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Prospects of utilization of date seed oil in food application

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Abstract
The genetic diversity of date palms is widespread date seed oil is regarded as one of the most valuable vegetable oils because of its abundance in fatty acids, phenolic compounds, and antioxidants. There are numerous advantages of DPSO for human health. In fact, DPSO has stronger oxidative stability than olive oil. DPSO performed well in protecting against UV rays and, consequently, against cellular damage. Date seed oil has been used to substitute some of the other vegetable oils in recipes. Sometimes we may not be aware that date seeds play crucial role in the production of products we use daily, such as, cream, various medicines. It is known that date seeds can be used to treat both common and infected wounds. Date seed oil is also good for hair health, skin, and fertility. The use of date seed oil in wax coats is another unusual use. Since date pit oil may operate as both a hydrophobic and an antibacterial agent at the same time, it has been largely substituted for water in the integration process Therefore, using date pits in food may help the date fruit industry make better use of its waste materials, increase local food security, and reduce adverse environmental effects.

Keywords: Date seed, extraction, date seed oil, butter sustitute

1. Introduction
Date palm is belonged to a family known as areaceae family it it is the major plant grown in the western asia and northern asia. Its cultivation is believed to have expanded from Mesopotamia, which is Iraq now, where it is believed to have originated. In the distant past (approximately 5000 years ago), the Middle East, North Africa, and the Arabian Peninsula (Kader and Hussein 2009) [70]. According to the definition given by (Monia Jemni *et al*., 2019) [71] The date (*Phoenix dactylifera* L.) fruit has a remarkable nutritional, biochemical, and physicochemical property. Dates are a staple food in many cultures, whether they are eaten raw or in various processed forms. The genetic diversity of date palms is widespread. The date seed, which is the fruit's steel body and a vital part, is a rectangular object with points on both ends that rests in the centre of the fruit. In general, the length of the seed is like three times the breadth, and it weighs between 0.5 and 4 g and is 12 to 20 mm in length. Date seeds are a valuable source of protein, carbohydrates, fibre, food, ash, fat, water, and oil, and they weigh between 10 and 20 percent of the entire fruit. It also contains a variety of essential elements, including as calcium, iron, copper, magnesium, manganese, and zinc, as well as phosphorus, sodium, potassium, and potassium. Some of its frequent names are date seeds, date pits, date kernels, and date stones.
On the other hand, date seed oil is regarded as one of the most valuable vegetable oils because of its abundance in fatty acids, phenolic compounds, and antioxidants. There are numerous advantages of DPSO for human health. In fact, DPSO has stronger oxidative stability than olive oil, according to (Besbes *et al*., 2004) [4, 12, 32] These authors also noted that DPSO performed well in protecting against UV rays and, consequently, against cellular damage. Other research indicated that date seed oils are good sources of -tocotrienol, which is said to be a substance that effectively lowers cholesterol, which increase the risk of breast cancer in people (Hammadi Hamza *et al*., 2021) [72]. Date seed has high amounts of crude oil, protein, and dietary fibre, according to a chemical study (9.0, 5.1, and 73%, respectively (Al-Farsi and Lee, 2008) [10].
Date seeds are regarded as a type of dry waste that is light in weight and large (i.e., low density and quality), and these wastes accumulate in large quantities, posing a serious problem because they are thought to be an environmental hazard when burned and serve as a place of refuge for pests like rodents and insects.

As a result, it's essential to figure out how to incorporate these wastes into applications for food and sustainable engineering as a more competitive, cost effective, and environmentally friendly alternative for the synthesis of materials or the extraction of the oil that can be further used as a butter substitute. (Shukair, A. A., *et al*., 2006) [101] discovered a potential application for date seeds when he realized that the seed oil was contained in lipid droplets, which are extremely stable structures. Such lipid droplets are also protected by a layer of specialized proteins, which enables them to create extremely stable emulsions. It has been hypothesized that these oily emulsions might operate as "molecular magnets," attracting the dioxins and removing them from the environment. 100 g of dates can supply more than 15% of the daily required amount of these minerals. The two main vitamins in dates are vitamins B complex and C. Dates contain a high amount of dietary fiber (8.0 g/100 g), with most of the fiber being insoluble. Dates are good source of carotenoids and phenolic antioxidants. As comparison with the flesh, date seeds have higher levels of fat (9.0 g/100 g) and protein (5.1 g/100 g). Additionally, it has significant levels of phenolics (3942 mg/100 g), antioxidants (80400 micro mol/100 g), and dietary fiber (73.1 g/100 g). According to several earlier studies, dates are practically the Known for its healthy lifestyle because they include variety of crucial elements (Siddiqi *et al*., 2020) [73]. Date fruit contains amino acids, which are organic substances that are essential to human health and are used as the building blocks of proteins (Rambabu *et al*., 2020) [74]. Essential amino acids and nonessential amino acids are the two categories into which amino acids are divided. Lysine and leucine make up most of the essential amino acids in both fresh and dried dates, whereas proline, glutamic, aspartic, and glycine make up the non-essential amino acids (Al-Farsi & Lee, 2008) [10]. Dates are a substantial source of macro minerals including K, Mg, Ca, and P as well as a good source of water-soluble vitamins like B1, B2, B9, A, and C in moderate amounts (Younas *et al*., 2020) [75] and (Alghamdi *et al*., 2018) [76].

While a sizable amount of the dates that are harvested are consumed fresh, on other hand the dates which are of lower-quality are also utilized in production of products including syrup, jam, powder, and juice (Barreveld *et al*., 1993) [77]. Up to 20% from total production of dates which may be lost at the time of post-harvest process due to overripening, bad handling and transportation, incorrect storage, contamination, and improper packaging (Nancib *et al*., 2015) [78]. Date processing businesses produce date residues including date seeds, date press cake (DPC), and cull dates (outgrade dates), which are utilized as animal feed or end up in sewers and dumps (Majzoobi *et al*., 2019) [79]. Date seed oil has been used to substitute some of the other vegetable oils in recipes. Sometimes we may not be aware that date seeds play a significant role in the production of products we use daily, such as soap, cream, or various medicines. It is known that date seeds can be used to treat both common and infected wounds.

A significant date palm producer is Saudi Arabia. In the middle of 2019 exports saw a 27% increase, and both demand and production have been rising quickly. The date palm, Phoenix roebelenii, is a tropical and subtropical plant with a natural range of south eastern Asia. It is the primary crop grown throughout Southwest Asia, North Africa, the Middle East, and the Arabian Peninsula. 1,092,104 ha are used for date palm cultivation globally, and 9,075,446 t are produced overall. Asia and Africa are the two regions that produce the most date palms, with a combined output share of 57% and 42.2%, respectively. The economies of the nations that produce dates rely heavily on dates (Gurevich *et al*., 2005) [80].

2. Chemical composition of date seed oil

2.1 Fatty Acids Composition

Five major fatty acids-oleic acid (C18:1), linoleic acid (C18:2), palmitic acid (C16:0), myristic acid (C14:0), and lauric acid (C12:0), which together make up more than 90% (Nehdi I *et al*., 2018) [37] (Boukouada M *et al*., 2009) [39] of the total fatty acid contents-are present in the fatty acid profiles of various date seed oils, although in varying amounts. Capric (C10:0), palmitoleic (C16:1), linolenic (C18:3), and gadoleic (C20:1) acids were among the fatty acids found in lesser concentrations. In general, the type of date, the stage of ripening, the extraction technique, (Al-Shahib W., and Marshall R.J. 2003) [9] and the fatty acid composition of the date seed oil can all affect the oil's composition. Lauric, myristic, and palmitic acids (Saturated), palmitoleic and oleic acids(mono-saturated), and polyunsaturated fatty acids, such as linoleic and linolenic acids, are all present in date seed oil in amounts of about 50, 43, and 8%, respectively (Habib H. *et al*., 2009) [98]. According to Al-Shahib and Marshall, oleic and lauric acids, respectively, have the highest proportions of saturated and unsaturated fatty acids. According to. (Besbes S *et al*., 2004) [4, 12, 32], Iranian dates (Sayer, Khenizi, Majul, Shekar, Zahedi, Goftar, and Khasuee varieties) and Tunisian dates (Deglet Nour and Allig types) carried more unsaturated fatty acids than saturated ones. However, lauric (17.8%) for the Deglet Nour cultivar and linoleic acid (15%) for the Allig cultivar were the two main saturated fatty acids, with oleic acid being the main unsaturated fatty acid (41-48%).

These date seed oils are less unsaturated than regular olive oils. As a result, date seed oil is an excellent supplier of oleic acid and its fatty acid composition is comparable to that of rice bran oil (Abdul Afiq M.J., and Abdul Rahman R 2013) [14, 20]. The oil is referred to as being of the oleic-lauric, oleic-linoleic, or oleic-palmitic type, depending on whether lauric, linoleic, or palmitic acid accompanies oleic acid. (Al-Hooti *et al*., 1997) [5] for instance, claimed that date seed oils from the United Arab Emirate were of the oleic-linoleic or oleic-linolenic types. Another study classified Iranian date seed oils as being of the oleic-lauric type. According to (Suresh *et al*., 2013) [81] oils from Omani date seeds can be classified as being of the oleic-myristic type. Lauric acid also has antibacterial capabilities that limit the growth of germs and their ability to produce toxins, which makes it healthier than trans-fatty acids and has a preventative effect on the development of prostatic hyperplasia. (Babu S.V., Veeresh B. 2009) [198]

2.2 Sterol Composition

Phytosterol content in vegetable oils are used to assess the quality of the oil and identify changes over time. Oils include phytosterols in their esterified forms. A substantial portion of the unsaponifiable fraction consists of tocols and sterols. (Warner K. *et al*., 1997) [48]

There are three main types of sterols in date seed oil: sitosterol, campesterol, and 5-avenasterol. Other minor sterols

include cholesterol, stigmasterol, 5,24-stigmastadienol, 7-avenasterol, and 7-stigmastenol. (Besbes S *et al*., 2004) [4, 12, 32].

The range of sterol concentrations in Date palm seed oil was 4.70 to 8.45 mg/g. (Laghouiter O.K. *et al*., 2018) [82]. These numbers are comparable to those of other seed oils like soybean (9 mg/g) and rapeseed (5 mg/g). Compared to other date seed species, such as P. canariensis seed oil (3.36 mg/g oil) and palm kernel oil (1.05 mg/g oil), its amount is greater (Besbes S.*et al*., 2004) [4, 12, 32]. The functional qualities of oils depend on their sterol components, particularly their resistance to oxidation. As a result, they could provide several health advantages. According to research by Tapiero *et al*., sterols from vegetable oils lower blood levels of total and low-density lipoprotein (LDL) cholesterol in people by preventing the intestinal absorption of cholesterol. (Tapiero H. *et al*., 2003) [49]. In Deglet Nour and Allig varieties of date seed oils, cholesterol was found to make up around 0.90% and 0.50% of the total sterols, respectively. These values are slightly lower than those of palm oil (2.30%) but greater than that of soybean and olive oils (0.40%) (Feinberg *et al*., 1987) [83]. The utilisation of date seed oil sterols as novel therapeutic agents for the treatment of hypercholesterolemia.

2.3 Tocopherols and Tocotrienols

Tocopherols and tocotrienols are natural compounds of plant origin. They are supplied in various amounts in a diet, mainly from vegetable oils, some oilseeds, and nuts. The main forms in the diet are α- and γ-tocopherol, due to the highest content in food product (Kacper szewcyz *et al*., 2021). It varies from vegetable oil to another. Tocopherols and Tocotrienols are mainly found from sources of vegetable oil like soybean, sunflower, and peanuts but tocopherol depends on origin of oil. (Wong R. *et al*., 2012) [84]. According to (Nehdi, I.; Omri, S.; Khalil, M.; Al-Resayes, S. *et al*., 2010) [3, 36] date seed oil content approximately 74.1 mg/100 g of Tocopherols and Tocotrienols. As compared to olive oil date seed oil has the higher number of Tocopherols and Tocotrienols content (Nehdi, I. *et al*., 2017) [104]. According to (Fahad, A.J.; Mehmet, Q.A. *et al*., 2017) [105] different oils varieties from different origin or places contains different qualitative and quantitative Tocopherols and Tocotrienols composition. Tocotrienols are the major tocols found in date seed oil by all cultivars tested (45%) (Fahad *et al*., 2014) [85]. According to the (Nehdi *et al*., 2018) [37] there are about six Saudi Arabian cultivars date seed oil which contained seven tocols, namely α-tocopherol, β-tocopherol, γ-tocopherol, δ-tocopherol, α-tocotrienol, γ-tocotrienol, and δ-tocotrienol.

Due to lipoperoxyl radical scavenging activity of tocopherols and tocotrienols makes it important for human health (Nehdi, I.; Sbihi, H. *et al*., 2013) [86]. As compared to α-tocopherol, benefits of tocotrienols are higher than it (Watson and Preedy *et al*., 2009) [87]. Tocopherols and Tocotrienols also help to increase the stability of the oil as it protects the oil from free radical damage (Gunstone, F.D. *et al*., 2002) [88]. It has many biological functions as well for example neuro protective, anticancer, cardioprotective, antidiabetic, nephroprotective activities (Ahsan, H.; Ahad, A *et al*., 2014) [89].

2.4 Phenolic Compound

Phenolic compounds are an essential component of the unsaponifiable matter of oils and are often referred to as "minor constituents." Despite their relatively low concentration in oils, these compounds can have a significant impact on various characteristics, including flavor, shelf life, and resistance against oxidation. Phenolic compounds are natural antioxidants that are found in various plants and plant-based products, including date seed oil. Date seed oil is a byproduct of the date fruit industry and is extracted from the seeds of the date fruit. (Hamza Ourradi *et al*., 2021) [72] Studies have identified various types of phenolic compounds in date seed oil, including hydroxybenzoic acid derivatives, hydroxycinnamic acid derivatives, and flavonoids. Some specific phenolic compounds found in date seed oil include vanillic acid, ferulic acid, protocatechuic acid, and quercetin. The phenolic compound content of date seed oil can vary depending on the variety of date. A study was conducted by (Besbes *et al*., 2004) [4, 12, 32] Deglet Noor dates Studies have shown that the phenolic content in Deglet Noor date seed oil is high, with ferulic acid being the predominant phenolic compound. **(**Ricardo Salomón-Torres *et al*., 2019) [90] Medjool date seed oil has been found to contain a high number of phenolic compounds, including vanillic acid, ferulic acid, and p-coumaric acid. Ajwa date seed oil is also rich in phenolic compounds, with studies showing high levels of ferulic acid and protocatechuic acid. Khalas date seed oil by (Myhara *et al*., 1999) [91] has been found to contain significant amounts of phenolic compounds, including ferulic acid, vanillic acid, and p-coumaric acid. Phenolic compounds in date seed oil can be susceptible to degradation due to various factors such as heat, light, and oxygen exposure. Overall, to maximize the stability of phenolic compounds in date seed oil, it is important to store it in cool, dark, and airtight conditions, and to avoid exposing it to high temperatures, light, and oxygen. Date seed oil is known to contain high levels of phenolic compounds, which are natural antioxidants that can provide various health benefits. Here's a comparison of the phenolic compound content of date seed oil with some other seed oils by **(**Besbes *et al*., 2004) [4, 12, 32]. (Al-Rimawi, F., Abuirjeie, M., & Abu-Zaiton, A. *et al*., 2015) [99] compared the phenolic compound content of date seed oil with that of other vegetable oils, including olive, corn, sunflower, soybean, and sesame oils. Researcher found that date seed oil had the highest total phenolic content (314.6 mg GAE/100g oil) compared to the other oils tested, and also had the highest antioxidant activity. According to (Özkan, G., Kirmizibekmez, H., & Şahin, S. *et al*., 2017) [100] phenolic compound content of date seed oil with that of other fruit seed oils, including apricot, peach, plum, and cherry seed oils. The researchers found that date seed oil had the highest total phenolic content (56.8 mg GAE/g oil) compared to the other fruit seed oils tested. According to (Benmoussa, H., Abushelaibi, A., Ahmedi, A., & Abid, M. *et al*., 2019) [26] phenolic compound content of date seed oil with that of other vegetable oils, including sunflower, soybean, and canola oils. (Benmoussa *et al*., 2019) [26] found that date seed oil had a higher total phenolic content (31.51 mg GAE/g oil) compared to the other oils tested, except for canola oil, which had a slightly higher phenolic content (32.56 mg GAE/g oil).Date seed oil has gained attention in recent years due to its high content of phenolic compounds, which have been linked to various health benefits. These compounds have been found to possess anti-inflammatory, antioxidant, and antimicrobial properties, among others **(**Karmowski, J., & Figiel, A. *et al*., 2021) [7] has shown that these phenolic compounds in date seed oil can provide various health benefits, such as reducing

inflammation, protecting against oxidative stress, improving liver function, and having antimicrobial activity against various types of bacteria and fungi. And also phenolic compounds in date seed oil have been linked to various health benefits, including reducing the risk of chronic diseases such as cancer, diabetes, and heart disease. Overall, the high content of phenolic compounds in date seed oil is a key factor in its potential health benefits and has led to ongoing research to further investigate its applications and potential as a natural product for various health conditions.

Table 1: Oil yield and free fatty acid of various date seed oil varieties

Palm Date Variety	Extraction Method	% Yield of Oil	Fatty Acid Composition (%)	Tocopherols (mg/100 g)	Tocotrienols (mg/100 g)	Phenolic Compounds (mg GAE/100g)	Refrences
Deglet Noor	Mechanical pressing	10-13%	Lauric acid (1-2), Myristic acid (17-19), Palmitic acid (10-12), Stearic acid (3-4), Oleic acid (45-47), Linoleic acid (14-16)	11.8-13.9	13.2-18.4	15.5-17.8	Ayadi, M. A., Abdelmaksoud, W., Ennouri, M., Attia, H., & Gharbi, I. *et al*., (2012) [65].
Medjool	Solvent extraction	16-18%	Palmitic acid (22-26), Oleic acid (39-43), Linoleic acid (9-11), Stearic acid (2-4), Lauric acid (1-2), Myristic acid (1-2)	9.4-11.1	13.6-17.2	12.3-14.9	Elmoghazy, M., Aboul-Enein, A. M., & Abdel-Hamid, M. *et al*., (2014) [66].
Barhi	Mechanical pressing	10-13%	Palmitic acid (16-20), Oleic acid (41-44), Linoleic acid (17-21), Stearic acid (1-3), Lauric acid (1-2), Myristic acid (1-2)	12.2-14.5	13.6-17.7	16.7-18.9	El-Adawy, T. A., Rahma, E. H., & El-Bedawey, A. A. *et al*., (2003) [67]
Khadrawy	Solvent extraction	14-16%	Palmitic acid (21-25), Oleic acid (38-42), Linoleic acid (11-13), Stearic acid (2-4), Lauric acid (1-2), Myristic acid (1-2)	8.5-10.7	14.2-18.4	12.4-14.6	Saafi, E. B., Zine, K., Hammami, M., Trabelsi-Ayadi, M., & Achour, L. *et al*., (2014) [68]
Zahidi	Mechanical pressing	10-13%	Palmitic acid (14-18), Oleic acid (43-46), Linoleic acid (23-26), Stearic acid (1-3), Lauric acid (1-2), Myristic acid (1-2)	8.8-11.2	13.1-17.1	12.9-15.1	Zaid, A., & Arias-Jiménez, E. *et al*., (2002) [69]

Note that the content of tocopherols, tocotrienols, and phenolic compounds in palm dates can vary depending on factors such as the variety of date, the geographic region, and the maturity of the fruit. The values listed in the table are approximate and may not be representative of all sources of palm dates.

2.5 Iodine value (IV)

It is a useful property that is used to evaluate an oil's degree of unsaturation and its durability in industrial applications, although it does not specify the fatty acid composition (Wu H *et al*., 2011 and O' Brrien R.D 2009) [108, 109]. A high IV in an oil indicates a higher concentration of unsaturated fatty acids and numerous unsaturated linkages (Guderjan M., *et al*., 2007) [110]. IV of also known for anticipation and reflect the oil's drying property. A dry oil has an IV of around 190, a semi-dry oil of about 130, and a wet oil of about 100. Date seed oil is therefore considered as non-drying when its IV is less than 100 (Pearson D 1976**)** [124]. The iodine value of Iranian date seeds oil was 46-65 g/100 g oil **(**Dehdivan and Panahi 2019) [112]. Similarly, the IV for Tunisian date seed oil was described by (Besbes *et al*., 2004) [4] as being between 44 and 61 grams per 100 grams of oil, while (Nehdi *et al*., 2014) [114] calculated a value for C. humilis that was lower than that of other palm oils, including P. canariensis (77.66 grams per 100 grams of oil) (Nehdi I., 2010) [3, 36].

2.6 Acid value

Several studies have reported the acid value of date seed oil, which is a measure of the amount of free fatty acids in the oil. The acid value of date seed oil can vary depending on factors such as the variety of dates used, the extraction method, and storage conditions. According to the (Benmoussa *et al*., 2019) [25] acid value of date seed oil was found to be 6.83 ± 0.06 mg KOH/g oil, indicating a relatively low level of free fatty acids in the oil. The acid value is an important parameter for evaluating the quality of edible oils, as high levels of free fatty acids can indicate that the oil is rancid or has undergone hydrolytic degradation. One study conducted in Algeria reported an acid value of 7.35 ± 0.20 mg KOH/g for date seed oil extracted using a solvent extraction method (Benmoussa *et al*., 2019) [25]. Another study conducted in Saudi Arabia reported an acid value range of 4.33-4.70 mg KOH/g for date seed oil extracted using a cold press method (Al-Farsi *et al*., 2006) [27-30]. A study from Iran reported an acid value of 6.72 mg KOH/g for date seed oil extracted using a Soxhlet extraction method (Hosseini *et al*., 2015) [28]. According to (Aladedunye, F. A., & Przybylski, R. *et al*., 2009) [21] The acid value of date seed oil was found to be lower than that of soybean oil and palm olein but higher than that of corn and sunflower oils. (Bouhlali, E. D., *et al*., 2014) [22] the acid value of date seed oil with argan and olive oils. The acid value of date seed oil was found to be higher than that of argan oil but lower than that of olive oil. (El-Adawy, T. A., & Taha, K. M. 2001) [23-24]. The acid value of date seed oil was found to be higher than that of cottonseed and soybean oils but lower than that of sunflower, sesame, and safflower oils.

3. Physicochemical Characteristics

3.1 Viscosity

Like many other vegetable oils, date seed oil exhibits a certain level of viscosity, which is a measure of its resistance to flow. The viscosity of date seed oil can be influenced by various factors, such as temperature, pressure, and the presence of impurities. At room temperature, date seed oil has a relatively low viscosity, meaning it flows easily. However, as the

temperature decreases, the oil's viscosity increases**,** (Ramadan, M. F., and Morsel, J.T. 2003) [115] making it thicker and more resistant to flow. This is because as the temperature drops, the molecules in the oil slow down and start to stick together, creating more friction and resistance to flow. In addition, the presence of impurities or contaminants in date seed oil can also increase its viscosity **(**Yilmaz, E., Ozcan, M M., and Al Juhaimi, F 2017) [116]. These impurities can cause the oil to become thicker and more viscous, which can negatively affect its quality and performance. Overall, the viscosity of date seed oil can have important implications for its various applications, such as in food production, cosmetics, and industrial processes (Al - Muhtaseb, A.H., and Al-Hamadani, H.A. 2004) [117] Understanding the factors that affect its viscosity can help ensure that it is used effectively and efficiently in different settings.

3.2 peroxide value

One of the most used physicochemical tests to assess the quality of oils is peroxide value (PV). Peroxide value for date seed oil ranges between (1.243-1.01 meq O_2/kg. **(**Eimad dine Tariq Bouhlali *et al*., 2017). Date seed oil may be regarded as safe for human consumption due to its low peroxide value of less than 30 meq peroxide/kg (Gotoh and Wada., 2006) [119]. All examined kinds and clones of date seed oil (as crude seed oil) had extremely low values for both acidity and peroxide, showcasing the high quality of the date seed oils and demonstrating their suitability for use in culinary applications. Additionally, this implies that the oil can be kept in storage for a very long time without degrading (Liu *et al*., 2021) [120]. Peroxidise Value of two date seed varieties were taken [IAH (Khalt abdelghani) date seed variety to the KKL (Khalt khel)], ranging from 1.06 mequiv O2/kg to 5.61 mequiv O2/kg. The KKL seed oil has the highest peroxide value (5.61 meq O2/kg), indicating that it is the most prone to autoxidation**.** (A. Alahyane *et al*., 2021) [121].

3.3 Color

(Al-Farsi *et al*., 2006) [27-30] mentions the color of date seed oil as being yellow to reddish-brown. The color of date seed oil is attributed to the presence of natural pigments, including carotenoids and chlorophylls. The exact color of the oil can vary depending on the variety of dates used, the location where they were grown, and the method of extraction. Generally, date seed oil extracted using the Soxhlet method is darker in color than that extracted using cold-pressing methods. The yellow to reddish-brown color of date seed oil makes it an attractive ingredient in food and cosmetic formulations.

3.4 The saponification value

The saponification value (SV) is a measurement of the molecular weight of a fatty acid. It tell us about nature of fatty acids and is based on their average molecular weight According to (Boran, G. 2006) [122]. According to (Nehdi *et al*., 2007) [123], the date seed oil's which are having high SV indicates a high content of low molecular weight triacylglycerols. Date seed oil with high saponification value indicates that it has has high content of low molecular weight triacyglycerols. Date seed oil has an average SV ranging from 198 to 228 mg KOH/g oil (Pearson D *et al*., 1976) [124]. These values were comparable to palm oil (196-205 mg KOH/g), corn oil (187-196 mg KOH/g), and palm kernel oil (247 mg KOH/g) (Akinhanmi T.F *et al*., 2008) [125]. The following average properties have been reported for four date palm seed oils (Zahidi, Medjool, Halawi and Degrette Noor): Saponification value 221 and unsaponifiables 0.8% (Devshony *et al*., 1992) [17].

3.5 Melting Point

The following physicochemical properties of date seed oil can affect its melting point:

Antioxidants: Date seed oil contains antioxidants such tocopherols and phenolic chemicals, which can change the oil's oxidation stability and thus alter its melting point. (Al-Farsi, M., & Alasalvar, C. 2011) [15]

Crystal structure: The oil's crystal structure may also affect the melting point of the substance. Higher melting points are typically found in oils with more organized, crystalline structures than in those with more disordered structures. Ahmad, M., & Ashraf, M. (2016) [126].

Impurities: By interfering with the crystal structure of impurities like moisture or free fatty acids, impurities can also impact the melting point of date seed oil. Al-Rawahi, N., Al-Mahrooqi, R., Al-Riyami, Q., & Al-Sabahi, J. (2015) [127]

3.6 Storage Stability

For use in food, date seed oil's storage stability is a crucial factor to take into account. Antioxidants and other bioactive substances found in date seed oil can alter how stable it is when stored. As high temperatures can cause oxidative degradation and rancidity of the oil, date seed oil should be stored in a cool, dry area out of direct sunlight (Gharby, S., *et al*., 2017) [128]. Since oxygen exposure can result in the generation of free radicals and the degradation of fatty acids, date seed oil should be stored in airtight containers to avoid oxidation. Moisture can also affect how well date seed oil holds up to storage since it encourages microbial development and hydrolytic rancidity (Al-Muhtaseb, *et al*., 2017) [129]. Date seed oil needs to be shielded from light since exposure to light can cause photo-oxidation and oil deterioration. Date seed oil's antioxidant concentration may also affect how stable it is in storage. Oils having higher concentrations of phenolic compounds and other natural antioxidants, such as tocopherols, tend to have better storage stability than oils with lower antioxidant contents. (Al-Mahasneh, M. A., & Taamneh, Y. M. 2016) [130].

4. Methods of extraction

4.1 Soxhlet method

The Soxhlet extraction is a method of extraction that utilizes the principles of continuous solvent percolation and repeated distillation and condensation of the solvent. Soxhlet extraction is a commonly used method for extracting oil from date seeds. This method is preferred because it is efficient, produces high yields of oil, and is relatively easy to perform. The yield of oil obtained from date seeds using Soxhlet extraction can vary depending on several factors, including the variety of date seeds used, the particle size of the seeds, the solvent used, and the extraction time (Mokni Ghribi *et al*., 2016) [170]. There are several studies that have reported the yield of oil from different varieties of date seeds using Soxhlet extraction. According to (Al-Marzooqi, *et al*., 2017) [29] analyzed the oil yield of six different varieties of date seeds using Soxhlet extraction and reported yields ranging from 5.9% to 9.5%. According to (Al-Farsi, M., Al-Amri, A., & Al-Hadhrami, A.

et al., 2006) [27-30] reported an oil yield of 7.75% from Khalas date seeds, while another study reported a yield of 4.4% from Sukkari date seeds. Overall, the yield of oil from date seeds using Soxhlet extraction can vary depending on the variety of date seeds used, as well as other factors such as particle size and solvent choice. When comparing the yield of date seed oil obtained by Soxhlet extraction with other oils, it can be observed that the yield of date seed oil is relatively low compared to some other oils, such as soybean oil or sunflower oil (Al-Farsi, S. H., *et al*., 2019) [173]. The extraction time required for Soxhlet extraction can also vary depending on the oil source and extraction conditions. According to (Alamri, A. M., *et al*., 2021) [174] extraction time for date seed oil is relatively longer compared to coconut oil or palm oil. Soxhlet extraction can be an effective method for the extraction of date seed oil and other oils. However, it is important to consider the yield, extraction time, and quality of the oil when comparing Soxhlet extraction with other extraction methods.

Soxhlet extraction is generally considered a safe and reliable method for the extraction of organic compounds. but the use of organic solvents in Soxhlet extraction can have potential negative effects on the environment. According to (Mahesh, R. S. G., *et al*., 2015) [168] they found that Soxhlet extraction had the highest environmental impact in terms of energy consumption and greenhouse gas emissions when compared to other extraction methods**.** (Zhang, L., *et al*., 2017) [169] evaluated the potential for solvent emissions and their impacts on water quality during Soxhlet extraction of poly- and perfluoroalkyl substances (PFASs) from environmental samples. They found that the use of organic solvents in Soxhlet extraction can lead to the contamination of water sources with PFASs and other pollutants.

4.2 Ultrasonic-Assissted Extraction

The term "sonication-assisted" or "ultrasound-assisted solvent extraction" (UAE) refers to another cutting-edge extraction technique that could help in the extraction of oil from date seeds. Due to its importance to the sustainability of the environment, it has gained attention as an innovative green technology. UAE is a cutting-edge method that uses ultrasonic sound waves of high intensity and frequency to increase vibration and change the physical and chemical properties of plant tissues (disrupting plant cell walls), improving the relationship between a solvent and the plant material and allowing the release of extractable compounds (Takadas F *et al*., 2017) [92]. Cell disruption occurs when cavitation, a phenomenon brought on by ultrasonic transmission in a liquid, occurs. The movement and interaction of sound waves modify the physicochemical properties of substances, resulting in several rarefactions and compressions in the solvent and the formation of tiny bubbles in the liquid. Acoustic cavitation is a process that causes cell wall disintegration. UAE causes cavitations and the development of cracks and microfractures on seed surfaces, which improves the ability to pass of the solvent into the plant tissues in this manner. **(**Jadhav A., *et al*., 2016) [47].

Utilizing UAE is a novel way to increase the effectiveness of bioactive compounds' extraction from plants and seeds while also raising oil yield. The UAE can be known for accelerating output and cutting the time required for extraction. The extraction effectiveness of seed oil by UAE was comparable to or superior to that of traditional extraction (Soxhlet), but with a notable decrease in extraction time (Luque - Garcia J. *et al*., 2004) [164]. This fact has also been evaluated for the extraction of oil from date seeds, (Jadhav A., *et al*., 2016) [47] and it was found that the UAE method uses less energy (76.64% less than the Soxhlet method), shortening the extraction time (75% less than the Soxhlet method), resulting in a more effective approach.

4.3 Supercritical Fluid Extraction (SFE)

In various industries, including food, pharmaceuticals, and cosmetics, where a sustainable and "green" extraction is desired, supercritical fluid extraction (SFE) has been utilised gradually. This method is widely used for extracting seed oils due to its selectivity, low applied extraction temperatures, and frequently quick processing periods (Hossein Ahangari, *et al*., 2021) [175]. SFE is best alternative in comparison with solvent extraction because of its various advantageous characteristics as compared to the traditional method for the extractio (King, J. *et al*., 2014) [165]. Using supercritical carbon dioxide (SC-CO_2) as solvent makes it green and ecological method. It is also biologically safe as there is no residue remain after getting final product because of this nature of SFE it also considered as trustable technique for the extraction of various vegetable matrix oils (Yin, J.-Z. *et al*., 2005) [166]. SC-CO_2 is the most frequently used solvent in SFE and is thought to be the most effective approach for extracting chemicals from plant matrices due to the strong solvating power and diffusion capacity of CO_2 **(**Herrero M. *et al*., 2010) [167]. According to (Aris *et al*., 2013) [46] pressure is the primary factor in increasing a solute's solubility, which leads to increase in yield of date seed oil.

Accordind to (Takadas *et al*., 2017) [44] when there is increase in temperature, the vapour pressure also rises, which causes the density of CO_2 to drop. This could reduce the oil output. In a distinct study on Algerian date seed oil extracted by using the SC-CO_2 method, (Louaer, M. *et al*., 2019) [163] evaluated the impact of the various parameters (pressure, particle size and temperature) on the extraction yield and fatty acid profile. The effects of the various variables (pressure, particle size and temperature) were investigated on the extraction yield and fatty acid profile. from these results demonstrated that temperature and the interaction between temperature and pressure considerably increased the amount extracted of date seed oil. Comparable to soxhlet extraction, the fatty acid composition was 49.85% saturated fatty acids, 42.75% monounsaturated fatty acids, and 7.55% polyunsaturated fatty acids. SC-CO_2 extraction is therefore thought to be a very promising method for extracting date seed oil and adding value to this byproduct. With yields comparable to Soxhlet extraction, it represents a secure method for extracting edible oils without the use of any contaminating organic solvent. The biggest disadvantage of SC extraction is its high cost of equipment compared to traditional extraction.

5. Application of Date Seed Oil

5.1 In Food Industries: Date pits have been used in several culinary items with a variety of functions. Date pits, either in their raw or processed forms, have been added to a variety of foods, including baked items, dairy products, drinks, meat, sweets, and sauces. Numerous ratios for the incorporation of date pits in meals have been suggested by studies that analyzed the nutritious content, health advantages, and sensory appeal. Despite these existing uses, date pits are underutilized, and by employing primary treatments (like

grinding or treating with acid or alkali) and secondary treatments (such as using particular chemicals, enzymatic, and microbial), they might be used in novel applications. Date pits have also been used in more inventive ways, such as the fabrication of edible coverings that degrade over time and can increase shelf life and the manufacture of low-fat foods by lowering oil absorption during frying. To make hot beverages (akin to caffeine-free coffee), 36% of pastry products, and 14% of meat products, date pits are employed. Date pits have been used for a long time in the Arab world to make drinks that are generally comparable to Arabic coffee in nature since they are readily available and inexpensive. The fiber-rich date pits can be utilized as an ingredient in baked goods. In addition to the traditional nutritional enrichment, their use in fortification has expanded to include increasing other capacities. (Sayas-Barberá *et al*., 2020) [185].

5.2 Use of Date seeds in Beverage Industry

The creation and preparation of drinks is one of the earliest uses of date pits. Hot beverages that resemble coffee are brewed using roasted date pits; they can either substitute coffee entirely or in part. In certain cases, beverages made with date pits additionally include milk, spices, or herbs. The ideal roasting conditions, taking into account the date pit powder's physicochemical and organoleptic characteristics, were found to be 199.9 °C for 21.5 min. Date pit powder has been treated to a variety of roasting times and temperatures. Each of the three blends was lower in caffeine than regular coffee and had superior nutritional value. (Rahman *et al*., 2007) [183]; (Fikry *et al*., 2019) [184]. The examination of the chemical makeup and thermal transition characteristics of powdered, roasted date pits shed light on the constitution and characteristics of this biomaterial. Date pit powder, namely 100, 92.5, and 61.67% of date pits, were mixed with barley, cardamom, button roses, nutmeg, and cloves, among other ingredients, in three distinct concentrations. The three blends were all lower in caffeine and had superior nutritional value than regular coffee. Comparing a mix with 61.67% date pit concentration to a control, the blend with 8.7 and 8.5 ratings, respectively, was found to have the highest overall sensory acceptability. Antioxidant activity occurred at 91.7 and 84.2%, respectively, which is higher than control coffee. Similar to this, six cappuccino and latte formulations were made utilizing date pit powder in place of Nescafe product at percentages of 10, 20, 30, 40, 50, and 60%. A sensory investigation revealed that the caffeine-free cappuccino formulation with 50% replacement had the highest content of minerals, dietary fibres, and antioxidants. To make a cocoa drink, 9% date pit powder instead of cocoa was added. It was discovered through a sensory analysis of taste that this was rated as tasting superior to the original cocoa beverage.2020's (Al-Garni *et al*., 2020) [135] (El Sheikh *et al*., 2014) [136]. Date Pit drink was made with a ratio of 1:15 (w:v), and its chemical makeup was assessed. Their findings revealed that the prepared beverage has 2% protein, 0.9 mg/g copper, 2% calcium, 0.9 mg/g iron, 0.4 mg/g manganese, 5.0 mg/g magnesium, 6.7 mg/g potassium, 0.74 g/L glucose, and 0.6 g/L fructose. (Mirghani, *et al*., 2012) [137].

5.3 Use of Date Seeds in Bakery Industry

It is effective to increase customers' daily fibre consumption by adding dietary fiber to meals. Due to their high fibre content, date pit-infused bakery goods have garnered a lot of attention. Additionally, adding date pit fibers to bakery items (particularly bread, biscuits, cakes, and muffins) increases their shelf life. Additionally, date pits serve as a substitute for fat, increase loaf volume, and retain consumer approval. It was discovered that incorporating milled date pits into the dough for bread at a concentration of 4 to 12% resulted in a decent loaf volume and a significant amount of fiber. By having a beneficial hypoglycemic effect, it has been proposed that putting 15% of raw, milled date pits into breads will reduce the risk of acquiring diabetes. **(**Al-Amri *et al*., 2014) [192] (Halaby *et al*., 2014) [141]. When bread was stored for five days, adding date pit germs and granular residue to the dough at a ratio of 0.5-3% was associated with a reduction in bread deterioration. Date pits must be treated in a precise manner in order to improve bread functionality. Large-scale use is made of a defatting technique that involves removing oil to create defatted date pit powder. According to (Bouaziz *et al*., 2010) [189], a 1-3% enrichment level is the ideal one for using defatted date pits in bread. Using hemicellulose as a bread additive, (Bouaziz F. *et al*., 2020) [52] extracted water soluble polysaccharides. They found that by adding 0.75% hemicellulose to 0.5% soluble polysaccharides, the sensory attributes (such as outstanding look, color, odor, taste, softness, and overall satisfaction) was improved. Modified starch (0.0-0.9%), date pit powder (0-20%), and chestnut flour (added at 0-50%) were all utilized in varying proportions to make gluten-free cookies by (Mohammadi *et al*., in 2022) [143]. According to a sensory investigation, the combination that received the highest rating from consumers had 22% date pit powder, 28% chestnut flour, and 0.9% modified starch. It has been shown that a 5% date pit to olive seed powder ratio is the optimum combination for maintaining the quality of biscuits. [Samea, R. *et al*., 2019] [187]. Researchers have found that the synergistic effects of date pit powder and fenugreek seed in coconut cookies allow for a 60-day storage period while maintaining the biscuits' sensory appeal. Further research revealed that adding date pit powder at a concentration of 0.03% produced the greatest sensory analysis score (Hira *et al*., 2017) [145]. Results were compared with a control cake that had no date pits in the sponge cake compositions. A 5 and 10% addition of date pit powder was made. The comparison of the control cake and the cake enhanced with date pits at 10% showed that the latter one had greater amounts of total the phenol (from 0 to 38.53 GAE g/100 g dry weight), and, therefore, a greater percentage of free radical scavenging activity, higher mineral contents, increased potassium from 41 to 3,894 mg/kg and sodium from 2 to 178 mg/kg, higher protein contents raised from 8.5 to 19.9%, and higher fiber contents 1.7 to 13.7%.

5.4 Use of Date seed in Meat Industry

By adding more antioxidants, vitamins, minerals, or dietary fiber, meat products can have a higher nutritional value. Meat tenderizing is a promising additional use for date pit oil. Enriching the diet with fiber may also improve the structural qualities of meat products. One of the meat industry's top aims is to reduce the amount of fat in meat products. Dietary fiber derived from fruit by products have been demonstrated to increase functionality because they help meat products retain more water and prevent cooking loss. Date seed powder is often used in meat preparations as a natural preservative, fat replacement, fiber source, and tenderizing agent. It has been demonstrated that adding date seed powder to beef burgers

increases their cooking and shelf life. On days 3, 6, and 10 of storage (in both cooked and refrigerated burgers), color change was seen for control burgers versus burgers fortified with date pits. Burgers containing date pits had higher yellowness readings while raw compared to the control but lower readings when cooked. The panelists agreed that date pits would improve the meat's redness, and they were right. A consumer panel ultimately decided that beef burgers with 1.5-3% date pits substituted offered sensory acceptability. (Sayas-Barberá, *et al*., 2020) [185]. The functional elements from date pits have been extracted using a variety of polar solvents. When tested as a tenderizing agent (for knuckle meat) at a ratio of 1 ml/100 g meat, these extracts were found to improve the textural aspects of the knuckle meat. A mixture of date pit powder, wheat germ, and pumpkin flour was used to replace the animal fat in meatballs. By 25 to 75% less animal fat was used as a result. When compared to a control batch of full-fat meatballs, it was discovered that the cooking output of meatballs created with this combination was higher for both frying (83.51-94.75) and roasting (81.62-85.85%). Comparing this formulation and the control meatballs, there were also only minor differences in flavor, aroma, and texture (Nor *et al*., 2008) [147]. (Essa R., *et al*., 2022) [149] and (Ursachi, C. *et al*., 2020) [186]

5.5 Use of Date seeds in Dairy Industry

Date pits can improve the performance of dairy products by being added to them. The probiotic bacteria's rate of survival and the physicochemical and sensory qualities of the yoghurt were both maintained for up to 2 weeks in the case of the 1% date pit powder. The substitution of date pit powder at 5% yielded the highest ratings for general acceptability and sensory acceptance. The addition of date pit powder to spreadable cheese in levels up to 10% was also shown to be satisfactory regarding antioxidant activity and sensory aspects (Darwish *et al*., 2020) [151]. (Alqattan, A. M. *et al*., 2021) [152].

5.6 Use of Date Seeds in desserts, Condiments and Spreads

Date pits have been a common ingredient in sauces, pastes, and sweets of many kinds. Insoluble dietary fibers can be added to foods to lower calories, increase shelf life, and enhance texture. To make chocolate sauce, a cocoa substitute is mixed with date pit powder in ratios of 5, 10, and 15%. Other desserts, such custard, have date pits added to them at an amount that makes up close to 30% of the overall composition. Custard that has been improved with date pits using this method is comparable to a commercial product in terms of viscosity, gel hardness, and cohesiveness. At concentrations of 0.50% and below, ketchup with date pits added received the strongest sensory ratings for texture; however, overall acceptance scores were significantly greater at the 0.5 and 1% levels. Date pits have been added to custard at a rate of roughly 30% of the total mixture. Custard enriched with date pits was found to be comparable to a commercial product in terms of viscosity, gel hardness, and cohesiveness; panelists approved of the custard's color and flavor and thought it was satisfactory overall (Al-Amri *et al*., 2014b) [139]. By adding 3% date pits to a date fruit paste, (Al-Farsi *et al*., 2007) [7] improved the antioxidant activity to 580-929 mol of Trolox equivalent/g fresh weight. In a different study, date pit oil was used in place of vegetable oil to make mayonnaise, and it was found that the flavor of the product was superior to the control. High quantities of oleic acid and organic antioxidants, including polyphenols and -tocopherol, are found in date pit oils.

They are also more yellow compared to other vegetable oils in color. Due to its excellent oxidative stability, date pit oil can be stored readily. (Al-Amri *et al*., 2014) [141] (Abushal *et al*., 2021) [191].

5.7 Additional Uses for Date Seed or Date Seed Oil

5.7.1 Wax Coating: Date pit oil is used in wax coatings, which is another unusual application. Date pit oil is a liquid, aromatic substance that is yellowish in color at room temperature. The principal elements of wax coatings are polymers that are hydrophilic, a thickening agent, a hydrophobic agent, and an emulsifying agent. Since date pit oil can operate as both a hydrophobic and an antibacterial agent at the same time, it has been integrated by partially substituting water. Edible wax coatings are frequently used to stop the disease from spreading and reduce the loss of water from plant products. An improved appearance, reduced bruising while handling and transit, less weight loss, and the capacity to serve as an active ingredient carrier are just a few benefits of wax coating. Date pit oil has been substituted for water in the standard wax formulation at a rate of 0.5-2.0%, much to how date pit oil has been employed as an appetizing wax coating to extend the storage life of guava fruit. According to the outcomes following a 16-day storage period, the biggest substitution ratio, or 2.0%, produced the best characteristics when it comes to of storage stability (i.e., pH, firmness, titratable acidity, total soluble solids, and ascorbic acid content. **(**Ahmed A. *et al*., 2019) [26]. (Al-Saggaf *et al*., 2017) [193], (Mrabet *et al*., 2020) [194], and (Iñiguez-Moreno *et al*., 2021) [195].

5.7.2 In Feed Stock Industries: Incorporation of Date seeds in Animal feedstock has lead to Increase in weight gain, better feed efficiency. Comparable to the corn soybean meal diet for broiler chicks, adding date seed to the starter and finisher diets increased body weight gain, feed conversion, and growth performance. According to the findings, date seed can support and improve the growth performance of broilers when added to their meals at a rate of 10%. In sheep, date seed proved successful in accelerating body weight increase and the accumulation of back fat. Rats receiving a normal date seed (14%) feeding regimen had significantly higher plasma levels of testosterone and heavier bodies. Lysine, which is frequently the limiting amino acid in diets based on cereals, is present in greater concentrations in the protein of date seeds. As a result, part of the costly vegetable proteins in animal or poultry feed can be replaced with date seed.

5.7.3 Use of Date Seeds in Biodegradable Films and Coatings: One of the most innovative technologies for extending food shelf life is biodegradable film, which lowers physiological disturbances, which includes moisture, respiration, gas exchange, and oxidative reaction rates while retaining food quality and nutritional content through solute migration. Date pits were looked into in this application as a mixture blended with other materials; this composite was used in raw and processed forms. When date pit powder was mixed with maize starch at different ratios (range: 10-40%), the presence of date pits at 28% was connected to superior morphological traits. One of the most famous applications of date pit is coating potato strips with hydrocolloids and

phenolic extracts to prevent oil absorption during deep-fat frying (Alqahtani *et al*., 2021) [157], (Rojas-Graü *et al*., 2009) [158].

5.7.4 Cosmetics - Applications of Date Fruits and Seeds: The fruits and seeds of dates are thought to possess important nutritional and pharmacological qualities. They can also be found in many cosmetic and beauty products. Lots of High concentrations of chemical compounds, usually synthetically generated substances like hydroquinone, are present in cosmetic items. According to (Hammani *et al*., 2019) [176], date-derived activated carbon acted as a catalyst to increase the reactivity of hydroquinone. On the other hand, date seeds are used to make cosmetics. As a result, consumers have been drawn to nanotechnology-based cosmetic goods; the other method might be utilised to create a new line of cosmetics. Single-walled nanotubes, activated carbon, and nanosized vitamin E have all been developed and effectively used in cosmetics as delivery systems. Recently, natural ingredients have been employed in cosmetics to treat various skin conditions and provide UV protection. because UV radiation can lead to cancer, sunburn, wrinkles, and premature ageing, a long-term solution is needed to defend against it and stop its negative effects.

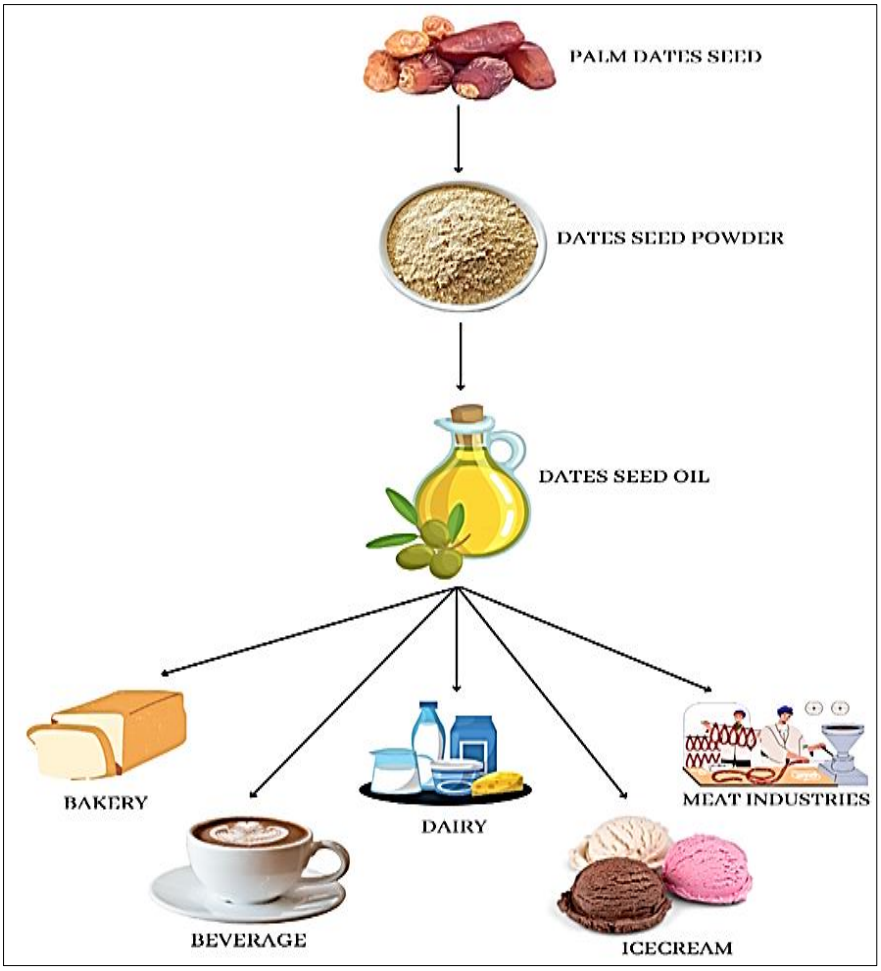

Fig 1: Application of date seed oil:

Table 2: Application of date seed oil

Application	Product used with Range	References
In food industry		
a) In Beverages	Coffee, Cocoa drink from date seed powder (6.6 - 100%)	(Rahman *et al*., 2007) [183], (Fikry *et al*., 2019) [184]. (Rahman *et al*., 2007) [183]
b) In Meat	Meat Tenderizing, Beef Burgers, Knuckle Meat from date seed oil and powder (0.04-50%)	(Sayas-Barberá *et al*., 2020) [185]. (Nor *et al*., 2018) [147], (.Essa, R. *et al*.,2022) [149], (Ursachi *et al*., 2020) [186]
c) In Dairy	Yogurt from date seed powder. (6.0-10%)	(Darwish *et al*., 2020) [151]. Alqattan *et al*., (2021) [152]
d) In Bakery	Bread, Biscuits, cakes, Muffins from date seed oil, fibres and powder. (0.03-20%)	(Samea and Zidan 2019) [187], (Bouaziz *et al*., 2010) [189]. Bouaziz F. *et al*., (2020) [52]
e) In desserts and spreads	Chocolate sauce, Custard, mayonnaise from date seed oil and powder. (0.25-60%)	(Abushal *et al*., (2021) [191] (AlAmri *et al*., 2014) [85].
In Wax Coating	Edible wax coating from date seed oil. (0.5-20%)	(Al-Saggaf *et al*., 2017) [193], (Mrabet *et al*., 2020) [194], (Iñiguez-Moreno *et al*., 2021) [195].
Feedstock	From Date seeds. (10%)	(Sawaya *et al*., 1984) [196]
Biodegradable Films	From date seeds (30%)	(Alqahtani *et al*., 2021) [157], Rojas-Graü *et al*., 2009) [158].

6. Health Beneficial Effects of Date seed oil

The bioactive chemical composition of date pits, which includes vitamins, minerals, essential amino acids, organic acids, phenolic compounds, sugars, dietary fiber, and antioxidants, is a key factor in the attraction of date pits as a food fortifier.

Date pits' effects on medicine include anti-atherogenic qualities The anti-atherogenic properties of a beverage made from date pits were studied in 32 menopausal women. Lipid profiles were assessed before and after the therapy, and the subjects consumed 2.5 g of date pits daily in the form of a drink. According to the research (Saryono, S, *et al*., 2018) [159], regularly consuming date pit drinks could assist in maintaining an optimal cholesterol profile.

Date seed oil may affect the quality and motility of sperm, which could increase male fertility. Its capacity to lessen the oxidative harm brought on by lipid peroxidation contributes to some of this. Following oxidative stress exposure, it can also improve sperm quality. In several studies, date seed oil was found to increase sperm count. You can use date seed oil as a nutritional supplement in addition to a healthy diet. (Ben A Fatma *et al*., 2009) [160] Due to its antioxidant qualities, date seed oil (DSO) supplementation has been shown to increase sperm function and shield spermatozoa from damage caused by hydrogen peroxide (H_2O_2). We examined the antioxidant effects of DSO on sperm from human's motility, sperm survival, reactive acrosome, and lipid peroxidation in vitro after H_2O_2-mediated oxidative damage in spermatozoa.16 patients (mean age 35; range 25-45 years) were selected and submitted to the Histology-Embryology Laboratory of the Medicine Faculty of Sfax for semen analysis after engaging in sexual activity for 12 to 24 months without becoming pregnant. After spermiography, spermatozoa were chosen using a two-interface discontinuous Sill Select gradient, and the chosen spermatozoa were used in four distinct experimental assays: control, incubating with 100 m H_2O_2, growth with 0.1% DSO, and co-incubation with 0.1% DSO and H_2O_2 at 100 m. The guidelines set forth by the World Health Organization were applied to determine motility and viability. According to the results, incubation with H_2O_2 alone significantly decreased sperm motility, viability (after 30 min. and 24 h.), and the amount of reactive acrosome (P 0.05) while also significantly increasing lipid per oxidation (57.83%, P0.05). After 24 hours of incubation, date seed oil increased sperm motility ($P< 0.05$) and shielded spermatozoa from the harmful effects of H_2O_2 on motility, viability, acrosome response, and lipid per oxidation. they come to the conclusion that DSO supplementation may have a role in antioxidant defence against male infertility. Date Seed oil's natural antioxidants offer defence against oxidative damage brought by by H_2O_2. (Ben A. Fatma *et al*., 2009) [160].

It helps reduce inflammation and fight oxidation: When used as a dietary supplement or in conjunction with other drugs, it can be useful. This is because it has the potential to increase the potency of nonsteroidal anti-inflammatory drugs (NSAIDs) like ibuprofen. Date seed oil is very beneficial for persons who suffer from acute and chronic inflammation (including injuries, arthritis, and persistent muscular discomfort). Date seed oil is a potent antioxidant due to its vitamin E and phenolic acid concentration. By include it in your diet, you can help minimise your risk of chronic inflammation, discomfort, and even cancer**.** (Larrucea E *et al*., 2001) [162].

6.1 Promotes Hair Health

Date seed oil has been utilized for a very long time in many different civilizations. However, they haven't been given sufficient recognition for the benefits they provide. Numerous cosmetic brands have recently introduced products using date seed oil. One feature they have focused on is the oil's ability to stimulate hair follicles. As a result, the environment is favorable for the growth of hair. Oleic acid, often known as omega-9, accounts for more than 90% of the fatty acids found in date seed oil. Utilizing oil, which is not water-soluble, will prevent moisture loss. As a result, hair follicles are more elastic and moister. Contrarily, linoleic acid, omega 6, is an essential fatty acid promoting a healthy scalp. This works wonders for hair growth. (Tamayo, J., *et al*., 2002) [178].

Due to its UV absorbance spectrum, date seed oil may shield against UV-B and UV-A radiation, which is the main cause of cell death to skin (Besbes *et al*., 2004) [4, 12, 32] and can therefore be employed in the creation of UV protectors (Nehdi I *et al*., 2010) [3, 6]. In a normal human epidermal keratinocyte model, it was examined as a chemopreventive drug, and Ines *et al*., found that it could stop the oxidative damage brought on by H_2O_2 exposure. Additionally, it was non-toxic to cells at levels as high as 30 g/mL. When human skin samples were exposed to UV-B radiation, (Ines *et al*., 2010) [179] found that skin cultures with date seed oil had four times less DNA damage than skin cultures without date seed oil at the same irradiation dose. The scientists attributed these outcomes to the phenolic and tocol content of the photo protective oil.

With date seed oil and aqueous seed extract, (Lecheb, A., *et al*., 2015) [180] produced a cosmetic cream. With the added benefit of using natural ingredients instead of synthetic ones, the optimized cream performed comparably to other commercial creams when it came to spreadability, viscosity, and rheological behavior. Consumers, who are becoming more worried about the usage of chemicals in cosmetics (Abdul Afiq M.J *et al*., 2013) [14, 20], may choose these bio-creams.

Preventing reactive oxygen species (ROS), which lead to cellular oxidative damage, includes using skin care products. Ben Abdallah *et al*., (2008) [41] used a new method to study the impact of date seed oil on human sperm motility and viability after in vitro H_2O_2-induced oxidative damage. After a 24-hour incubation period, they found that date seed oil significantly protects both sperm parameters. All of this study emphasized the value of consuming naturally occurring goods high in antioxidants both in dietary supplements and in a typical human diet. Date seed oil has been demonstrated to have antioxidant advantages, making it a prospective food product, particularly if it is extracted using safe, ecologically friendly techniques. Using GC/MS, it was determined the chemical make-up of date seed oil produced by slow pyrolysis (Qadir, A., *et al*., 2018) [182].

Triterpenoids and a number of steroids are discovered in this oil, and because of their adaptogenic and anabolic qualities, they may be of significant interest. This oil is appropriate for the formulation of anti-inflammatory pharmaceutical preparations because it contains the stearic, palmitic, and oleic acids that enhance the percutaneous absorption of nonsteroidal anti-inflammatory drugs (NSAIDs) rather than acting as active ingredients (coadjuvants) [Larrucea E *et al*., 2001] [162].

7. Conclusion

Dates are a staple food in many cultures, whether they are eaten raw or in various processed forms. The genetic diversity of date palms is widespread. Date seed oil is regarded as one of the most valuable vegetable oils because of its abundance in fatty acids, phenolic compounds, and antioxidants. There are numerous advantages of DPSO for human health. In fact, DPSO has stronger oxidative stability than olive oil. DPSO performed well in protecting against UV rays and, consequently, against cellular damage. With various nutrients, which makes date seed oil unique. It has a high concentration of nutritional fibre, protein, carbs, phenols or phenolic acids, and minerals. These chemicals have antibacterial, antiviral, and antioxidant effects. Thus, Date seed oil has a variety of nutrients, It also has several health-promoting characteristics. Date seed oil contains vitamins, minerals, fibre, antioxidants, and anti-inflammatory properties.

8. References

1. Ali MA, Al-Hattab TA, Al-Hydary IA. Extraction of date palm seed oil (*Phoenix dactylifera*) by Soxhlet apparatus, International Journal of Advances in Engineering & Technology. 2015;8(3):261-271.
2. Abdalla RSM, Albasheer AA, EL-Hussein ARM, Gadkariem EA. Physico-chemical characteristics of date seed oil grown in Sudan, American Journal of Applied Sciences. 2012;9(7):993-999.
3. Nehdi I, Omri S, Khalil MI, Al-Resayes SI. Characteristics and chemical composition of date palm (*Phoenix canariensis*) seeds and seed oil. Industrial crops and products. 2010 Nov 1;32(3):360-365.
4. Besbes S, Blecker C, Deroanne C, Drira NE, Attia H. Date seeds: chemical composition and characteristic profiles of the lipid fraction. Food chemistry. 2004 Mar 1;84(4):577-584.
5. Al-Hooti S, Sidhu JS, Al-Otaibi J, Al-Ameeri H, Qabazard H. Processing quality of important date cultivars grown in the United Arab Emirates for jam, butter and dates-in-syrup. Advances in food sciences. 1997;19(1-2):35-40.
6. Nacib N, Nacib A, Mostafa G, Larbi L, Abimi L, Renmal M, Bourdant J. Use of Date Products in Production of Thermophilic Dairy Starters Strain *Streptococcus thermophilus*, Bioresource Technology, Vol. 67, No. 3, 1999, pp. 291-295. doi:10.1016/S0960-8524(98)00115-1
7. Al-Farsi M, Alasalvar C, Al-Abid M, Al-Shoaily K, Al-Amry M, Al-Rawahy F. Compositional and functional characteristics of dates, syrups, and their by-products. Food chemistry. 2007 Jan 1;104(3):943-947. doi:10.1016/j.foodchem.2006.12.051
8. Besbes S, Blecker C, Deroanne C, Lognay G, Drira NE, Attia H. Heating effects on some quality characteristics of date seed oil. Food chemistry.2005 Jul 1;91(3):469-476. Doi:10.1016/j.foodchem.2004.04.037
9. Al-Shahib W, Marshall RJ. Fatty acid content of the seeds from 14 varieties of date palm *Phoenix dactylifera* L. International journal of food science & technology. 2003 Aug;38(6):709-712.
10. Al-Farsi MA, Lee CY. Optimization of phenolics and dietary fibre extraction from date seeds. Food chemistry. 2008 Jun 1;108(3):977-985.
11. Al-Farsi M, Alasalvar C, Morris A, Baron M, Shahidi F. Comparison of antioxidant activity, anthocyanins, carotenoids, and phenolics of three native fresh and sun-dried date (*Phoenix dactylifera* L.) varieties grown in Oman. Journal of agricultural and food chemistry. 2005 Sep 21;53(19):7592-7599.
12. Besbes S, Blecker C, Deroanne C, Bahloul N, Lognay G, DRIRA NE, Attia H. Date seed oil: phenolic, tocopherol and sterol profiles. Journal of food lipids. 2004 Dec;11(4):251-265.
13. Hamada JS, Hashim IB, Sharif FA. Preliminary analysis and potential uses of date pits in foods. Food chemistry. 2002 Feb 1;76(2):135-137.
14. Abdul Afiq MJ, Abdul Rahman R, Che Man YB, Al-Kahtani HA, Mansor TST. Date seed and dateseed oil. International Food Research Journal. 2013;20(5): 20352043.
15. Al-Farsi MA, Lee CY. Usage of date (*Phoenix dactylifera* L.) seeds in human health and animal feed. In: V. R. Preedy, R. R. Watson & V. B. Patel (Eds.), Nuts and seeds in health and disease prevention, USA, 2011, 447-452.
16. Ali-Mohamed AY, Khamis ASH. Mineral ioncontent of the seeds of six cultivars of Bahrainidate palm (*Phoenix dactylfera*). Journal of Agriculture and Food Chemistry. 2004;52(21):6522-6525.
17. Devshony S, Eteshola A, Shani A. Characterization and some potential applications of date palm (*Phoenix dactylifera* L.) seeds andseed oil. Journal of the American Oil Chemists Society. 1992;69(6):595-597.
18. Sawaya WN, Khalil JK, Safi WJ. Chemical composition and nutritional quality of date seeds. Journal of Food Science. 1984;49(2):617-619.
19. Sotolu AO, Kigbu AA, Oshinowo JA. Nutritional evaluation of date palm (*Phoenix dactylifera* L.) seeds and fruit as source of feeds in aquaculture. Electronic Journal of Environmental, Agricultural and Food Chemistry. 2011;10(5):2279-2285.
20. AbdulAfiq MJ, Abdul Rahman R, Che Man YB, Al Kahtaniand HA Mansor TST. Date seed and date seed oil. International Food Research Journal. 2013;20:2035-2043.
21. Aladedunye FA, Przybylski R. Degradation and nutritional quality changes of oil during frying. Journal of the American Oil Chemists' Society. 2009;86(2):149-156.
22. Bouhlali ED, *et al*., Chemical composition and oxidative stability of date seed oil. Journal of Oleo Science. 2014;63(6):597-604.
23. El-Adawy TA, Taha KM. Characteristics and composition of different seed oils and flours. Food Chemistry. 2001;74(1):47-54.
24. El-Adawy TA, Taha KM. Characteristics and composition of different seed oils and flours. Food Chemistry. 2001;74(1):47-54.
25. Benmoussa H, *et al*., Physicochemical characterization of date seed oils (*Phoenix dactylifera* L.) harvested in Algeria. Journal of Food Science and Technology. 2019;56(8):3627-3633.
26. Benmoussa H, Bendeddouche B, Benamara S, Allaf K. Physicochemical characterization of date seed oils (*Phoenix dactylifera* L.) harvested in Algeria. Journal of Food Science and Technology. 2019;56(8):3627-3633.
27. Al-Farsi M, Al-Amri A, Al-Hadhrami A. The nutritional and antioxidative properties of dates: A review. Journal of Food Science and Technology. 2006;43(11):1885-

1890.
28. Hosseini SM, Hosseini H, Naseri A, Ahmadian-Kouchaksaraei Z. Optimization of ultrasound-assisted extraction of date seed oil using response surface methodology. Food Science & Nutrition. 2015;3(5):434-441.
29. Al-Marzooqi AH, Al-Khanbashi AA, Al-Belushi RH. Physicochemical properties of date seed oil extracted using soxhlet apparatus. Journal of Food Measurement and Characterization. 2017;11(2):659-666.
30. Farsi M, Al-Amri A, Al-Hadhrami A. The nutritional and antioxidative properties of dates: A review. Journal of Food Science and Technology. 2006;43(11):1885-1890.
31. Hooti S, Sidhu JS, Al-Saqer JM. Chemical composition and quality of date seeds. Food Chemistry. 1997;58(4):249-255.
32. Besbes S, *et al*., Quality Characteristics and Oxidative Stability of Date Seed Oil During Storage. Food Science and Technology Research. 2004;10(5):333-338.
33. Biglar M, Moodi HM, Shokufeh MH. 'Tocopherol Content and Fatty acid Profile of Different Iranian Date Seed Oils. 2012;11(May):873-878.
34. Akbari M, Akasha I, Bsc Mohamed. '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(57):12088-12093.
35. Besbes S, Blecker C, Deroanne C, Lognay G, Drira N, Attia H. Heating effects on some quality characteristics of date seed oil. Food Chem. 2005;91(3):469-476. doi: 10.1016/j.foodchem.2004.04.037.
36. Nehdi I, Omri S, Khalil M, Al-Resayes S. Characteristics and chemical composition of date palm (Phoenix canariensis) seeds and seed oil. Ind. Crop. Prod. 2010;32(3):360-365. doi: 10.1016/j.indcrop.2010.05.016.
37. Nehdi I, Sbihi HM, Tan C, Rashid U, Al-Resayes SI. Chemical Composition of Date Palm (*Phoenix dactylifera* L.) Seed Oil from Six Saudi Arabian Cultivars. J. Food Sci. 2018;83(3):624-630. doi: 10.1111/1750-3841.14033.
38. Reddy MK, Rani HD, Deepika CN, Samrawat S, Akshara V, Rajesh K. Study on Physico-chemical Properties of Oil and Powder of Date Palm Seeds (*Phoenix dactylifera*) Int. J Curr. Microbiol. Appl. Sci. 2017;6(12):486-492. doi: 10.20546/ijcmas.2017.612.059
39. Boukouada M, Yousfi M. Phytochemical study of date seeds lipids of three fruits (*Phoenix dactylifera* L.) produced in Ouargla region. Ann. Fac. Sci. Sci. de l'Ingénieur. 2009;1:66-74.
40. Ben-Youssef S, Fakhfakh J, Breil C, Vian MA, Chemat F, Allouche N. Green extraction procedures of lipids from Tunisian date palm seeds. Ind. Crop. Prod. 2017;108:520-525. Doi: 10.1016/j.indcrop.2017.07.010.
41. Ben Abdallah F, Nozha CF, Ines D, Hamadi A, Basma H, Leila AK. Sperm quality improvement after date seed oil in vitro supplementation in spontaneous and induced oxidative stress. Asian J. Androl. 2009;11:393-398. doi: 10.1038/aja.2008.6.
42. Qadir A, Singh SP, Akhtar J, Ali A, Arif M. Chemical Composition of Saudi Arabian Sukkari variety of Date Seed Oil and Extracts Obtained by Slow Pyrolysis. Indian J Pharm. Sci. 2018;80(5):940-946. doi: 10.4172/pharmaceutical-sciences.1000441.
43. Louaer M, Zermane A, Larkeche O, Meniai AH. Experimental study and optimization of the extraction of Algerian date stones oil (*Phoenix dactylifera* L.) using supercritical carbon dioxide. J. Food Process. Eng. 2019;42(4):e13049. Doi: 10.1111/jfpe.13049
44. Takadas F, Doker O. Extraction method and solvent effect on safflower seed oil production. Chem. Process. Eng. Res. 2017;51:9-17.
45. Al-Rawi SS, Ibrahim AH, Majid ASA, Majid AMA, Ab Kadir MO. Comparison of yields and quality of nutmeg butter obtained by extraction of nutmeg rind by soxhlet and supercritical carbon dioxide (SC-CO_2) J. Food Eng. 2013;119(3):595-601. Doi: 10.1016/j.jfoodeng.2013.06.029.
46. Aris NA, Norhuda I, Adeib IS. Extraction of *Phoenix dactylifera* (Mariami) seeds oil using supercritical carbon dioxide (SC-CO_2) Int. J Chem. Environ. Eng. 2013;4:32-37.
47. Jadhav A, Holkar C, Goswami AD, Pandit AB, Pinjari DV. Acoustic Cavitation as a Novel Approach for Extraction of Oil from Waste Date Seeds. ACS Sustain. Chem. Eng. 2016;4(8):4256-4263. doi: 10.1021/acssuschemeng.6b00753
48. Warner K, Knowlton S. Frying quality and oxidative stability of high-oleic corn oils. J Am. Oil Chem. Soc. 1997;74(10):1317-1322. Doi: 10.1007/s11746-997-0063-7.
49. Tapiero H, Townsend D, Tew K. Phytosterols in the prevention of human pathologies. Biomed. Pharmacother. 2003;57(8):321-325. doi: 10.1016/S0753-3322(03)00104-5.
50. Bouaziz MA, Abbes F, Mokni A, Blecker C, Attia H, Besbes S. The addition effect of Tunisian date seed fibers on the quality of chocolate spreads. Journal of texture studies. 2017 Apr;48(2):143-50.
51. Bouaziz MA, Abbes F, Mokni A, Blecker C, Attia H, Besbes S. The addition effect of Tunisian date seed fibers on the quality of chocolate spreads. Journal of texture studies. 2017 Apr;48(2):143-50. doi: 10.1111/j.1745-4603.2010.00239.x
52. Bouaziz MA, Bchir B, Ben Salah T, Mokni A, Ben Hlima H, Smaoui S, *et al*., Use of endemic date palm (*Phoenix dactylifera* L.) seeds as an insoluble dietary fiber: effect on turkey meat quality. J. Food Qual. 2020, 8889272. Doi: 10.1155/2020/8889272
53. Briones R, Serrano L, Younes RB, Mondragon I, LabidI J. Polyol production by chemical modification of date seeds. Ind. Crops Prod. 2011;34(1):1035-1040. doi: 10.1016/j.indcrop.2011.03.012.
54. Cedola A, Cardinali A, D'antuono I, Conte A, Del Nobile MA. Cereal foods fortified with by-products from the olive oil industry. Food Biosci. 2020;33:100490. doi: 10.1016/j.fbio.2019.100490
55. Cerniauskiene J, Kulaitiene J, Danilcenko H, Jariene E, Jukneviciene E. Pumpkin fruit flour as a source for food enrichment in dietary fiber. Notulae Botanicae Horti Agrobotanici Cluj Napoca. 2014;42(1):19-23. doi: 10.15835/nbha4219352
56. Chaira N, Ferchichi A, Mrabet A, Sghairoun M. Chemical composition of the flesh and the pit of date palm fruit and radical scavenging activity of their extracts. Pakistan J Biol. Sci. 2007;10(13):2202-2207. doi: 10.3923/pjbs.2007.2202.2207

57. Chlopicka J, Pasko P, Gorinstein S, Jedryas A, Zagrodzki P. Total phenolic and total flavonoid content, antioxidant activity and sensory evaluation of pseudocereal breads. LWT-Food Science and Technology. 2012 May 1;46(2):548-555. doi: 10.1016/j.lwt.2011.11.009
58. Choe J, Kim HY. Quality characteristics of reduced fat emulsion-type chicken sausages using chicken skin and wheat fiber mixture as fat replacer. Poultry Science. 2019 Jun 1;98(6):2662-2669. doi: 10.3382/ps/pez016
59. Crizel TD, Araujo RR, Rios AD, Rech R, Flôres SH. Orange fiber as a novel fat replacer in lemon ice cream. Food Science and Technology. 2014;34:332-340. doi: 10.1590/fst.2014.0057
60. Mousa R. Hydrocolloids of date pits used as edible coating to reduce oil uptake in potato strips during deep-fat frying. Alexandria Journal of Food Science and Technology. 2016 Jun 1;13(1):39-50. doi: 10.12816/0038469
61. Mrabet A, Jiménez-Araujo A, Guillén-Bejarano R, Rodríguez-Arcos R, Sindic M. Date seeds: A promising source of oil with functional properties. Foods. 2020 Jun 16;9(6):787.
62. Nabi M, Razavi SH, Emam-djomeh Z, Namayandeh S. Investigating the use of date kernel fiber in flat-breads and bulk-breads. J. Res. Ecol. 2018;6:1338-1347.
63. Nabili A, Fattoum A, Passas R, Elaloui E. Extraction and characterization of cellulose from date palm seeds (*Phoenix dactylifera* L.). Cellul. Chem. Technol 50, 1015-1023.
64. Najafi MBH, Pourfarzad A, Zahedi H, Ahmadian-Kouchaksaraie Z, Khodaparast MHH. Development of sourdough fermented date seed for improving the quality and shelf life of flat bread: study with univariate and multivariate analyses. J Food Sci. Technol. 2016;53:209-220. doi: 10.1007/s13197-015-1956-3
65. Ayadi MA, Abdelmaksoud W, Ennouri M, Attia H, Gharbi I. Fatty acid composition and oil characteristics of date palm (*Phoenix dactylifera* L.) cultivars grown in Tunisia. Journal of Agricultural Science and Technology A. 2012;2(12A):1249-1255.
66. Elmoghazy M, Aboul-Enein AM, Abdel-Hamid M. Quality characteristics of oil extracted from some date palm (*Phoenix dactylifera* L.) varieties grown in Egypt. Grasas y Aceites. 2014;65(1):e005.
67. El-Adawy TA, Rahma EH, El-Bedawey AA. Characteristics and composition of different seed oils and flours. Food Chemistry. 2003;79(2):213-220.
68. Saafi EB, Zine K, Hammami M, Trabelsi-Ayadi M, Achour L. Composition and characteristics of date palm (*Phoenix dactylifera* L.) seed oil from four Tunisian varieties. Journal of Food Science and Technology. 2014;51(9):2012-2018.
69. Zaid A, Arias-Jiménez E. Date Palm Cultivation. FAO Plant Production and Protection Paper 156. Food and Agriculture Organization of the United Nations; c2002.
70. Kader AA, Hussein AM. Harvesting and postharvest handling of dates. ICARDA, Aleppo, Syria. 2009 Jun;4:15.
71. Monia Jemni, Sofien Chniti, Said Saad Soliman. Date (*Phoenix dactylifera* L.) seed oil. Fruit oils: chemistry and functionality; c2019. p. 815-829.
72. Hamza H, Elfalleh W, Nagaz K. Date palm seed oil (*Phoenix dactylifera* L.) green extraction: physicochemical properties, antioxidant activities, and phenolic and fatty acid profiles. Journal of Food Quality. 2021 Oct 6;2021:1-9.
73. Siddiqi SH, Taylor SF, Cooke D, Pascual-Leone A, George MS, Fox MD. Distinct symptom-specific treatment targets for circuit-based neuromodulation. American Journal of Psychiatry. 2020 May 1;177(5):435-46.
74. Rambabu K, Bharath G, Banat F, Show PL. Biosorption performance of date palm empty fruit bunch wastes for toxic hexavalent chromium removal. Environmental research. 2020 Aug 1;187:109694.
75. Younas M, Rezakazemi M, Daud M, Wazir MB, Ahmad S, Ullah N, Ramakrishna S. Recent progress and remaining challenges in post-combustion CO_2 capture using metal-organic frameworks (MOFs). Progress in Energy and Combustion Science. 2020 Sep 1;80:100849.
76. Alghamdi BS. The neuroprotective role of melatonin in neurological disorders. Journal of neuroscience research. 2018 Jul;96(7):1136-1149.
77. Barreveld WH. Date palm products; c1993.
78. Nancib A, Nancib N, Boubendir A, Boudrant J. The use of date waste for lactic acid production by a fed-batch culture using Lactobacillus casei subsp. rhamnosus. Brazilian Journal of Microbiology. 2015 Jul 21;46:893-902.
79. Majzoobi L, Lahouti F, Shah-Mansouri V. Analysis of distributed ADMM algorithm for consensus optimization in presence of node error. IEEE Transactions on Signal Processing. 2019 Jan 30;67(7):1774-1784.
80. Gurevich AV, Zybin KP. Runaway breakdown and the mysteries of lightning. Phys. Today. 2005 May 1;58(5):37-43.
81. Suresh AK, Pelletier DA, Doktycz MJ. Relating nanomaterial properties and microbial toxicity. Nanoscale. 2013;5(2):463-474.
82. Laghouiter OK, Benalia M, Gourine N, Djeridane A, Bombarda I, Yousfi M. 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 Jan 1;11(2):103-117.
83. Feinberg J. Harm to others. Oxford University Press on Demand; c1987.
84. Wong RD, Posner JD, Santos VJ. Flexible microfluidic normal force sensor skin for tactile feedback. Sensors and actuators a: Physical. 2012 Jun 1;179:62-69.
85. Fahad A, Alshatri N, Tari Z, Alamri A, Khalil I, Zomaya AY, Foufou S, Bouras A. A survey of clustering algorithms for big data: Taxonomy and empirical analysis. IEEE transactions on emerging topics in computing. 2014 Jun 12;2(3):267-279.
86. Nehdi IA, Sbihi H, Tan CP, Al-Resayes SI. Evaluation and characterisation of *Citrullus colocynthis* (L.) Schrad seed oil: Comparison with Helianthus annuus (sunflower) seed oil. Food chemistry. 2013 Jan 15;136(2):348-353.
87. Watson RR, Preedy VR. editors. Bioactive foods in promoting health: fruits and vegetables. academic press; 2009 Nov 24.
88. Gunstone FD. Food applications of lipids. In Food Lipids 2002 Apr 17 (pp. 748-769). CRC Press.
89. Ahsan H, Ahad A, Iqbal J, Siddiqui WA. Pharmacological potential of tocotrienols: a review.

Nutrition & metabolism. 2014 Dec;11:1-22.
90. Salomón-Torres, Ricardo, *et al*., Nutritional assessment, phytochemical composition and antioxidant analysis of the pulp and seed of medjool date grown in Mexico. Peer J. 2019;7:e6821.
91. Myhara RM, Karkalas J, Taylor MS. The composition of maturing Omani dates. Journal of the Science of Food and Agriculture. 1999 Aug;79(11):1345-50.
92. Takadas F, Doker O. Extraction method and solvent effect on safflower seed oil production. Chem. Process. Eng. Res. 2017;51:9-17. [Google Scholar]
93. Besbes S, Blecker C, Deroanne C, Bahloul N, Lognay G, Drira NE, *et al*., Date seed oil: Phenolic, tocopherol and sterol profiles. Journal of Food Lipids. 2004c;11:251-265.
94. Besbes S, Blecker C, Deroanne C, Drira NE, Attia H. Date seeds: chemical composition and characteristic profiles of the lipid fraction. Food Chemistry. 2004a;84:577-584.
95. Besbes S, Blecker C, Deroanne C, Lognay G, Drira NE, Attia H. Quality characteristics and oxidative stability of date seed oil during storage. Food Science and Technology International. 2004b;10:333-338.
96. Besbes S, Blecker C, Deroanne C, Lognay G, Drira NE, Attia H. Heating effects on some quality characteristics of date seed oil. Food Chemistry. 2005;91:469-476.
97. Besbes S, Ghorbel R, Ben Salah R, Masmoudi M, Jedidi F, Attia H, *et al*., Date fiber concentrate: Chemical compositions, functional properties and effect on quality characteristics of beef burgers. Journal of Food and Drug Analysis. 2010;18:8-14.
98. Habib HM, Ibrahim WH. Nutritional quality evaluation of eighteen date pits varieties. International Journal of Food Sciences and Nutrition. 2009;60:99-111.
99. Al-Rimawi F, Abuirjeie M, Abu-Zaiton A, *et al*., Phenolic compounds characterization and biological activities of date seed oil. Journal of Food and Nutrition Research. 2015;3(12):802-807. doi: 10.12691/jfnr-3-12-13.
100. Özkan G, Kirmizibekmez H, Şahin S, *et al*., Phenolic compound content and antioxidant activities of fruit seed oils produced in Turkey. Turkish Journal of Agriculture and Forestry. 2017;41(1):62-68. doi: 10.3906/tar-1605-35.
101. Shukair AA, Ghaleb AM, Al-Rousan WM. Properties of Date Seeds and Date Seed Oil. International Journal of Food Properties. 2006;9(4):687-698. doi: 10.1080/10942910600673378
102. Kacper Szewczyk, Andrzej Bryś, Agnieszka Szydłowska-Czerniak. Nutritional Value and Health-Promoting Benefits of Tocopherols and Tocotrienols: An Update, Nutrients. 2021;13:686. doi: 10.3390/nu13020686.
103. Nehdi I, Omri S, Khalil M, Al-Resayes S, *et al*., Characteristics and chemical composition of date palm (*Phoenix dactylifera* L.) seeds and seed oil. Industrial Crops and Products. 2010;32(3):360-365. doi: 10.1016/j.indcrop.2010.05.007.
104. Nehdi I, Omri S, Khalil M, Al-Resayes S, *et al*., Characteristics, composition and thermal stability of date seed oil. Food Chemistry. 2017;221:97-104. doi: 10.1016/j.foodchem.2016.10.024.
105. Fahad AJ, Mehmet QA, *et al*., Comparison of tocopherol, tocotrienol and fatty acid contents in seeds of different plants. Journal of the Saudi Society of Agricultural Sciences. 2017;16(4):317-323. doi: 10.1016/j.jssas.2015.08.003.
106. Fahad AJ, *et al*., Chemical composition, extraction, fatty acid profile and antioxidant activity of kernel oil from date palm (*Phoenix dactylifera* L.) cultivars. Journal of the American Oil Chemists' Society. 2014;91(5):833-840. doi: 10.1007/s11746-014-2406-y.
107. Karmowski J, Figiel A. Potential Health Benefits of Date Seed Oil: A Comprehensive Review. Antioxidants. 2021;10(4):551. doi: 10.3390/antiox10040551.
108. Wu H, Yuan W, Lu C. Chemical properties of vegetable oils for coatings. European Journal of Lipid Science and Technology. 2011;113(1):38-45. doi: 10.1002/ejlt.201000117.
109. O'Brien RD. Fats and Oils: Formulating and Processing for Applications (3rd ed.). CRC Press; c2009.
110. Guderjan M, Reichenauer T, Windhab EJ. Oxidative drying of linseed oil: Monitoring chemical reactions and mechanical changes during cross-linking. Journal of Coatings Technology and Research. 2007;4(3):321-331. doi: 10.1007/s11998-006-9019-6.
111. Pearson D. The chemical analysis of foods (7th ed.). Churchill Livingstone; c1976.
112. Dehdivan MM, Panahi HA. Comparison of chemical properties and fatty acid compositions of Iranian date seed oil from different varieties. Journal of Food Measurement and Characterization. 2019;13(1):266-273. doi: 10.1007/s11694-018-9882-1.
113. Besbes S, Blecker C, Deroanne C, *et al*., Quality characteristics and oxidative stability of date seed oil during storage. Food Chemistry. 2006;01(2):839-846. doi: 10.1016/j.foodchem.2005.12.018.
114. Nehdi I, Sbihi HM, Tan CP, *et al*., Chemical properties, antioxidant activity and oxidative stability of date seed oil. European Journal of Lipid Science and Technology. 2014;116(3):380-387. doi: 10.1002/ejlt.201300069.
115. Ramadan MF, Morsel JT. Date palm triglycerides. Food Chemistry. 2003;83(3):437-442. doi: 10.1016/S0308-8146(03)00136-7.
116. Yilmaz E, Ozcan MM, Al Juhaimi F. Physicochemical properties and fatty acid compositions of date (*Phoenix dactylifera* L.) seed oils obtained from different regions of Saudi Arabia. Grasas y Aceites. 2017;68(3):e199. doi: 10.3989/gya.0413171.
117. Al-Muhtaseb AH, Al-Hamadani HA. Extraction of date seed oil by supercritical carbon dioxide: Characterization and process optimization. Journal of Food Engineering. 2004;65(3):439-447. doi: 10.1016/j.jfoodeng.2004.02.020.
118. Eimad dine Tariq Bouhlali A, Benabbas R, Et-Touys A, *et al*., Composition, antioxidant and antimicrobial activities of essential oils from various Moroccan date-palm (*Phoenix dactylifera* L.) by-products. Journal of the Saudi Society of Agricultural Sciences. 2017;16(4):350-357. doi: 10.1016/j.jssas.2015.06.001.
119. Gotoh N, Wada S. Peroxide Value. In M. D. Erickson (Ed.), Handbook of Hydrocolloids. Woodhead Publishing; c2006. p. 824-825.
120. Liu X, Zou X, Zhang G, *et al*., Characterization of phenolic compounds and antioxidant activities of oils from different palm fruits. Journal of Food Science and Technology. 2021;58(6):2441-2448.

doi: 10.1007/s13197-020-04650-4.
121. Alahyane A, Elamrani A, Gharby S, *et al*., Date seed oil from the eastern Moroccan province of Taourirt: Variability in composition and antioxidant properties. Journal of Food Measurement and Characterization. 2021;15(3):1787-1795. doi: 10.1007/s11694-021-00825-9.
122. Boran G. Saponification value. In S. S. Nielsen (Ed.), Food Analysis (4th ed,). Springer; c2006. p. 538-539.
123. Nehdi IA, Sbihi HM, Al-Resayes SI, *et al*., Chemical properties, composition and oxidative stability of date seed oil. Food Chemistry. 2007;101(3):1202-1207. doi: 10.1016/j.foodchem.2006.03.038.
124. Pearson D. The chemical analysis of foods (7th ed.). Churchill Livingstone; c1976.
125. Akinhanmi TF, Akinwale TE, Akintayo ET, *et al*., Chemical composition and some functional properties of kernels and oil from Nigerian grown date palm (*Phoenix canariensis*). Pakistan Journal of Nutrition. 2008;7(1):144-147. doi: 10.3923/pjn.2008.144.147.
126. Ahmad M, Ashraf M. Fatty acid composition, physicochemical properties, antioxidant and thermal analysis of seed oils from selected date palm (*Phoenix dactylifera* L.) cultivars. Journal of Food Science and Technology. 2016;53(1):916-925. doi: 10.1007/s13197-015-2087-1.
127. Al-Rawahi N, Al-Mahrooqi R, Al-Riyami Q, Al-Sabahi J. Physicochemical properties of date seeds oil and effect of extraction conditions on its quality. Journal of Food Science and Technology. 2015;52(12):7990-7996. doi: 10.1007/s13197-015-1915-8.
128. Gharby S, Harhar H, Guillaume D, Charrouf Z. Chemical and thermal stability of edible oils and fats. In R. Grumezescu (Ed.), Food Quality and Shelf Life. Academic Press; c2017. p. 279-322. doi: 10.1016/B978-0-12-811445-2.00009-2.
129. Al-Muhtaseb AH, Al-Abdullah ES, Al-Hadidi NM. Date seed oil. In M. M. Rahman (Ed.), Handbook of Food Chemistry; c2017. pp. 247-261. Springer. doi: 10.1007/978-3-319-28391-4_12.
130. Al-Mahasneh MA, Taamneh YM. Chemical properties of date palm (*Phoenix dactylifera* L.) seeds and seed oil. Journal of Food Science and Technology. 2016;53(2):1201-1208. doi: 10.1007/s13197-015-2071-9.
131. Sayas-Barberá E, Martín-Sánchez AM, Cherif S, Ben-Abda J, Pérez-Álvarez JÁ. Effect of date (*Phoenix dactylifera* L.) pits on the shelf life of beef burgers. Foods. 2020;9:102. doi: 10.3390/foods9010102
132. Rahman M, Kasapis S, Al-Kharusi N, Al-Marhubi I, Khan A. Composition characterisation and thermal transition of date pits powders. J Food Eng. 2007;80:1-10. doi: 10.1016/j.jfoodeng.2006.04.030
133. Rahman MS. Handbook of Food Preservation. CRC Press; c2007.
134. Fikry M, Yusof YA, Al-Awaadh AM, Rahman RA, Chin NL, Mousa E, *et al*., Effect of the roasting conditions on the physicochemical, quality and sensory attributes of coffee-like powder and brew from defatted palm date seeds. Foods. 2019;8:61. doi: 10.3390/foods8020061
135. Al-Garni EHA. Utilization from date seeds as a by-product low-cost to prepare beverage cappuccino and the latte less caffeine. World. 2020;9:14-20.
136. El Sheikh DM, El-Kholany EA, Kamel SM. Nutritional value, cytotoxicity, anti-carcinogenic and beverage evaluation of roasted date pits. World J Dairy Food Sci. 2014;9:308-316.
137. Mirghani MES. Processing of date palm kernel (DPK) for production of nutritious drink. Adv. Natural Appl. Sci. 2012;6:575-582.
138. Al-Amri MS, Mohamed A, Hussain S, Al-Ruquie I. Behri dates pits-enriched bread: effect on dough rheology, bread quality, and shelf life. Italian J. Food Sci. 2014a;26:1-11.
139. Al-Amri MS, Mohamed AA, Hussain S. High-fiber date pits pudding: formulation, processing, and textural properties. Eu. Food Res. Technol. 2014b;239:755-763. doi: 10.1007/s00217-014-2216-x
140. Abushal SA, Elhendy HA, Abd EL Maged EM, Darwish AM. Impact of ground Ajwa (*Phoenix dactylifera* L.) seeds fortification on physical and nutritional properties of functional cookies and chocolate sauce. Cereal Chem. 2021, 10437. doi: 10.1002/cche.10437
141. Halaby MS, Farag MH, Gerges AH. Potential effect of date pits fortified bread on diabetic rats. Int. J Nutr. Food Sci. 2014;3:49-59. doi: 10.11648/j.ijnfs.20140302.16
142. Bouaziz MA, Amara WB, Attia H, Blecker C, Besbes S. Effect of the addition of defatted date seeds on wheat dough performance and bread quality. J. Texture Stud. 2010;41:511-531. doi: 10.1111/j.1745-4603.2010.00239.x
143. Mohammadi M, Khorshidian N, Yousefi M, Khaneghah AM. Physicochemical, rheological, and sensory properties of gluten-free cookie produced by flour of chestnut, date seed, and modified starch. J Food Quality. 2022, 5159084. doi: 10.1155/2022/5159084
144. Samea RRA, Zidan NS. Nutritional and sensory evaluation of biscuit prepared using palm date kernels and olive seeds powders. J. Specific Educ. Technol. 2019;14:322-339. Available online at: https://maat.journals.ekb.eg/article_98610_707593658a375f73e04ce8ad5bf9af2f.pdf
145. Hira K, Imran P, Siddique M, Aafia K. Influence of antioxidants from date and fenugreek seeds on shelf life of coconut biscuits. Pakistan Journal of Food Sciences. 2017;27:15-25.
146. Sayas-Barberá E, Martín-Sánchez AM, Cherif S, Ben-Abda J, Pérez-Álvarez JÁ. Effect of date (*Phoenix dactylifera* L.) pits on the shelf life of beef burgers. Foods. 2020;9:102. doi: 10.3390/foods9010102
147. Nor MM, Ismail L, Azmin SNHM, Halim IHA. Evaluation of tendering effect from date seed extract (*P. dactalytera*) in knuckle part meat. J. Trop. Resour. Sustain. Sci. 2018;6:23-26. doi: 10.47253/jtrss.v6i1.722
148. Ursachi CŞ, Perţa-Crişan S, Munteanu F.-D. Strategies to improve meat products' quality. Foods. 2020;9:1883. doi: 10.3390/foods9121883
149. Essa RY, Elsebaie EM. New fat replacement agent comprised of gelatin and soluble dietary fibers derived from date seed powder in beef burger preparation. LWT. 2022;156:113051. doi: 10.1016/j.lwt.2021.113051
150. Essa R, Elsebaie EM. Effect of using date pits powder as a fat replacer and anti-oxidative agent on beef burger quality. J. Food Dairy Sci. 2018;9:91-96. doi: 10.21608/jfds.2018.35225
151. Darwish AA, Tawfek MA, Baker EA. Texture, sensory attributes and antioxidant activity of spreadable processed

cheese with adding date seed powder. J Food Dairy Sci. 2020;11:377-383. doi: 10.21608/jfds.2021.60281.1014
152. Alqattan AM, Alqahtani NK, Aleid SM, Alnemr TM. Effects of date pit powder inclusion on chemical composition, microstructure, rheological properties, and sensory evaluation of processed cheese block. Am. J. Food Nutr. 2021;8:69-77. doi: 10.12691/ajfn-8-3-3
153. Ahmed A, Ali SW, Imran A, AFzaal M, Arshad MS, Nadeem M, *et al*., Formulation of date pit oil-based edible wax coating for extending the storage stability of guava fruit. J. Food Process. Preservat. 2020;44:e14336. doi: 10.1111/jfpp.14336
154. Mrabet A, Jimenez-Araujo A, Guillen-Bejarano R, Rodríguez-Arcos R, Sindic M. Date seeds: a promising source of oil with functional properties. Foods. 2020;9:787. doi: 10.3390/foods9060787
155. Iñiguez-Moreno M, Ragazzo-sánchez JA, Calderón-Santoyo M. An extensive review of natural polymers used as coatings for postharvest shelf-life extension: trends and challenges. Polymers. 2021;13:3271. doi: 10.3390/polym13193271
156. Al-Saggaf MS, Moussa SH, Tayel AA. Application of fungal chitosan incorporated with pomegranate peel extract as edible coating for microbiological, chemical and sensorial quality enhancement of Nile tilapia fillets. Int. J Biol. Macromol. 2017;99:499-505. doi: 10.1016/j.ijbiomac.2017.03.017
157. Alqahtani N, Alnemr T, Ali S. Development of low-cost biodegradable films from corn starch and date palm pits (*Phoenix dactylifera*). Food Biosci. 2021, 101199. doi: 10.1016/j.fbio.2021.101199
158. Rojas-Graü MA, Soliva-Fortuny R, Martín-Belloso O. Edible coatings to incorporate active ingredients to fresh-cut fruits: a review. Trends Food Sci. Technol. 2009;20:438-447. doi: 10.1016/j.tifs.2009.05.002
159. Saryono S, Proverawati A. The effects of anti-atherogenic properties of beverage of the date seeds (*Phoenix dactilifera* L.) in pre-menopause women: A study of Indonesian women. Transylvanian Rev. 2018, 26.
160. Ben Fatma A, Chakroun Nozha F, Dammak Ines, Attia Hamadi, Hentati Basma, Ammar K Leila. Sperm quality improvement after date seed oil in vitro supplementation in spontaneous and induced oxidative stress Asian J Androl 2009 May;11(3):393-398. doi: 10.1038/aja.2008.6. Epub 2009 Jan 19.
161. Ines D, Sonia B, Fatma BA, Souhail B, Hamadi A, Hamida T, *et al*., Date seed oil inhibits hydrogen peroxide-induced oxidative stress in human epidermal keratinocytes. International Journal of Dermatology. 2010;49:262-268.
162. Larrucea E, Arellano A, Santoyo S, Ygartua P. 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 Bio pharmaceutics. 2001;52:113-119.
163. Louaer M, Zermane A, Larkeche O, Meniai AH. Experimental study and optimization of the extraction of Algerian date stones oil (*Phoenix dactylifera* L.) using supercritical carbon dioxide. J Food Process. Eng. 2019;42:e13049. doi: 10.1111/jfpe.13049. [CrossRef] [Google Scholar]
164. Luque-García J, De Castro MDL. Ultrasound-assisted Soxhlet extraction: An expeditive approach for solid sample treatment. J. Chromatogr. A. 2004;1034:237-242. doi: 10.1016/j.chroma.2004.02.020. [PubMed] [CrossRef] [Google Scholar]
165. King J. Modern Supercritical Fluid Technology for Food Applications. Annu. Rev. Food Sci. Technol. 2014;5:215-238. doi: 10.1146/annurev-food-030713-092447. [PubMed] [CrossRef] [Google Scholar]
166. Yin JZ, Wang A, Wei W, Liu Y, Shi WH. Analysis of the operation conditions for supercritical fluid extraction of seed oil. Sep. Purif. Technol. 2005;43:163-167. doi: 10.1016/j.seppur.2004.10.016. [CrossRef] [Google Scholar]
167. Herrero M, Mendiola JA, Cifuentes A, Ibáñez E. Supercritical fluid extraction: Recent advances and applications. J Chromatogr. A. 2010;1217:2495-2511. doi: 10.1016/j.chroma.2009.12.019. [PubMed] [CrossRef] [Google Scholar]
168. Mahesh RSG, Srinivasan MP, Meera M. Environmental impact assessment of extraction of oil from mango seed kernel using different solvents. Journal of Cleaner Production. 2015;87:51-58. doi: 10.1016/j.jclepro.2014.09.075.
169. Zhang L, Xie Y, Li Q, Chen H. Solvent emissions and their impacts on water quality during Soxhlet extraction of poly- and perfluoroalkyl substances (PFASs) from environmental samples. Environmental Science & Technology. 2017;51(6):3225-3232. doi: 10.1021/acs.est.6b05455.
170. Mokni Ghribi A, Sila A, Makhlouf I, Cheikhrouhou S, Bougatef A. Chemical composition and profile characterisation of date seeds (*Phoenix dactylifera* L.) cultivated in Tunisia. Food Chemistry. 2016;194:608-615. doi: 10.1016/j.foodchem.2015.08.106.
171. Al-Marzooqi AH, Al-Khanbashi AA, Al-Belushi RH, *et al*., Optimization of oil extraction from six date palm (*Phoenix dactylifera* L.) seeds using soxhlet extraction. Journal of the American Oil Chemists' Society. 2017;94(3):427-437. doi: 10.1007/s11746-016-2971-6.
172. Al-Farsi M, Al-Amri A, Al-Hadhrami A, *et al*., Compositional and functional characteristics of dates, syrups, and their by-products. Food Chemistry. 2006;104(3):943-947. doi: 10.1016/j.foodchem.2006.12.020.
173. Al-Farsi S, Lee CY, Alasalvar C. Optimization of extraction conditions for date seed oil using response surface methodology. Food Chemistry. 2019;279:126-134. doi: 10.1016/j.foodchem.2018.12.007.
174. Alamri AM, Nasser RA, Sughir AH, Alharbi RS, *et al*., A comparative study of the physicochemical properties of oils extracted from coconut (Cocos nucifera), palm (Elaeis guineensis) and date (*Phoenix dactylifera*) seeds. Plants. 2021;10(1):119. doi: 10.3390/plants10010119.
175. Hossein Ahangari, Jerry King W, Ali Ehsani, Mohammad Yousefi, *et al*., Supercritical Fluid Extraction of Oil from Seeds: A Review. Journal of the American Oil Chemists' Society. 2021;98(1):11-31. doi: 10.1002/aocs.12482.
176. Hammani H, Taky M, Moussaoui Y, Bellenger V, Benguedach A, El Hamri R. Synthesis of date seed-derived activated carbon catalysts for hydroquinone; c2019.

177. Bouaziz MA, Abbes F, Mokni A, Blecker C, Attia H, Besbes S. The addition effect of Tunisian date seed fibers on the quality of chocolate spreads. J. Texture Stud. 2017;48:143-150. doi: 10.1111/jtxs.12225oxidation. Research on Chemical Intermediates, 45(2), 901-917. doi: 10.1007/s11164-018-3684-2.
178. Tamayo J, Vargas C, Zapata C, Avilan R, Delgado G, Rodríguez S. Effect of the essential oil of mint (*Mentha piperita*) on the hair growth of mice. Revista de la Facultad de Medicina. 2002;50(4):168-171.
179. Ines D, Rym A, Saâd B, Naceur EB, Mohamed B. Protective effect of date palm fruit extract (*Phoenix dactylifera* L.) on UVB-induced skin photoaging in rats. Annals of the New York Academy of Sciences. 2010;1190(1):357-359.
180. Lecheb A, Benamara S, Belarbi M. Formulation and evaluation of a cream containing date seed oil and aqueous date seed extract. Journal of Medicinal Plants Research. 2015;9(1):1-9.
181. Abdul Afiq MJ, Chien ST, Tham CL, Yee WX, Zaidan UH, Abas F, *et al*., Consumer awareness, perceptions and attitudes towards natural products in Malaysia. International Food Research Journal. 2013;20(3):1275-1281.
182. Qadir A, Nabi G, Mumtaz MW, Rashid U. Date Seed Oil: Extraction, Chemical Composition, and Potential Applications. Journal of the American Oil Chemists' Society. 2018;95(6):707-716.
183. Rahman M, Kasapis S, Al-Kharusi N, Al-Marhubi I, Khan A. Composition characterisation and thermal transition of date pits powders. J Food Eng. 2007;80:1-10. doi: 10.1016/j.jfoodeng.2006.04.030
184. Fikry M, Yusof YA, Al-Awaadh AM, Rahman RA, Chin NL, Mousa E, *et al*., Effect of the roasting conditions on the physicochemical, quality and sensory attributes of coffee-like powder and brew from defatted palm date seeds. Foods. 2019;8:61. doi: 10.3390/foods8020061
185. Sayas-Barberá E, Martín-Sánchez AM, Cherif S, Ben-Abda J, Pérez-Álvarez JÁ. Effect of date (*Phoenix dactylifera* L.) pits on the shelf life of beef burgers. Foods. 2020;9:102. doi: 10.3390/foods9010102
186. Ursachi CŞ, Perţa-Crişan S, Munteanu FD. Strategies to improve meat products' quality. Foods. 2020;9:1883. doi: 10.3390/foods9121883
187. Samea RRA, Zidan NS. Nutritional and sensory evaluation of biscuit prepared using palm date kernels and olive seeds powders. J Specific Educ. Technol. 2019;14:322-339. Available online at: https://maat.journals.ekb.eg/article_98610_707593658a375f73e04ce8ad5bf9af2f.pdf
188. Bouaziz F, Ben Abdeddayem A, Koubaa M, Ellouz Ghorbel R, Ellouz Chaabouni S. Date seeds as a natural source of dietary fibers to improve texture and sensory properties of wheat bread. Foods. 2020;9:737. doi: 10.3390/foods9060737
189. Bouaziz MA, Amara WB, Attia H, Blecker C, Besbes S. Effect of the addition of defatted date seeds on wheat dough performance and bread quality. J Texture Stud. 2010;41:511-531. doi: 10.1111/j.1745-4603.2010.00239.x
190. Bouaziz MA, Bchir B, Ben Salah T, Mokni A, Ben Hlima H, Smaoui S, *et al*., Use of endemic date palm (*Phoenix dactylifera* L.) seeds as an insoluble dietary fiber: effect on turkey meat quality. J. Food Qual. 2020, 8889272. doi: 10.1155/2020/8889272
191. Abushal SA, Elhendy HA, Abd EL Maged EM, Darwish AM. Impact of ground Ajwa (*Phoenix dactylifera* L.) seeds fortification on physical and nutritional properties of functional cookies and chocolate sauce. Cereal Chem. 2021, 10437. doi: 10.1002/cche.10437
192. Al-Amri MS, Mohamed A, Hussain S, Al-Ruquie I. Behri dates pits-enriched bread: effect on dough rheology, bread quality, and shelf life. Italian J. Food Sci. 2014a;26:1-11.
193. Al-Saggaf MS, Moussa SH, Tayel AA. Application of fungal chitosan incorporated with pomegranate peel extract as edible coating for microbiological, chemical and sensorial quality enhancement of Nile tilapia fillets. Int. J Biol. Macromol. 2017;99:499-505. doi: 10.1016/j.ijbiomac.2017.03.017
194. Mrabet A, Jimenez-Araujo A, Guillen-Bejarano R, Rodríguez-Arcos R, Sindic M. Date seeds: a promising source of oil with functional properties. Foods. 2020;9:787. doi: 10.3390/foods9060787
195. Iñiguez-Moreno M, Ragazzo-sánchez JA, Calderón-Santoyo M. An extensive review of natural polymers used as coatings for postharvest shelf-life extension: trends and challenges. Polymers. 2021;13:3271. doi: 10.3390/polym13193271
196. Sawaya WN, El-Atrash KR, Khalil JK. Date seeds as a potential feedstock for livestock. In Proceedings of the third symposium on the date palm. Food and Agriculture Organization of the United Nations; c1984. p. 245-250.
197. Suresh V, Bhat R, Hegde G. Physicochemical and phytochemical properties of oils from Omani date seeds. Journal of Food Science and Technology. 2013;50(1):99-105. DOI: 10.1007/s13197-011-0576-0
198. Babu SV, Veeresh B. Potential health benefits of minor lipids and phytosterols present in oils. International Journal of Food Properties. 2009;12(4):727-736. DOI: 10.1080/10942910802096182