Research* **2010**, *51*, 55-58, 10.3109/03008200902998709.
40. F. Lecheb; S. Benamara; Feasability of a cosmetic cream added with aqueous extract and oil from date (Phoenix dactylifera L.) fruit seed using experimental design. *Journal of Cosmetic Science* **2015**, *66*, 359-370.
41. Muhammad Azeem; Muhammad Asif Hanif; Jamal Nasar Al-Sabahi; Asif Ali Khan; Saima Naz; Aliya Ijaz; Production of biodiesel from low priced, renewable and abundant date seed oil. *Renewable Energy* **2016**, *86*, 124-132, 10.1016/j.renene.2015.08.006.
42. Sulaiman Al-Zuhair; Hanifa Taher; Salama Al Dhaheri; Shereen Wajeeh; Mutasim Nour; Emad El-Najjar; Biodiesel Production from Oils Extracted from Date Pits. *Green and Sustainable Chemistry* **2017**, *7*, 48-56, 10.4236/gsc.2017.71004.
43. R.G. Yousuf; J.B. Winterburn; Waste date seed oil extract as an alternative feedstock for Poly(3-hydroxybutyrate) synthesis. *Biochemical Engineering Journal* **2017**, *127*, 68-76, 10.1016/j.bej.2017.08.007.