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## *Phoenix dactylifera* L. (Ajwa Dates): An energetic plant fruit with immense nutraceuticals value for strengthening the power of resistance

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**Abstract**

*Phoenix dactylifera* L. (family Arecaceae) is a unique natural products fruit that contains a high amount of carbohydrates, alkaloids, carotenes, steroids, anthocyanins, flavonoids, vitamins, and tannins used in various forms of diseases such as bleeding, dyspnoea, cough, burning sensation, syncope, trauma, and tuberculosis. Date Fruits are utilized worldwide especially in Arab zones as a part of the essential diet for a long time. Its fruit is now utilized in several traditional systems of medicine (TSM), particularly in Ayurvedic formulations, to treat a variety of maladies. It has different pharmacological actions like antibacterial, antiviral, antifungal, anticancer, antioxidant, anti-inflammatory, anti-diabetic, antimutagenic, anti-asthmatic, nephroprotective, gastrointestinal protective, hepatoprotective, Cerebro-protective, neuroprotective, immunostimulatory activity, and aphrodisiac activities. Its formulations are advocated for the treatment of lead-induced hepatotoxicity, chemotherapy side effects such as methylprednisolone, and male and female infertility. *Phoenix dactylifera* fruits and date seeds have been mentioned in various literature and early Ayurvedic writings for their phytochemical, phytopharmacological, traditional, and folklore applications.

**Keywords:** *Phoenix dactylifera*, Arecaceae, Ajwa dates, pharmacological properties, phytochemistry, traditional uses, oxidative stress

**Introduction**

The date palm, *Phoenix dactylifera* L., is a tropical tree of the family Arecaceae. It is among primogenital cultivated plants as a source of income, and it has contributed to the Arabian cape's daily life for the past 7000 years. In Arabia, North Africa west of Morocco, Iraq, and Iran dates are a traditional crop. Date fruit fostering has been increasing in current decades, implying a significant rise in agricultural production in the same planted area [1]. Dates are a major source of income and a quick meal for locals in various nations where they are grown, and they have played a vital role in the economies, people, and ecology of the places. Dates were also introduced to various producing regions in India/Pakistan, Australia, Mexico, Southern Africa, and the United States within the last three centuries [2]. The annual global output of dates is roughly 8.53 million 58 tonnes [3]. Saudi Arabia, Egypt, and Iran were the three leading date producers, however, Ajwa dates are primarily grown in Saudi Arabia's Madina Tayyiba. Ajwa dates are a flexible, dry date fruit with a delicate texture [4]. "Whoever has ingested seven dates between the two places (from east and west of Madina) when he gets up every morning, he would not be effected on that day by poison and magic until the evening," declared Allah's last Messenger (Sallallaahu Alayhi Wasallam) [5]. Dates have spiritual significance for Muslims all across the world, and they are mentioned several times in the Quran. They are generally served to break the day-long fast during the holy month of Ramadan [6]. It also aids in the delivery of pregnant women by stimulating the womb muscles throughout pregnancy and facilitating womb movement during delivery. Dates help to treat a myriad of disorders of the liver, as well as slowing down the aging process and offering immunity against brain and body tiredness [7, 4, 8]. The Ajwa date fruits are enriched in many essential nutrients and may be termed a nutritional powerhouse. The most astonishing nutritional fact about dates is that they are extremely high in fiber as well as several essential minerals like calcium, potassium, and magnesium. Dates have 75 g carbs, 2 g proteins, 0.39 g fats, 8 g dietary fibers, 10 IU vitamin A, 2.7 mcg vitamin K, 0.6 mg vitamin C, 0.05 mg vitamin E, 0.06 mg thiamine, 18 mcg folate, 0.066 mg riboflavin, 1.27 mg niacin, and 0.165 mg vitamin B6 per 100 g. 100 grams of dates contain 39 milligrams of calcium, 43 milligrams of magnesium, 2 milligrams of sodium, 656 milligrams of potassium, 62 milligrams of phosphorus, 0.29 milligrams of zinc, 1 milligram of iron, 0.2 milligrams of copper, and 0.26

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milligrams of manganese [9-11]. Several folkloric and biological activities determined based on *in vitro* and animal models have been presented regarding the possible health repercussions of dates. These include maintaining a healthy nervous system and energy production, as well as maintaining healthy bones, skin, and eyesight, safeguarding the heart and circulatory system by reducing triglycerides and LDL cholesterol levels in the blood, preventing atherosclerosis and heart problems, and preventing anemia [12-14]. The Ajwa dates fruits and their preparations may be utilized in the management of long-suffering patients with significantly impaired or suppressed immune systems due to their high level of nutraceuticals properties for increasing the power of resistance [15]. We focused on the role of Ajwa dates as an adaptogen in influencing the indication of immune activities, with a special focus on their beneficial effects in humans.

### Ethno-pharmacological data collection

#### Method

Various Hadith sources gave insights on the utilization of Ajwa date plants in the treatment of impaired and suppressed immune systems (Sahih al-Bukhari; Sunan Ibn Majah; Tirmidhee and Sahih Muslim), journal papers and books on traditional studies are accessible, as well as research on the effects of daily date fruit consumption by patients with severely impaired immune systems. Secondary searches were conducted using the plant name *Phoenix dactylifera*; Arecaceae; Ajwa dates; pharmacological characteristics, phytochemistry, traditional applications, and oxidative stress

in databases such as Pubmed, Google Scholar, and Scopus up to 2021.

### Morphological characters of different components of the plant

The date plant is a perennial plant of the Arecaceae palm family that is cultivated for its sweet, delectable fruit. The cultivation of dates was most likely done long before Christ's time [16]. The dates tree has evergreen leaves that are 5-7 cm long and 2 cm broad, spines on the petiole, and 155 leaflets that are 31 cm (l) and 2 cm (w). The fruit is a monocot, terete berry with apical stigma, meaty carpels, and membrane pith (among the seed and flesh), and its characteristics vary widely dependent on the geography and climatic circumstances. Seed properties, like those of the fruit, vary depending on type, habitat, and growth circumstances. The seed's weight can range from 0.6 to 5 g, and its length and breadth are 11 to 33 mm and 6 to 13 mm, respectively. The seed is oblong, with a thin embryo and a firm endosperm made up of cellulose deposits on the cell walls' interiors date palms typically require 5 to 8 years to bear fruit after being planted, and 7 to 10 years to provide commercially viable yields. In a single harvest season, mature date palms may produce 150-300 lb (70-140 kg) of dates. Many harvests are necessitated because they do not mature at the same time. Date bunches should be clipped and bagged or covered before reaching maturity allowing for the surviving fruits to keep growing and be safeguarded from the weather and creatures that eat them (Figure 1, A-J) [4].



**Fig 1:** *Phoenix dactylifera*. Tree (A); Male flowers (B); Female flowers (C-D); Immature fruits (E-F); Mature fruits (G); Mature fruits for the market (H-I); Seeds (J) Home spun (K, L, N, P); Ample rutted dates (M); Unblended date paste (O & Q); Date conserves (R).

### Production and harvesting of dates

There are approximately 100 million date palm trees on the globe, covering 14 million acres in 30 nations. Date output in the globe is estimated to be at 5.4 million metric tonnes per year (Mt). Egypt, Iran, and Saudi Arabia are three of the world's most powerful countries. Pakistan, Algeria, the United Arab Emirates, Oman, Sudan, and Morocco are the top exporters of dates, while France, India, the United Kingdom, and the United Arab Emirates are the top importers [17].

Date harvesting techniques have remained mostly unaltered for generations. New approaches to making data gathering easier have just lately been established. Pickled dates are traditionally collected by hand in the fall or early winter when they are at the suitable yellow-orange stage. Dates are harvested when they are immature, half-ripe, or completely ripe. For dried and shriveled fruits, some may even pick fruits that are long past the maturity stage [18].

### Bioactive compounds

In date fruit, there are a wide variety of carotenoids, polyphenols, sterols, and tannins. Dates are low in calories and abundant in fiber. Date variety, fruit harvesting stage, warehousing, postharvest production, and the region of origin of the dates all affect the concentration and composition of these components [19-21]. In their development period, date fruits experience a dramatic transition in their chemical composition and functional content, with lowering fiber, mineral, and vitamin levels while boosting the concentrations of simple sugars [21-23].

### Carotenoids

Boudries *et al.* analyzed the carotenoid makeup of three different kinds of dates at three different stages of edible

ripeness [24]. Date fruits contain less Neoxanthin, violaxanthin, and antheraxanthin than previously assumed, according to new research (Figure 2).

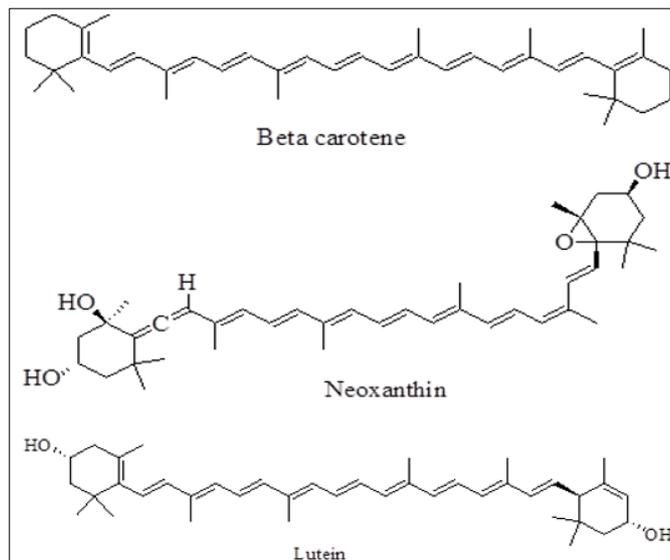


Fig 2: Carotenoids of date fruits

### Phytohormones and phytosterols

Date fruit contains phytosterols even when it is in a less ripe state. Dates' edible part included a mixture of plant sterols termed crystalline, which included -sitosterol, stigmasterol, campesterol, and iso fucosterol [22]. Formononetin, secoisolariciresinol, lariciresinol, daidzein, genistein, pinoresinol, and glycitein, are among the phytoestrogens found in date fruit (Figure 3) [25].

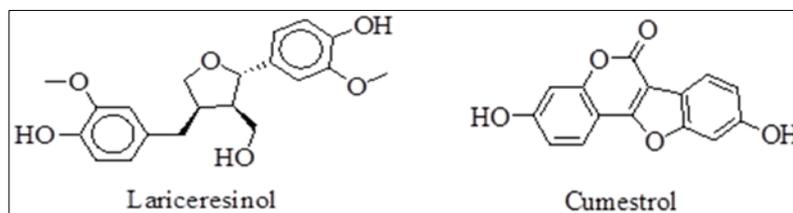


Fig 3: Phytosterols of date fruits

### Phenolics

The phenolic acids in dates are copious [26-28]. Researchers from the University of Oman discovered the benzoic acid derivatives p-hydroxybenzoic acid, protocatechuic acid, vanilliqueic acid, gallic acid, and syringic acid, including the benzoin derivatives o-coumaric, p-coumaric, caffeic, and ferulic acids (see table below) in Omani date fruits [29]. Mansouri *et al.* reported P-coumaric acid and ferulic acid among the primary polyphenolic compounds in 7 diverse genotypes of fruits cultivated in Algeria. Additionally, the acids xanthoxylin, hydrocaffeic, and coumaroylquinic acid have been reported in the literature (Figure 4) [30]. By correlating the lag phase and UV spectrum of these substances to the standard retention time and wavelength of other phenolic acids, researchers discovered caffeic acid, protocatechuic acid, syringic acid, chlorogenic acids, and ferulic acid in date extract [31, 32]. There have been new studies on Amari and Hallawi dates, both of which are in the Tamer stage [33]. Compared to Tamer dates, Khalal stage dates exhibited a substantially higher phenolic acid content, at 0.7289 g per 100 g of weight (weight/weight) [34].

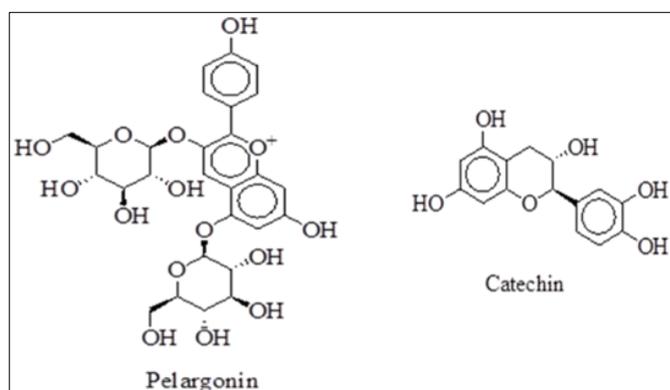


Fig 4: Phenolic compounds of date fruits

### Flavonoids

Apigenin, luteolin, and quercetin are flavonoid glycosides found in abundance in date fruit harvested during the Khalal stage of maturation from the Deglet Noor variety, according to research that also detected flavonoid sulfates and flavonoid sulfate isomers in the fruit (Figure 4). A study published in

2006 by Hong *et al.* According to Chaira *et al.*, the greater flavonoid content of this cultivar than any of the other nine Tunisian date types is responsible for its superior antiradical efficiency [35-36]. Diosmetin 7 O-L arabinofuranosyl (12) – Dapiofuranoside (Diosmetin1) and diosmetin 7 O–Dapiofuranoside were isolated from date fruits for the first time (Diosmetin 2). It's seen in Figure 5; [37]. Carotenoids, polyphenols, tannins, and sterols are abundant in date fruit [38]. The proportion and distribution of these contents varies considerably depending on a myriad of criteria, including date variety, fruit harvesting stage, preservation, postharvest processing, date origin, and soil quality [19-21]. Numerous studies suggest that the phytochemicals of date fruits vary substantially through the ripening process, with a surge in sugar levels and a steady decline in fiber, mineral, and vitamin levels [23-25].

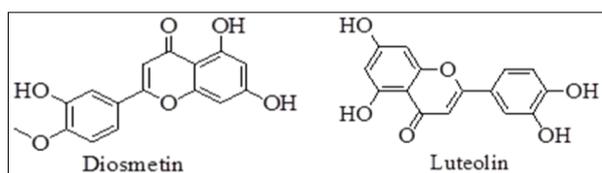


Fig 5: Flavonoid's compound of date fruits

### Pharmacological activities of *Phoenix dactylifera*

**Antioxidant activity:** *In vitro* investigations indicated that the extracts of date fruit were a potent scavenger of different kinds of free radicals and protein oxidation in rat tissue homogenate [14]. Since then, other studies have used a variety of dates to validate similar conclusions [39-40]. The antioxidant activities of Tunisian dates were investigated and according to the study, the Korkobbi type exhibited the highest lipoperoxyl radical scavenging ability, whereas the Rotbi species was excellent at scavenging hydroxyl radicals [35].

The abundance of phenolic compounds, in date fruits, has been linked to their antioxidant activity, but sun-drying and ripening have been found to diminish antioxidant activity [41-43]. Dates contain selenium, which is known to have powerful antioxidants. Several investigations have demonstrated that selenocysteine residues, which are a critical feature of ROS-detoxifying seleno-enzymes (GPx, thioredoxin reductases, and maybe selenoprotein P), are the primary source of this vital trace element's antioxidant activity [44]. When diverse phenolic compounds and selenium are mixed, it appears to be the most likely source of reported free radical scavenging and antioxidant activities [45].

### Anti-mutagenic activity

In the Ames mutagenicity experiment, Vayalil (2002) [14] discovered that the date fruit extract exhibits antimutagenic characteristics. The extract inhibited benzo (a) pyrene-induced mutagenicity in Salmonella tester strains TA-98 and TA-100 with metabolic activity in a dose-dependent manner. In TA-98 and TA-100, low doses of 3.6 mg/plate and 4.3 mg/plate were observed to suppress the generation of His<sup>+</sup> revertant by 50% and 50%, respectively [14]. Date that has been reported to have antimutagenic characteristics include proanthocyanins [46, 47, 48] and phenolic acids [48]. Selenium is plentiful in dates, and investigations have shown that it possesses antimutagenic properties against a plethora of mutagens and carcinogens at low quantities [49-51].

### Effect on the hemolytic activity

Date substantially reduced the development of *S. pyogenes* in

*In vitro* studies, the date extract inhibited the Streptococcal exotoxin streptolysin hemolytic activity at low doses, owing to erythrocyte membrane integrity and streptolysin enzyme inhibition. The inhibitory action was unaffected by deproteinization, indicating that the inhibitory element was steroidal rather than proteinaceous [52]. Dates include anthocyanins, carotenoids, procyanidins, and flavonoids, which have been reported to have membrane-protective effects in studies [53, 54], therefore these compounds are probably attributable to the RBC membrane's protection.

### Antiviral activity

Using *Pseudomonas aeruginosa* ATCC 25668, the antiviral activity of a crude acetone extract of date fruit (*P. dactylifera*) against lytic *Pseudomonas* phage ATCC 14209-B1 was studied [55]. Date pit extracts substantially suppressed bacterial lysis and hindered the infectivity of *Pseudomonas* phage ATCC 14209-B1. With a MIC of 10 mg/ml, date pits' antiviral effect was revealed to be mediated by phage binding [55]. The antiviral investigation should indeed be broadened to encompass viruses that are beneficial to humans.

### Antifungal activity

Barhi date extract caused cell wall deformation, weakening, and partial collapse in *Candida albicans* [56]. At high concentrations, cell lysis, cytoplasmic material leakage, and necrosis were all detected. Overall, findings indicate that date extract phytochemicals may have a broad spectrum of anti-*Candida* effects and that further research might lead to therapeutic applications. Flavonoids have been reported to have antifungal activity *in vitro* against *Candida albicans* and *Candida krusei*, implying that the antifungal results are attributed to their presence in the extract [57, 58].

### Anti-inflammatory properties

Excessive free radical generation by activated inflammatory leukocytes is exceedingly damaging, especially in the setting of chronic inflammation, and aggravates arthritis, diabetes, and other disorders. As a result, keeping them under control is essential for greater health and vitality. In the rat adjuvant arthritis model, extracts of date fruit pulp exhibit anti-inflammatory activities. The extracts augmented antioxidant levels in the blood while decreasing lipid peroxide levels. The extracts boosted body weight gain and the FER, implying that they are beneficial. The extract of the pulp was shown to be safe up to 7 g/kg in acute toxicity tests with mice [59]. Proanthocyanidin [60], flavonoids [61], polyphenols [62], carotene [63], and the mineral selenium [64], all date components, have anti-inflammatory properties and may have contributed to the therapeutic benefits, according to numerous studies.

### Gastrointestinal protective activity

Peptic ulcers can be alleviated by eating dates. Rats were given aqueous and ethanol extracts of dates and date pits had an increase in GIT transit time. These findings back with the ethnomedicinal theory that dates can relieve stomach ulcers and function as a natural laxative [65]. Both aqueous and ethanolic date fruit extracts were shown to be active in healing ethanol tempted stomach ulcers in the rats [13].

### Antihyperlipidemic activity

Coronary heart disease is associated with low levels of HDL cholesterol and higher levels of LDL cholesterol [66-67]. The findings are comparable when rats were given date seed

fibers (2.5%) [68]. Preliminary studies show that the phytochemicals caffeic acid [69, 70], proanthocyanidin [71], catechin [72], quercetin [72, 73], anthocyanins [74], and selenium existing in different animal models of study have cardioprotective and antihyperlipidemic effects and contributed to the observed effects [75, 76].

#### Hepatoprotective activity

The most significant health concerns with no effective prophylactic therapies effects. Date extract treatment reduced the levels of hepatic marker enzymes, when compared to dimethoate alone treated controls. The biochemical findings were backed up by histological data [77]. Date extract exhibits hepatoprotective properties, as per histopathological examinations, particularly corroborate the biochemical findings [78]. Selenium [79], anthocyanin [80], ferulic acid [81-83], and quercetin (Janbaz *et al.*, 2005), chlorogenic acids [84], -carotene [85], proanthocyanidins [86], apigenin [87], and luteolin [88], date constituents, were all found to exhibit hepatoprotective effects in mice when exposed to CCl<sub>4</sub>. The presence of these compounds is probably attributable to the date extract's hepatoprotective qualities.

#### Nephroprotective activity

The prominent detrimental impact of pharmacological treatments, nephrotoxicity, must be minimized or avoided. The reno-protective effects of date fruit extract on gentamicin-induced nephrotoxicity in rats were addressed by Al Qarawi *et al.* [89]. The rat kidneys were fed date flesh and pit extract, which lowered plasma creatinine and urea levels and safeguarded the renal tubules sections from gentamicin-induced damage [89]. Selenium [90] and quercetin [91] have previously been demonstrated to safeguard rats against gentamicin-induced nephrotoxicity, implying that these substances are to blame.

#### Anticancer activity

For the first time in an experiment conducted, Ishurda and John [92] determined that glucans synthesized from date fruits have anti-cancer properties. The authors demonstrated dose-dependent anticancer effects with Sarcoma-180 solid tumors, with optimum activity at 1 mg/kg. According to the authors, the anticancer action identified might be connected to their (13)-d-glucan linkages [92]. *In vitro*, incubation with the -glucan-containing solution reduced cell viability by inducing apoptosis in PC-3 cells in a dose-dependent manner. When the Sarcoma-180 tumor was treated with glucans synthesized from dates, a comparable mechanism of action was elicited [93].

#### Immunostimulatory activity

Immune activation is a safe and effective means of avoiding and treating contagious illnesses. Immunostimulants boost the immune system of the host and induce a broad immunological response to microbial infections. They also stimulate cytokine synthesis or activate B- and T-lymphocytes, which stimulates humoral and cell-mediated responses [94]. Taking phytochemicals to boost the immune system is a long-standing practice. Parturient mice were given an ethanol extract of dry dates, which increased both cell and humoral immunity [94]. Selenium [95], carotenoids [96], quercetin [97], kaempferol [98], and isorhamnetin [99] have all been found to have immunostimulatory effects in studies and might be responsible for the reported results.

#### Gonadotropic activity

Dates have remained a key ingredient in conventional aphrodisiacs and tonic confections, and scientific data supports this claim. In guinea pigs, date extracts accelerated spermatogenesis, elevated testosterone, FSH, and LH levels, and raised sperm count [67]. Date pits have also been proven to enhance growth in animals, which has been linked to an increase in estrogen or testosterone levels in the blood [100, 101]. The phytochemicals genistein [102, 103], vitamin A [104], and selenium [105], which have all been documented to maintain testicular processes and have gonadotropic action, might well have added to the findings.

#### Neuroprotective activity

In a study on the neuroprotective benefits of *P. dactylifera* against bilateral common carotid artery occlusion, rats received a methanolic extract of *P. dactylifera* fruits at doses 30, 100, and 300 mg/kg for 15 days [106]. *P. dactylifera* extract substantially decreased the depletion of GSH, SOD, and CAT expression triggered by ischemia at doses of 100 and 300 mg/kg, although there were no substantial changes at the smaller dosages (30 mg/kg). As a consequence, the methanolic extract of *P. dactylifera* exhibited dose-dependent antioxidant protection and brain damage.

#### Antidiabetic activity

Mard *et al.* tested the anti-diabetic efficacy of *P. dactylifera* ethanolic extract of leaves on diabetes in male rats produced by alloxan [107]. In rats that had fasted overnight, a freshly produced solution of alloxan monohydrate in normal saline was given IP at a dosage of 150 mg/kg. After 1 hour, the animals were free to eat as much as they wanted. Blood glucose levels were measured before and after the alloxan injection. PDE (100, 200, and 400 mg/kg), PDE fractions (50, 100, and 200 mg/kg), or glipalamide (4 mg/kg) were given to the treatment groups, whereas diabetic control mice were given saline (5 mL/kg) PO thrice (14 days). In alloxan-induced diabetic rats, standard treatment with PDE or its components significantly reduced blood glucose, serum triacylglycerol, and cholesterol as a comparison to the control group.

The anti-diabetic properties of aqueous, ethanol, methanol and acetone extracts of distinct Omani *P. dactylifera* seed types were assessed *in vitro* [108]. All extracts of *P. dactylifera* seeds from all date types have considerable anti-diabetic action, however, the aqueous extract inhibited -glucosidase and -amylase the most, indicating the existence of non-phenolic water-soluble chemicals as inhibitors of these enzymes. As a result, *P. dactylifera* seeds extract decreases the influence of carbohydrates on blood sugar levels and might be used in conjunction with anti-diabetic diets and medications.

#### Cerebro-protective activity

Date Seed Extract (DSE) was studied for its ability to protect against cerebral ischemia damage. DSE was given at an i.p. dosage of 80 mg kg<sup>-1</sup> 30 minutes after MCAO. Total antioxidant Activity (TAS), Superoxide Dismutase (SOD), and Malondialdehyde (MDA) were all tested. There were additional morphological examinations and behavioral activities. SOD and TAS activities were significantly reduced by MCAO [109]. MCAO significantly increased MDA levels. Because of the temporary ischemia, motor coordination was also affected. In male rats, DSE treatment reduced all of the

changes and neuronal damage caused by MCAO. The findings revealed that DSE therapy might protect cortical neurons from brain damage, most likely due to its antioxidant activities.

### Aphrodisiac

The impact of *Phoenix dactylifera* pollen (PDP) on male rats' sexual behavior was studied using serum Estradiol and Testosterone levels. Sixty male rats were randomly assigned to one of six groups. PDP extract was administered in doses of 35 mg/kg, 70 mg/kg, 105 mg/kg, 140 mg/kg, and 350 mg/kg [110]. One hour after injecting the extract into male rats and mating with a receptive female. Male sexual behavior was aroused in all dosages. In comparison to controls, extract substantially enhanced mount, ejaculation, intromission rates, and ejaculation delay (p 0.001). Latencies for mounting and intromission were dramatically decreased (p 0.001). The dosage of 140 mg/kg had the greatest impact.

### Protective effect in Chemotherapy

The mechanism by which ajwa dates elicit apoptosis in human triple-negative breast cancer MDA-MB-231 cells is unknown, however, it has been exploited in conventional medicine to treat a variety of ailments. Liquid chromatography-mass spectrometry was used in ethanolic Ajwa Dates Pulp Extract (ADPE) and studied anticancer

activities against MDA-MB-231 cells. ADPE included photo components from the classes of carbohydrates, phenolics, flavonoids, and terpenoids, according to LC-MS analysis. MDA-MB-231 cells were inhibited dose- and time-dependently in the MTT experiment. More crucially, in ADPE-treated MDA-MB-231 cells, ROS triggered changes in mitochondrial membrane potential. ADPE induced the down regulation of Bcl-2 and the AKT/mTOR pathway by up regulating p53, Bax, and cleaved caspase-3 [111].

### Antiallergic activity

The impact of a ripened date palm fruit water extract on allergic responses was assessed in mice. The allergy score in rodents on date palm tree fruit extract-added food was considerably lower in the fruit extract diet. In the spleen cells of rodents given the fruit extract-added diet, mRNA expression of Bruton's tyrosine kinase (Btk) and IL-2-inducible T cell kinase (Itk) was considerably reduced. Furthermore, in C3H/HeN mouse spleen cell cultures, chlorogenic acid, and pelargonic acid reduced these mRNA expressions. This research suggests that limiting the frequency of type 2 helper T (Th2) cells and modifying the expression of kinases involved in mast cell degranulation and Th2 cell proliferation potentially aid mice with allergies [112]. The pharmacological activities of *Phoenix dactylifera* (Dates) are discussed in Table 1.

**Table 1:** Pharmacological activity of *Phoenix dactylifera* fruits

Activity	Type of Extract/Phyto constituent	Observation
Antioxidant	Aqueous extract of the fruit	<i>In-vitro</i> studies showed a strong scavenger of superoxide and hydroxyl radicals, and it inhibited iron-induced lipid peroxidation and protein oxidation in rat brain homogenate [14, 35].
	p-Coumaric acid	In rat cardiac tissue, it stimulates the expression of antioxidant enzyme genes [41].
	Selenocysteine	Free radical scavenging and antioxidant activities [43].
	Water and methanol extract from leaves	Hydroxyl and superoxide anion radical scavenging activity [42].
Antimutagenic activity	Aqueous extract of the fruit	In Salmonella tester strains TA-98 and TA-100, metabolic activation inhibited benzo (a) pyrene-induced mutagenicity in a dose-dependent manner [14].
	Selenium	At low doses, selenium possesses antimutagenic properties against a myriad of mutagens and carcinogens [49].
Hemolytic activity	Aqueous extract of the fruit	Incubation of the bacteria for 24 hours with date fruit extract at 5, 10, and 20% dilution effectively inhibited the growth of <i>S. pyogenes in vitro</i> , resulting in a 30.8 percent, 64.7 percent, and 88.5 percent reduction in the microbial population [52].
	Anthocyanins, carotenoids, procyanidins, and flavonoids	Membrane-protective properties [53, 54].
Antiviral activity	Crude acetone extract from pits	Date extracts completely prevented bacterial lysis and inhibited Pseudomonas phage infectivity ATCC 14209-B1 (ATCC 14209-B1) (ATCC 14209) [55].
Antifungal activity	Aqueous extract of the whole plant	Cell lysis, cytoplasmic material leakage, and cell death were all observed at high concentrations [56].
	Flavonoids	Dates had antifungal activity against <i>Candida albicans</i> and <i>Candida krusei in vitro</i> [57, 58].
Anti-inflammatory properties	Methanolic and aqueous extract of fruit pulp	Foot edema, ESR, and plasma fibrinogen levels are all reduced [59].
Gastrointestinal protective activity	Aqueous and ethanolic extracts of fruits and pits	In rats, it was found to be helpful in the treatment of ethanol-induced stomach ulcers [65].
Antihyperlipidemic activity	Defatted date seed	Triglycerides, total cholesterol, and low-density lipoprotein levels in the blood were all reduced [67].
	Methanol water extract of leaf	Significant decrease in serum in serum LDL-c level [71].
Hepatoprotective activity	Aqueous extract of the fruit	Hepatic marker enzymes (transaminases, alkaline phosphatase, gamma-glutamyl transferase, and lactate dehydrogenase) were reduced, as were hepatic levels of malondialdehyde, while antioxidant enzymes were enhanced [77].
	Aqueous extract of pits	Reduced CCl <sub>4</sub> induced elevations in plasma enzyme and bilirubin concentrations [78].
	Aqueous suspension of seed	Reduced CCl <sub>4</sub> induced alteration in liver function parameters (AST, ALT, ALP, albumin) [81].
Nephroprotective activity	Aqueous extract of the fruit	Reduced plasma creatinine and urea levels, as well as damage to the proximal tubular sections caused by gentamicin [89].
	Selenium and Quercetin	Protect rats from gentamicin-induced nephrotoxicity [90, 91].
Anticancer activity	Gluten	Dose-dependent anticancer efficacy with an optimal activity at 1 mg/kg [92].
	Gluten	Apoptosis was increased in a dose-dependent manner, reducing the viability of PC-3 cells <i>in vitro</i> . [93].

Immunostimulatory activity	Ethanollic extract of the whole plant	Improved both cell and humoral immunity <sup>[94]</sup> .
Gonadotropic activity	Aqueous extract of the fruit	Sperm count increased, spermatogenesis improved, and testosterone, follicle-stimulating hormone, and luteinizing hormone levels increased <sup>[101]</sup> .
Antibacterial activity	Ethyl acetone and hexane extract of seed	Effective inhibition of bacterial growth (Gram-positive bacteria MRSA) <sup>[99]</sup> .
Neuroprotective activity	Methanolic extract of the fruit	The methanolic extract of <i>P. dactylifera</i> protected against oxidative stress and brain damage in a dose-dependent manner <sup>[106]</sup> .
Antidiabetic activity	Ethanollic extract of leaves	When compared to the control group, oral treatment of PDE lowered blood glucose, serum triacylglycerol, and cholesterol in alloxan-induced diabetic rats. In comparison to the control group, plasma insulin levels were higher in the treated groups <sup>[107]</sup> .
	Aqueous, extract of seeds fruits	The highest inhibition of -glucosidase and -amylase was produced by aqueous extract, suggesting the existence of certain non-phenolic water-soluble chemicals as inhibitors of these enzymes <sup>[108]</sup> .
Cerebro-protective activity	Aqueous extract of seeds	DSE treatment may protect cortical neurons from damage caused by the brain, most likely due to its antioxidant qualities <sup>[109]</sup> .
Aphrodisiac	Aqueous extract of pollen	By enhancing mounting and anogenital investigatory behavior, date extract was found to increase Testosterone, Estradiol, and male inclination toward females <sup>[110]</sup> .
Cancer Chemotherapy	Ethanollic extract of pulp	ADPE caused cell arrest in the S and G2/M checkpoints, according to cell cycle studies. ADPE induced the down regulation of Bcl-2 and the AKT/mTOR pathway by up regulating p53, Bax, and cleaved caspase-3 <sup>[111]</sup> .
Antiallergic	Hot water extract from fruits	A decrease in the frequency of type 2 helper T (Th2) cells, as well as regulation of the expression of kinases involved in mast cell degranulation and Th2 cell development, may diminish allergy symptoms in mice <sup>[112]</sup> .

### Fatty acids of Date seed oil

The presence of five primary fatty acids (myristic acid, oleic acid, palmitic acid, linoleic acid, and lauric acid, comprise 90% of the total fatty acid contents of date seeds oil <sup>[113]</sup>. Some fatty acids, such as capric, palmitoleic, linolenic, and gadoleic acids, were found in reduced levels. The fatty acid content of date seed oil varies based on the type and stage of ripening, as well as the extraction process <sup>[114]</sup>. The majority of the fatty acids in date seed oil are found as triglycerides (tri-acylglycerols) and modest amounts of non-glycerides of fatty acids (typically less than 1%). These minor components were first investigated in the oil's unsaponifiable fraction. Nonglyceride fatty acid esters, hydrocarbons, sterols, triterpene alcohols, tocopherols, phenols, phospholipids, and flavonoids chemicals make up the nonglyceride portion of date seeds oil <sup>[115]</sup>.

### Date foodstuffs

#### Homespun

Include all recipes and cuisines for which the housewife purchases whole dates and incorporates or combines them for home use. There are numerous literature on dates being ingested in culinary combinations in both old and new literature. Because the date's organoleptic and nutritional properties are high in sugar and poor in protein and fat, a great variety of combinations are created to compensate for the nutritional deficiencies. Dates can alternatively be cooked in fresh milk or blended well with milk powder (Fig.1; K, L, N, P) <sup>[116]</sup>. Dates, butter, and honey, known as Khabis, are a refined delicacy, while dates and fish, a long-standing staple in the Gulf region, is a protein combo. A well-known delicacy is ground dates blended with sesame oil, which is arguably the most efficient way to spend the cold desert evenings <sup>[117]</sup>.

### Development of date products

The development of innovative items derived from dates to further expand market coverage and promotional strategies has always existed, and it has generally come from small-scale, regionally focused private companies. With the gradual transfer of date plantation ownership and the consolidation of date product attributes in major multi-food firms, development activity is now predominantly done behind

closed doors rather than in the open. An increase in the number of patent applications in this subject confirms this trend. Although the major focus has been on enhancing the (export) quality of dates from European nations, North Africa has contributed to these advancements <sup>[118]</sup>. The National Date Palm Research Centre at Hofuf, Al Hassa, is now the focal point for research <sup>[119]</sup>. Several attempts to refine current formulas and generate new date products have been documented in the technical literature during the last two decades.

### Ample rutted dates

The filled date is simmered in sugar syrup in the date pit with almond, imparting the date and syrup a unique hue <sup>[120]</sup>. Date preservation in syrup has been recognized and employed for a long time, but it has also been the center of intensive analysis. Peeled dates were placed into syrup with the pH altered from around 7 to 3 by citric acid and a variety of flavors (orange, banana, grapefruits, etc.) were added. Entire, pitted rut dates are stacked in jars, flavored with clove and cinnamon, and packed with almonds. The jars are sterilized in a water bath for 20 minutes at 90 °C after sealing (Fig.1; M) <sup>[121]</sup>.

### Unblended date paste

Making date paste is a straightforward process that is usually carried out in mincers. By switching dies with holes of varying diameters, the fineness of the grind may be changed. Although relative humidity is the most essential aspect in determining a product's texture (softness), it is not the only one. Date varieties with the same moisture content can yield a paste with varying degrees of suppleness. Furthermore, even if the moisture content is kept constant, date paste will harden during storage. When you consider the increased danger of browning and fermentation as moisture levels rise, it's evident that technical manipulation is required to match the characteristics of the source material and the intended final result <sup>[113, 122]</sup> (Fig.1; O & Q).

### Date pastes combinations

With the potential to manufacture date paste along with the required moisture content, and tenderness, the field for integrating and replenishing this sweet material with other

consumables items <sup>[123]</sup>. Date bar mixed with soy protein isolate (SPI), and dry skimmed milk (DSM) resulting in a nutritionally sound combination that scored highly in sensory tests. Permutations of date paste and roasted peanuts, as well as related products, have been supplemented by SPI, and DSM <sup>[115]</sup>. All of this study was done to provide healthy snacks for kids (Fig.1; O & Q).

#### Date conserves

Preserves are typically thought of as derived goods that are used to keep fresh meals from spoiling so that they can last longer in storage and be available to consumers. Sugar, salt, and (organic) acids are common natural auxiliary materials used in this procedure. Fruit jam, which is prepared by simmering fruit pieces with sugar that precludes germs from proliferating, is one of the most prevalent preservatives. If necessary, pectin is added as gelling agent, and the pH is adjusted by using citric, tartaric acid or ascorbic acid. The finalized merchandise is emptied into sterilized jars while still hot, sealed, and sterilized in a hot water bath (Fig.1; R) <sup>[24]</sup>.

Dates are not the most adaptive variety of fruit for jam manufacturing due to their inherent composition, which includes a high sugar content, a fairly high pH, and a less noticeable flavor. The amount of naturally occurring pectin in dates varies, so it's usually necessary to augment it, especially if you want a lighter jam. As a result, several research organizations have analyzed and explored date jam production to find the finest varieties and recipes <sup>[112, 118]</sup>.

#### Future research needs

To increase the quality and quantity of dates, researchers conducted a multilevel study. The hunt for date tree varieties best suited for each agricultural location should continue at the production level. To improve the health and production of the trees, it is thought that modern genetic engineering approaches should be used. Fruit harvesting and storage procedures must be upgraded in the hunt for better ways to neutralize, and finally eradicate, the traditional adversary of dates production. As agricultural labor becomes more limited, the technological ways of accurately and effectively collecting the fruit must be developed. Improved methods of storing the fruit before processing should also be investigated. The claim that dates eating has a particularly favorable effect on human health requires more evidence. Finally, the use of date seed oil industrial by-products should be investigated.

#### Conclusion

The pharmacological, phytochemical, and traditional applications of Ajwa dates were discussed in this review study (*Phoenix dactylifera* L.). Different types of dates are available at varied prices, with ajwa dates being the most expensive, healthy, and free of hazardous effects. It is fair to propose that they should be consumed daily for improved health and strength. Date fruits have a high therapeutic value due to the presence of phenolics, sterols, carotenoids, anthocyanins, procyanidins, flavonoids, minerals, and vitamins, among other phytochemicals. Date intake is beneficial to human health in both men and women, and the data imply that with the discovery and separation of active components, dates might be a viable commercial medicine for the treatment of cardiac, gastrointestinal, and neurological illnesses. Thus, because we mentioned pharmacology, phytochemistry, and specifically the different indications, properties, and action of dates in this review, it may be useful for future research because it supports the claims of various

folklore literature and different texts of the traditional system of medicine.

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#### Conflict of Interest: No

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