Chapter 3
Nutritional and Therapeutic Applications of Date Palm

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Abstract Date palm (*Phoenix dactylifera* L. Arecaceae family) is an ancient crop of Southwest Asia, widely known for its nutritional and therapeutic values. Date fruits are rich in carbohydrates, dietary fibres, proteins, minerals, vitamins etc. The therapeutic potential of date fruit is well documented in Ayurveda (Indian traditional medicine) and Middle Eastern folklore. Date fruits are highly nourishing and possess immense health benefits, which is highly attributed to the presence of phytochemicals viz., polyphenols, flavonoids, anthocyanins etc. This chapter speaks about the nutritional and pharmacological effects of date fruit. Date fruit is a real gift to mankind, because it's a unique combination of a natural product being tastier, inexpensive encompassing high nutritional and medicinal properties.

Keywords Date palm · *Phoenix dactylifera* · Fruit · Nutritional · Antioxidant · Anti-inflammation · Anticancer · Antimicrobial · Neuroprotection · Hepatoprotection

3.1 Introduction

Date palm (*Phoenix dactylifera* L.) is one of the most important tree species in the oasis areas of Northern Africa and Middle East countries. Date palm trees play a major role in creating favourable conditions in the oasis areas, to protect it from

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desertification. Date palm is one of the oldest plants in the World, which is cultivated by mankind throughout the world (Ghnimi et al. 2017). They were widely cultivated in many places of Asia, Africa, Arabian countries, and in Middle East. Similarly, date palm also being cultivated in places like Palestine from several million years ago where they do extensive farming in the regions of Jericho, Jordan Valley and Gaza strip. It is also considered to be rich in nutrition, therapeutic, socio-economic tree with all the environmental attributes that makes it to grow in all kinds of climatic conditions (Goor 1967).

Date palm belongs to Arecaceae family (Angiosperms, Monocotyledon), which consists of about 200 genera and more than 2500 species. The genera Phoenix consists of about 14 species, including *Phoenix dactylifera* L. The name dactylifera translates to "finger-bearing" which represents the fruit clusters produced by this plant (Ashraf and Hamidi-Esfahani 2011). The genome of date palm was re-sequenced to yield insights into the diversification of a fruit tree crop (Hazzouri et al. 2015). Regular consumption of dates protects the liver and helps to reduce the level of alkaline phosphatase. Previous reports have stated that consuming date fruits would help people in safeguarding against cardiovascular disease (CVD), which is the major cause of mortality worldwide. Date fruits help to reduce the blood pressure, cholesterol level and lipid oxidation. However, all the understanding behind this mechanistic observation is still unknown.

3.2 Nutritional Value of Date Palm

Depending on the cultivation, soil and environmental conditions the chemical composition of date palm varies with its ripening stage. During its ripening phase, it starts to lose its moisture content by undergoing a conversion of glucose to fructose. Amongst the various components found in date palm, carbohydrates play a major role for about 78% in particular sugars, and also supplies a high energy source to the human body (Makki et al. 1998). Further, the content of carbohydrate in date palm varies from 50 to 90 g/100 g. Several authors have reported that at the early stage, date palm consists of a small amount of fructose and glucose (Tang et al. 2013).

Further, the region of production and its variety can considerably affect the glucose and total sugar content found in date palm fruit (Ahmed et al. 1995; Ismail et al. 2006; Ali et al. 2009). During the digestion process of the date fruit, the glucose and fructose get readily absorbed which leads to an instant elevation in blood sugar levels. (Liu et al. 2000). Almost 50% of the sugars in date fruit is present in the form of fructose which double the amount of glucose which induces a feeling of satiety.

Date palm fruits are rich in dietary fibre source which further depends on the stage of the ripening process (Al-Shahib and Marshall 2003). These date palm consists of both soluble and insoluble fibres viz., cellulose, pectin, lignin etc. At the ripening stage of the fruit, the enzymes slowly break down into few soluble components by rendering the date palm softer and tender (Fennema 1996). Pectin is considered as

the most important fibre in date palm which gets accumulated during the initial stage of fruit growth. The dietary fibre found in date palm fruit further donates to their main nutritional value, as they are used in fibre-based food preparation and dietary supplements. An average amount of 100 g of daily intake of date palm fruit can meet the recommended dietary allowance of about 32% for dietary fibre (Marlett et al. 2002). The excess amount of insoluble fibre can lead to satiety and due to increased stool weight, it produces a laxative effect. These dietary fibres found in date palm fruit reveals many therapeutic effects viz., it lowers the blood cholesterol levels and it is also shown to lower the risk of several other diseases like hypertension, diabetes, bowel cancer and cardiovascular diseases (Marlett et al. 2002; Cummings et al. 1992).

These date palm fruit also consists of proteins and lipids in the range of 1–3% of its total composition. During the ripening process, the proteins found in date palm fruit play a prominent role in non-oxidative browning and precipitation of tannins (Barreveld 1993). Many essential amino acids are also found in the date fruits which are favourable for the human needs. Further, the date seeds are also a rich source of dietary fibre, phenolics and antioxidants (Almana and Mahmoud 1994; Hussein et al. 1998).

Date palm fruit comprises a wide range of both saturated and unsaturated fatty acids viz., capric, lauric, myristic, palmitic, stearic, oleic, linoleic and linolenic acids. In addition, date palm fruit comprises of a wide range of vitamins and minerals like selenium, copper, potassium, magnesium, iron, phosphorus and calcium. The high content of potassium and low sodium concentration found in date palm is beneficial for persons suffering from hypertension. On the other hand, boron and vitamins significantly aid in rheumatism and in the treatment of brain cancer. Date fruits act as natural supplements for iron deficiency without causing any adverse effects (Tang et al. 2013).

In addition to these compositions, date palm fruit also contain various phytochemicals like carotenoids, phenolics, glycosides and flavanols (Shahidi and Naczk 2004; Al-Farsi et al. 2005; Biglari et al. 2008). These carotenoids and phenolics found in date palm provide antioxidant and antimutagenic activity. It is further reported that most of the antioxidants found in date palm fruit is hydrophilic in nature. Further, date palm fruits not only act as good source of natural antioxidants, but also, they help in improving the products flavor and color due to their high content in active phenolics (Mansouri et al. 2005; Vayalil 2002; Biglari et al. 2008; Vinson et al. 2005). In particular, date palm fruit is considered as a moderate source of carotenoids compared with other dried fruits. Although all carotenoids in general do not act as provitamin A, date palm contributes to the human requirement of vitamin A (Hart and Scott 1995; Boudries et al. 2007). In addition, date palm fruit is found to have high medicinal properties.

3.3 Therapeutic Applications of Date Palm

The therapeutic applications of date palm are well recognized in Middle Eastern folklore and Indian traditional Medicine. The Holy Book "*Al-Qur'an* also mentions the nutritional significance and health benefits of dates. Date fruits decoction along with salt is given as a remedy for dehydration associated with diarrhoea in the Middle East (Al-Qarawi et al. 2005). Consumption of date fruits, particularly in the morning on an empty stomach helps to overcome the adverse effects of toxic material that the subject has been exposed to. Date palm is well recognized in Ayurveda (Indian Traditional Medicine) for its various therapeutic values viz., lower respiratory tract infections, sciatica, oedema, microbial infections, alcohol intoxication etc. (Nadkarni, 1976). Date fruits are high energy foods; with its potent antioxidant and antimutagenic activities it is found to provide strength, fitness and it is used as a cure against number of ailments and diseases including fever, stomach disorders, memory disturbances, nervous disorders, cancer, cardiovascular disorders and also proved to boost the immunity (Vayalil 2002; Allaith 2008).

3.3.1 Antioxidant Activity

Bouhlali et al. (2017a) examined different varieties of date palm and have reported that they possess antioxidant activity which strongly correlated with the polyphenol and flavonoid content. Vinson et al. (2005) report that date fruits contain the highest concentration of polyphenols among the dried fruits. This characteristic feature could be attributed to their greater exposure to sunlight and extreme temperature. Antioxidants are nature's defence which act against the reactive oxygen species (ROS), which play a significant role in many diseases. Antioxidants neutralise the free radicals, making them harmless to other cells. In most cases, the production of endogenous antioxidants is insufficient to meet out the needs, wherein exogenous supplementation would help to protect the body from the deleterious effects of ROS. Antioxidants viz., polyphenols, carotenoids, tannins etc., present in date fruits confer them with potent free radical scavenging property and antioxidant potential. Also, date fruits enhance the activity of antioxidant enzymes viz., superoxide dismutase and catalase (Ceballos- Picot et al. 1996; Al-Farsi and Lee 2008). Thouri et al. (2017) reports that date seeds also possess antioxidant potential and it could also be used as a cheap source of natural antioxidant.

3.3.2 Anti-Inflammatory Activity

Taleb et al. (2016) further reported that the anti-inflammatory activity of date is strongly linked to its secondary metabolites and anti-oxidant nature. Free radicals

play a key role in the upregulation of inflammatory response. Secondary metabolites viz., phenolics and flavonoids act as suppressor of NF-KB and function as anti-inflammatory agents. Hence, the anti-inflammatory effect of dates could be attributed to the presence of polyphenol (viz., gallic acid, ferullic acid, cafferic acid etc) and flavonoids (rutin, quercetin, luteolin etc). The difference in anti-inflammatory activities of different date varieties largely depend on the variations in their phenolic and flavonoid content (Bouhlali et al. 2017b). Zhang et al. (2013) analysed the various extracts of ajwa date fruit and confirm that the bioactive compounds present in them possess strong antioxidant and anti-inflammatory properties. The compounds inhibited cyclooxygenase enzymes viz., Cox-1 and Cox-2, the important mediators of inflammation. Al-Okbi and Mohammed (2012) investigated the effects of methanolic and water extracts of date fruit in adjuvant induced arthritis in rats, a model of chronic inflammation. They infer that the extracts were able to significantly reduce the foot swelling, despite normalizing the plasma levels of antioxidants. Algerin date fruit extract was able to decrease the edema size, levels of homocysteine and C-reactive protein in formalin – induced edema test in rats (Kehili et al. 2016).

3.3.3 Anticancer Activity

Presence of polyphenols, flavonoids, folic acid etc., are one of the significant advantages of date fruits. Consumption of dates builds up immunity and cancer protection. Khan et al. (2017) investigated the effect of ajwa date fruit extract on rat model of hepatocellular carcinoma and proved that date fruit extracts were able to reverse the liver to normal conditions by restoring the antioxidant enzymes, liver enzymes, cytokine balance etc. Ishrud and John (2005) provide evidence in mice regarding the anticancer activity of date fruits. Lybian date fruit extract possessed the ability to hinder the growth of sarcoma in female mice. The results of Al-Sayyed et al. (2014) state that date fruits provide potent protection against DMBA-induced mammary cancer in rat. Date fruit exerted their effects at various stages viz., initiation, promotion and progression stages of carcinogenesis. Regular intake of date fruits could improve the health of the colon by inhibiting the proliferation of colon cancer cells and also it enhances the growth of beneficial bacterial cells. Digested date extract and polyphenol extract strongly inhibited the growth of human epithelial colorectal adenocarcinoma cells (Caco-2) (Eid et al. 2014). This anticancer property of date fruit is due to the presence of phenolics and flavonoids which play a major role in up-regulation of apoptotic molecules such as p53, caspases and Bax or they act by downregulating the anti-apoptotic molecules viz., Akt, Bcl-2, nuclear factor κB (NFκB) etc. (Ishrud and John, 2005).

3.3.4 Neuroprotective Activity

Date palm fruits are an excellent source of dietary fibre, rich in total phenolics and natural antioxidants, such as anthocyanins, ferulic acid, protocatechuic acid and caffeic acid. Presence of these polyphenolic compounds, bestows it with neuroprotective action. Dietary supplementation of date fruits lowers the risk and progression of Alzheimer's disease (Subash et al. 2015). Dehghanin et al. (2017) analysed the effects of date seed extract in rat model of Alzheimer's disease and reported that DSE significantly restored memory and learning impairments. It significantly reduced the caspase-3 expression level and the number of degenerated neurons. Date extract offered potential neuroprotection against cerebral ischemia induced by bilateral common carotid artery occlusion in rats (Pujari et al. 2011). In Ayurveda date palm is known as *Kharjura* and is recommended for the treatment of psychosis, anxiety, cognitive dysfunction and nervous system disorders (Shanmugapriya and Patwardhan 2012). Date fruits exhibited profound cerebroprotective activity against cerebral ischemia in mice (Kalantaripour et al. 2012). Presence of sterols, ascorbic acid and flavonoids are attributed for this effect. Sheikh et al. (2016) investigated the neuropharmacological and analgesic properties of date fruit in rats and reported that the presence of polyphenols viz., catechin, epicatechin and trans-ferulic acid could be attributed to the above effect.

3.3.5 Nephroprotective Activity

Al-Qarawi et al. (2008) reviewed the effects of extract of date flesh and pits and reported that they were able to significantly reduce the plasma creatinine and urea concentration in gentamicin induced nephrotoxicity in rats. Also, they ameliorated the proximal tubular damage. Presence of versatile antioxidants viz., melatonin, tocopherols and vitamin C could be the factors behind nephroprotection.

3.3.6 Hepatoprotective Activity

The hepatoprotective effect of date extracts were proved by El Arem et al. (2014) in experimental rats. The results of the study conclude that the date extract could significantly protect the liver, by lowering the levels of hepatic marker enzymes (viz., aspartate transaminase, lactate dehydrogenase, alanine transaminase, gamma glutamyl transferase), hepatic thiobarbituric acid reactive substances (TBARS) and by enhancing the activities of antioxidants (superoxide dismutase, catalase etc). The studies of Saafi et al. (2011) also coincide with the above findings, wherein date fruit extracts serve a hepatoprotective action against dimethoate induced oxidative stress in liver. Date fruits were also able to reverse the effects of carbon tetrachloride

induced liver damage in experimental rat (Attia et al. 2016). The antioxidant, antiapoptotic and antifibrotic activities of date extract are primarily responsible for this hepatic protection (Elsadek et al. 2017).

3.3.7 Anti-Diabetic Activity

Date seeds also possess high nutrients, high energy values and good fatty acids. Hasan and Mohieldien (2016) studied the effect of date seed extract on streptozotocin induced diabetic rats. Date seed extract restored kidney and liver function and balanced the oxidative stress in diabetic experimental animals. The study clearly states the antidiabetic property of date seed extracts. Micheal et al. (2013) investigated the effects of diosmetin glycoside (isolated from the epicarp of date fruit), in alloxan induced diabetic experimental animals. The results showed that there was a marked improvement in the serum glucose level, liver function, antioxidant enzymes with a significant reduction in cholesterol and triglycerides. Date fruits could induce antidiabetic action by enhancing the output of insulin and by inhibiting the absorption of glucose. Flavonoids, steroids, phenols and saponins present in dates could be responsible for the above action. Phenolics present in dates are potent inhibitors of alpha glycosidase and alpha amylase, which leads to the reduction of carbohydrates digestion and absorption that may counteract the hyperglycemic condition (Ranilla et al. 2008). A study done by Miller et al. (2003) in healthy volunteers revealed that consumption of dates either alone or in mixed meals with plain yoghurt have a low glycaemic index. Intake of date fruit by diabetic patients helps to control their glycemic index and lipid profile.

3.3.8 Anti-Microbial Property

Samad et al. (2016) infer that date/date extracts could be widely used in the nutraceutical and pharmaceutical industries owing to their antibacterial and antioxidant properties. Methanolic extract of ajwa datefruit exhibited antibacterial activity against *Staphylococcus aureus, Bacillus cereus, Serratia marcescens* and *Escherichia coli.* Aqueous extract of date palm seeds and pollen possess antifungal activity against *Fusarium oxysporum* (Bentrad et al. 2017a). Presence of polyphenols in date extracts is responsible for their antifungal activity (Boulenouar et al. 2011), while presence of fatty acids viz., palmitic, stearic, oleic, linoleic acid etc. confer date fruits with their antibacterial property (Bentrad et al. 2017b). Date extracts from Tunisian cultivars possessed antimicrobial activity against both gram positive and gram negative bacteria; especially a profound activity was present against *E.coli* (Kchaou et al. 2016).

3.3.9 Effect on Infertility Issues in Male

El Arem et al. (2017) reported that date extracts offered protection over dichloroacetic acid induced oxidative damage in testes of male rats. This observed therapeutic potency of ADE might be due to several contributing factors, mainly due to the mineral (zinc, selenium, copper, iron, calcium, cobalt, magnesium, manganese) and vitamin (A, B, C) composition of these fruits (Baliga et al. 2011). Presence of polyphenolic compounds viz., flavonoids which are highly effective against ROS-mediated injury, also contribute towards protection of testicles (Garcia and Castillo 2008). Presence of quercetin, an essential bioflavonoid in date extracts is also one of important component responsible for the testicular protective effect. Quercetin prevents the formation of free radicals in cells and inhibits lipid peroxidation. Arsenic induced testicular damage in rats was significantly prevented by the antioxidant and antiapoptotic properties of quercetin (Baltaci et al. 2016). Microelements found in date palm pollen extract viz., estrone, sterols and other agents have a positive effect on male fertility. Also, date palm pollen extract suspension augments the plasma levels of estradiol and testosterone (Bahmanpour et al. 2006; Mahran et al. 1976).

3.3.10 Effect on Labour and Lactation in Female

Zangeneh et al. (2009) report that consumption of date fruits in late pregnancy accelerates labour and it increases the pain threshold level. Presence of fatty acids in date fruits aids in saving energy and strengthening uterus muscles. Al Kuran et al. (2011) report that date fruits influence oxytocin receptors, stimulates the uterine muscles to respond more comfortably to oxytocins, and better prepares the uterus and cervix for delivery. The study concludes that consumption of date fruits in that last 4 weeks of pregnancy reduces the need for induction, augments labour and produces a favourable delivery outcome. Khadem et al. (2007) further added that date fruits have the potential to reduce postpartum haemorrhage. Kordi et al. (2014) report that cervical dilation was higher in women consuming date fruit. Hence consumption of date fruit is recommended for pregnant women, especially in the last week of gestation. The labour intervention was also reduced by date fruits without adversely affecting the mother and infant (Razali et al. 2017). The presence of potassium, glycine and threonine in date fruits are thought to activate the production of prolactin. Date fruits are also recommended as galactogogue in feeding mothers, due to the presence of oxytocin (Tang et al. 2013).

3.3.11 Anti-Hemolytic Activity

Bacterial toxin of Streptolysin O (SLO) is generated by *Streptococcus pyogenes*, which causes the hemolysis of erythrocytes. Abuharfeil et al. (1999) report that the date fruit extract was able to neutralise the hemolytic activity of SLO at low concentrations. Date fruit extract even has the ability to inhibit the hemolytic activity of snake and scorpion venoms (Sallal et al. 1997). Bouhlali et al. (2016) infer that date fruit extract exhibited considerable anti-hemolytic activity in rabbit blood induced with AAPH (free radical generator), which positively correlated with the polyphenols and flavonoid content. Flavonoids and other polyphenols enhance the erythrocyte membrane stability, while the antioxidants scavenge the lipid peroxyl radicals generated by AAPH.

3.3.12 Other Medical Benefits

Dates decoction is used as an eye-lotion as it helps in the maintenance of eye hygiene and a remedy for ophthalmic disorders (Tang et al. 2013). Due to the rich phenolic content date fruits are considered as a cleansing agent and astringent in intestinal troubles. The aqueous extracts of dates have been shown to have antidiarrheal effects in rats (Al-Taher 2008).

3.4 Conclusion

The date is an ideal fruit with a delicious sweet taste. It is rich in nutrients viz., carbohydrates, vitamins, minerals etc. It is an excellent source of fibre and contains many potent phytochemicals such as polyphenols, flavonoids, anthocyanins, carotenoids etc. The various properties of date fruits especially antioxidant, anticancer, anti-inflammatory, neuroprotection, hepatoprotection etc., could be attributed to the presence of these phytochemicals. Consumption of date fruits on a regular basis offers potential health benefits viz., strength, fitness, immunity etc. Though, the chapter summarizes the nutritional and therapeutic applications of date palm, a thorough investigation of the molecular mechanisms involved is yet to be defined. Unravelling such paths will throw more light on this Middle East fruit, thereby paving the way for its addition in nutraceuticals and pharmaceutical supplements.

References

AAl-Sayyed HF, Takruri HR, Shomaf MS (2014) The effect of date palm fruit (*Phoenix dactylifera* L.) on the hormone 17-β-estradiol in 7,12-dimethylbenz (α) anthracene induced mammary cancer in rats. Med J Nutrition Metab 7(1):5–10. https://doi.org/10.3233/MNM-140001

Abuharfeil NM, El Sukhon S, Msameh Y, Sallal AJ (1999) Effect of Date Fruits, *Phoenix Dactyliferia L.*, on the Hemolytic Activity of Streptolysin O. Pharm Biol 37(5):335–339. https://doi.org/10.1076/phbi.37.5.335.6051

Ahmed IA, Ahemed AWK, Robinson RK (1995) Chemical composition of date varieties as influenced by the stage of ripening. Food Chem 54:305–309. https://doi.org/10.1016/0308-8146(95)00051-J

Al-Farsi MA, Lee CY (2008) Nutritional and functional properties of dates: a review. Crit Rev Food Sci Nutr 48:877–887. https://doi.org/10.1080/10408390701724264

Al-Farsi M, Alasalvar C, Morris A, Baron M, Shahidi F (2005) Compositional and sensory characteristics of three native sundried date (*Phoenix dactylifera* L.) varieties grown in Oman. J Agric Food Chem 53:7586–7591. https://doi.org/10.1021/jf050578y

Ali A, Al-Kindi YS, Al-Said F (2009) Chemical composition and glycemic index of three varieties of Omani dates. Int J Food Sci Nutr 60(S4):51–62. https://doi.org/10.1080/09637480802389094

Al-Kuran O, Al-Mehaisen L, Bawadi H, Beitawi S, Amarin Z (2011) The effect of late pregnancy consumption of date fruit on labour and delivery. J Obstet Gynaecol 31:29–31. https://doi.org/10.3109/01443615.2010.522267

Allaith AAA (2008) Antioxidant activity of Bahreini date palm (*Phoenix dactylifera*) fruit of various cultivars. Int J Food Sci Tech 43:1033–1040. https://doi.org/10.1111/j.1365-2621.2007.01558.x

Almana HA, Mahmoud RM (1994) Date-palm seeds as an alternative source of dietary fibre in Saudi bread. Ecol Food Nutr 32:261–270. https://doi.org/10.1080/03670244.1994.9991406

Al-Okbi SY, Mohamed DA (2012) Preparation and evaluation of functional foods in adjuvant arthritis. Grasas Aceites 63:394–402. https://doi.org/10.3989/gya.130811

Al-Qarawi AA, Abdel-Rahman H, Ali BH, Mousa HM, El-Mougy SA (2005) The ameliorative effect of dates (*Phoenix dactylifera L.*) on ethanol induced gastric ulcer in rats. J Ethnopharmacol 98:313–317. https://doi.org/10.1016/j.jep.2005.01.023

Al-Qarawi AA, Abdel-Rahman H, Mousa HM, Ali BH, El-Mougy SA (2008) Nephroprotective action of Phoenix dactylifera. In gentamicin-induced nephrotoxicity. Pharm Biol 46 (4):227–230. https://doi.org/10.1080/13880200701739322

Al-Shahib W, Marshall RJ (2003) The fruit of date palm: it's possible uses as best food for the future. Int J Food Sci Nutr 54(4):247–259. https://doi.org/10.1080/09637480120091982

Al-Taher AY (2008) Possible antidiarrheal effect of date-palm (*Phoenix dactylifera* L.) aqueous extracts in rats. Scientific Journal of King Faisal University (Basic and Applied Sciences) 9:1429–1435

Ashraf Z, Hamidi-Esfahani Z (2011) Date and Date Processing: A Review. Food Rev Int 27 (2):101–133. https://doi.org/10.1080/87559129.2010.535231

Attia H, Al-Rasheed N, Mohamad R, Al-Rasheed N, Al-Amin M (2016) The antifibrotic and fibrolytic properties of date fruit extract via modulation of genotoxicity, tissue-inhibitor of metalloproteinases and nuclear factor- kappa B pathway in a rat model of hepatotoxicity. BMC Complement Altern Med 16(1):414. https://doi.org/10.1186/s12906-016-1388-2

Bahmanpour S, Talaei T, Vojdani Z, Panjehshahin MR, Poostpasand A, Zareei S, Ghaeminia M (2006) Therapeutic effect of *Phoenix dactylifera* pollen on sperm parameters and reproductive system of adult male rats. Iran J Med Sci 31:8–12. http://ijms.sums.ac.ir/index. php/IJMS/article/view/2180/666

Baliga MS, Baliga BRV, Kandathil SM, Bhat HP, Vayalil PK (2011) A review of the chemistry and pharmacology of the date fruits (*Phoenix dactylifera* L.). Food Res Int 44:1812–1822. https://doi.org/10.1016/j.foodres.2010.07.004

Baltaci BB, Uygur R, Caglar V, Aktas C, Aydin M, Ozen OA (2016) Protective effects of quercetin against arsenic-induced testicular damage in rats. Andrologia 48(10):1202–1213. https://doi.org/10.1111/and.12561

Barreveld WH (1993). Date-Palm Products. Bulletin No 101. Food and Agriculture Organization of the United Nations, Rome. http://www.fao.org/docrep/t0681e/t0681e 00.htm

Bentrad N, Gaceb-Terrak R, Benmalek Y, Rahmania F (2017a) Studies on chemical composition and antimicrobial activities of bioactive molecules from date palm (*phoenix dactylifera* L.) Pollens and seeds. Afr J Tradit Complement Altern Med 4(3):242–256. https://doi.org/10.21010/ajtcam.v14i3.26

Bentrad N, Gaceb-Terrak R, Rahmania F (2017b) Identification and evaluation of antibacterial agents present in lipophilic fractions isolated from sub-products of Phoenix dactilyfera. Nat Prod Res 31(21):2544–2548. https://doi.org/10.1080/14786419.2017.1314282

Biglari F, Abbas FM, Alkarkhi FM, Azahar ME (2008) Antioxidant activity and phenolic content of various date palm (*Phoenix dactylifera*) fruits from Iran. Food Chem 107:1636–1641. https://doi.org/10.1016/j.foodchem.2007.10.033

Boudries H, Kefalas P, Hornero-Mendez D (2007) Carotenoid composition of Algerian date varieties (*Phoenix dactylifera*) at different edible maturation stages. Food Chem 101:1372–1377. https://doi.org/10.1016/j.foodchem.2006.03.043

Bouhlali ET, Bammou M, Sellam K, Benlyas M, Alem C, Filali-Zegzouti Y (2016) Evaluation of antioxidant, antihemolytic and antibacterial potential of six Moroccan date fruit (*Phoenix dactylifera* L.) varieties. J King Saud Univ Sci 28(2):136–142. https://doi.org/10.1016/j.jksus.2016.01.002

Bouhlali ET, Ramchoun M, Alem C, Ghafoor K, Ennassir J, Zegzouti YF (2017a) Functional composition and antioxidant activities of eight Moroccan date fruit varieties (*Phoenix dactylifera* L.). J Saudi Soc Agric Sci 16(3):257–264. https://doi.org/10.1016/j.jssas.2015.08.005

Bouhlali ET, El Hilaly J, Ennassir J, Benlyas M, Alem C, Amarouch M-Y, Filali-Zegzouti Y (2017b) Anti-inflammatory properties and phenolic profile of six Moroccan date fruit (*Phoenix dactylifera* L.) varieties. J King Saud Univ Sci 30(4):519–526. https://doi.org/10.1016/j.jksus.2017.08.011

Boulenouar N, Marouf A, Cheriti A (2011) Antifungal activity and phytochemical screening of extracts from *Phoenix dactylifera* L. cultivars. Nat Prod Res 25(20):1999–2002. https://doi.org/10.1080/14786419.2010.536765

Ceballos-Picot I, Witko-Sarsat V, Merad-Boudia M, Nguyen AT, Thévenin M, Jaudon MC, Zingraff J, Verger C, Jingers P, Latscha BD (1996) Glutathione antioxidant system as a marker of oxidative stress in chronic renal failure. Free Radic Biol Med 21:845–853. https://doi.org/10.1016/0891-5849(96)00233-X

Cummings JH, Bingham S, Heaton KW, Eastwood MA (1992) Fecal weight, colon cancer risk, and dietary intake of non-starch polysaccharides (dietary fibre). Gastroenterology 103:1783–1789. https://www.gastrojournal.org/article/0016-5085(92)91435-7/abstract

Dehghanian F, Kalantaripour TP, Esmaeilpour K, Elyasi L, Oloumi H, Pour FM, Asadi-Shekaari M (2017) Date seed extract ameliorates β-amyloid-induced impairments in hippocampus of male rats. Biomed Pharmacother 89:221–226. https://doi.org/10.1016/j.biopha.2017.02.037

Eid N, Enani S, Walton G, Corona G, Costabile A, Gibson G, Rowland I, Spencer JP (2014) The impact of date palm fruits and their component polyphenols, on gut microbial ecology, bacterial metabolites and colon cancer cell proliferation. J Nutr Sci 3:e46. https://doi.org/10.1017/jns.2014.16

El Arem A, Ghrairi F, Lahouar L, Thouri A, Behija Saafi E, Ayed A, Zekri M, Ferjani H, Haouas Z, Zakhama A, Achour L (2014) Hepatoprotective activity of date fruit extracts against dichloroacetic acid-induced liver damage in rats. J Funct Foods 9:119–130. https://doi.org/10.1016/j.jff.2014.04.018

El Arem A, Lahouar L, Saafi EB, Thouri A, Ghrairi F, Houas Z, Neffati F, Achour L (2017) Dichloroacetic acid-induced testicular toxicity in male rats and the protective effect of date fruit extract. BMC Pharmacol Toxicol. 18:17. https://doi.org/10.1186/s40360-017-0127-8

Elsadek B, El-Sayed ES, Mansour A, Elazab A (2017) Abrogation of carbon tetrachloride-induced hepatotoxicity in Sprague-Dawley rats by Ajwa date fruit extract through ameliorating oxidative stress and apoptosis. Pak J Pharm Sci 30(6):2183–2191. http://www.pjps.pk/wp-content/uploads/pdfs/30/6/Paper%2017.pdf

Fennema OR (1996) Food Chemistry, 3rd edn. Dekker M, New York, pp 365–339. https://www.zuj.edu.jo/download/food-chemistry-3rd-ed-o-fennema-9ed-marcel-dekker-1996-ww-pdf/

Garcia OB, Castillo J (2008) Update on uses and properties of citrus flavonoids: new findings in anticancer, cardiovascular, and anti-inflammatory activity. J Agric Food Chem 56:6185–6205. https://doi.org/10.1021/jf8006568

Ghnimi S, Umer S, Karim A, Kamal-Eldina A (2017) Date fruit (*Phoenix dactylifera* L.): An underutilized food seeking industrial valorization. NFS Journal 6:1–10. https://doi.org/10.1016/j.nfs.2016.12.001

Goor A (1967) The history of the date through the ages in the holy land. Econ Bot 21(4):320–340. https://doi.org/10.2307/4252895

Hart D, Scott KJ (1995) Development and evaluation of HPLC method for the analysis of carotenoids in fruits, and the measurement of the carotenoid content of vegetables and fruits commonly consumed in UK. Food Chem 54:101–111. https://doi.org/10.1016/0308-8146(95)92669-B

Hasan M, Mohieldein A (2016) In vivo evaluation of anti diabetic, hypolipidemic, anti-oxidative activities of saudi date seed extract on streptozotocin induced diabetic rats. J Clin Diagn Res 10(3):FF06–FF12. https://doi.org/10.7860/JCDR/2016/16879.7419

Hazzouri KM, Flowers JM, Visser HJ, Khierallah HS, Rosas U, Pham GM, Meyer RS, Johansen CK, Fresquez ZA, Masmoudi K, Haider N, El Kadri N, Idaghdour Y, Malek JA, Thirkhill D, Markhand GS, Krueger RR, Zaid A, Purugganan MD (2015) Whole genome re-sequencing of date palms yields insights into diversification of a fruit tree crop. Nat Commun 6:8824. https://doi.org/10.1038/ncomms9824

Hussein AS, Alhadrami GA, Khali YH (1998) The use of dates and date pits in broiler starter and finisher diets. Bioresour Technol 66:219–223. https://doi.org/10.1016/S0960-8524(98)00054-6

Ishruda O John FK (2005) The anticancer activity of polysaccharide prepared from Libyan dates (*Phoenix dactylifera* L.). Carbohydr Polym 59:531–535. https://doi.org/10.1016/j.carbpol.2004.11.004

Ismail B, Haffar I, Baalbaki R, Mechref Y, Henry J (2006) Physico-chemical characteristics and total quality of five date varieties grown in United Arab Emirates. Int Food Sci and Technol 41:919–926. https://doi.org/10.1111/j.1365-2621.2005.01143.x

Kalantaripour T, Asadi-Shekaari M, Basiri M, Najar AG (2012) Cerebroprotective effect of date seed extract (*Phoenix dactylifera*) on focal cerebral ischemia in male rats. J Biol Sci 12:180–185. https://doi.org/10.3923/jbs.2012.180.185

Kchaou W, Abbès F, Mansour RB, Blecker C, Attia H, Besbes S (2016) Phenolic profile, antibacterial and cytotoxic properties of second grade date extract from Tunisian cultivars (*Phoenix dactylifera* L.). Food Chem 194:1048–1055. https://doi.org/10.1016/j.foodchem.2015.08.120

Kehili HE, Zerizer S, Beladjila KA, Kabouche Z (2016) Anti-inflammatory effect of Algerian date fruit (*Phoenix dactylifera*). Food Agric Immunol 27:820–829. https://doi.org/10.1080/09540105.2016.1183597

Khadem N, Sharaphy A, Latifnejad R, Hammod N, Ibrahimzadeh S (2007) Comparing the efficacy of dates and oxytocin in the management of postpartum hemorrhage. Shiraz E-Medical Journal 8(2):64–71. https://cdn.shopify.com/s/files/1/0820/4871/ files/MEDJOULS -_Comparing the Efficacy of Dates and_Oxytocin in_the_Management of_Postpartum Hemorrhage.pdf

Khan F, Khan TJ, Kalamegam G, Pushparaj PN, Chaudhary A, Abuzenadah A, Kumosani T, Barbour E, Al-Qahtani M (2017) Anti-cancer effects of Ajwa dates (Phoenix dactylifera L.) in diethylnitrosamine induced hepatocellular carcinoma in Wistar rats. BMC Complement Altern Med 17:418. https://doi.org/10.1186/s12906-017-1926-6

Kordi M, Aghaei MF, Tara F, Nemati M, Taghi SM (2014) The Effect of Late Pregnancy Consumption of Date Fruit on Cervical Ripening in Nulliparous Women. J Midwifery Womens Health 2(3):150–156. https://doi.org/10.22038/JMRH.2014.2772

Liu S, Willett WC, Stampfer MJ, Hu FB, Franz M, Sampson L, Hennekens CH, Manson JAA (2000) Prospective study of dietary glycemic load, carbohydrate intake and risk of coronary heart diseases in U.S women. Am J Clin Nutr 71:1455–1461. https://doi.org/10.1093/ajcn/71.6.1455

Mahran GH, Abdel-Wahab SM, Attia AM (1976) A phytochemical study of date palm pollen. Planta Med 29:171–175. https://doi.org/10.1055/s-0028-1097648

Makki M, Hamooda A, Al-Abri A (1998) The Date Palm, Culture, Operation and Maintenance. Modern Color Publishers, Muscat. https://www.crcpress.com/Dates-Production-Processing-Food-and-Medicinal-Values/Manickavasagan-Essa-Sukumar/p/book /9781439849453

Mansouri A, Embarek G, Kokkalou E, Kefalas P (2005) Phenolic profile and antioxidant activity of the Algerian ripe date palm fruit (*Phoenix dactylifera*.). Food Chem 89:411–420. https://doi.org/10.1016/j.foodchem.2004.02.051

Marlett JA, Mc Burney MI, Slavin J (2002) Position of the American Diabetic Association: Health implications of dietary fiber. J Agric Food Chem 102:993–1000. https://doi.org/10.1016/j.jada.2008.08.007

Michael HN, Salib JY, Eskander EF (2013) Bioactivity of Diosmetin Glycosides Isolated from the Epicarp of Date Fruits, *Phoenix dactylifera*, on the Biochemical Profile of Alloxan Diabetic Male Rats. Phytother Res 27:699–704. https://doi.org/10.1002/ptr.4777

Miller CJ, Dunn EV, Hashim IB (2003) The glycaemic index of dates and date/yoghurt mixed meals. Are dates 'the candy that grows on trees'? Eur J Clin Nut 57:427–430. https://doi.org/10.1038/sj.ejcn.1601565

Nadkarni KM (1976) Indian Matria Medica, vol 1. Bombay Popular Prakashan, Mumbai. https://trove.nla.gov.au/version/21887031

Pujari RR, Vyawahare NS, Kagathara VG (2011) Evaluation of antioxidant and neuroprotective effect of date palm (*Phoenix dactylifera L.*) against bilateral common carotid artery occlusion in rats. Indian J Exp Biol 49:627–633. https://pdfs.semanticscholar.org/ 1d2b/a9458ea3aa4a23b469929331f22c7bf38e6e.pdf

Ranilla LG, Kwon YI, Genovese MI, Lajolo FM, Shetty K (2008) Antidiabetes and antihypertension potential of commonly consumed carbohydrate sweeteners using *in vitro* models. J Med Food 11:337–348. https://doi.org/10.1089/jmf.2007.689

Razali N, Mohd Nahwari SH, Sulaiman S, Hassan J (2017) Date fruit consumption at term: Effect on length of gestation, labour and delivery. J Obstet Gynaecol 37(5):595–600. https://doi.org/10.1080/01443615.2017.1283304

Saafi EB, Louedi M, Elfeki A, Zakhama A, Najjar MF, Hammami M, Achour L (2011) Protective effect of date palm fruit extract (*Phoenix dactylifera L.*) on dimethoate induced-oxidative stress in rat liver. Exp Toxicol Pathol 63(5):433–441. https://doi.org/10.1016/j.etp.2010.03.002

Sallal AK, Rim J, Amr ZS, Disi AM (1997) Inhibition of haemolytic activity of snake and scorpion venom by date extract. Biomed Lett 55(217):51–56. http://jglobal.jst.go.jp/en/public/200902115410640922

Samad MA, Hashim SH, Simarani K, Yaacob JS (2016) Antibacterial properties and effects of fruit chilling and extract storage on antioxidant activity, total phenolic and anthocyanin content of four date palm (*Phoenix dactylifera*) Cultivars. Molecules 21(4):419. https://doi.org/10.3390/molecules21040419

Shahidi F, Naczk M (2004) Phenolics in Foods and Nutraceuticals. CRC Press, Boca Rotan. https://www.crcpress.com/Phenolics-in-Food-and-Nutraceuticals/Shahidi-Naczk/p/book/9781587161384

Shanmugapriya M, Patwardhan K (2012) Uses of date palm in Ayurveda. In: Manickavasagan A, Essa MM, Sukumar E (eds) Dates: production, processing, food, and medicinal values. CRC Press, Boca Raton, pp 377–385. https://www.crcpress.com/Dates-Production-Processing-Food-and-Medicinal-Values/Manickavasagan-Essa-Sukumar/p/book/9781439849453

Sheikh BY, Zihad SMNK, Sifat N, Uddin SJ, Shilpi JA, Hamdi OA, Hossain H, Rouf R, Jahan IA (2016) Comparative study of neuropharmacological, analgesic properties and phenolic profile of

Ajwah, Safawy and Sukkari cultivars of date palm (*Phoenix dactylifera*). Orient Pharm Exp Med 16(3):175–183. https://doi.org/10.1007/s13596-016-0239-5

Subash S, Essa MM, Braidy N, Awlad-Thani K, Vaishnav R, Al-Adawi S, Al-Asmi A, Guillemin GJ (2015) Diet rich in date palm fruits improves memory, learning and reduces beta amyloid in transgenic mouse model of Alzheimer's disease. J Ayurveda Integr Med 6(2):111–120. https://doi.org/10.4103/0975-9476.159073

Taleb H, Maddocks SE, Morris RK, Kanekanian AD (2016) Chemical characterisation and the anti-inflammatory, antiangiogenic and antibacterial properties of date fruit (*Phoenix dactylifera* L.). J Ethnopharmacol 194:457–468. https://doi.org/10.1016/j.jep.2016.10.032

Tang ZX, Shi LE, Aleid SM (2013) Date fruit: chemical composition, nutritional and medicinal values, products. J Sci Food Agric 93:2351–2361. https://doi.org/10.1002/jsfa.6154

Thouri A, Chahdoura H, El Arem A, Omri Hichri A, Ben Hassin R, Achour L (2017) Effect of solvents extraction on phytochemical components and biological activities of Tunisian date seeds (var. Korkobbi and Arechti). BMC Complement Altern Med 17:248. https://doi.org/10.1186/s12906-017-1751-y

Vayalil PK (2002) Antioxidant and antimutagenic properties of aqueous extract of date fruit (*Phoenix dactylifera* L. *Arecaceae*). J Agric Food Chem 50:610–617. https://doi.org/10.1021/jf010716t

Vinson JA, Zubik L, Bose P, Samman N, Proch J (2005) Dried fruits: excellent in-vitro and in-vivo antioxidants. J Am Coll Nutr 24:44–50. https://doi.org/10.1080/07315724.2005.10719442

Zhang CR, Aldosari SA, Vidyasagar PS, Nair KM, Nair MG (2013) Antioxidant and antiinflammatory assays confirm bioactive compounds in Ajwa Date fruit. J Agric Food Chem 61:5834–5840. https://doi.org/10.1021/jf401371v

Zangeneh F, Moezi L, Amir Zargar A (2009) The effect of palm date, fig and olive fruits regimen on weight, pain threshold and memory in mice. Iranian Journal of Medicinal and Aromatic Plants. 25:149–158