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Prebiotic Properties of Dates and Their Impact on Health

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ABSTRACT

The date palm (*Phoenix dactylifera L.*), primarily cultivated in desert regions like the Middle East, is a significant source of nutrition, rich in sugars, polysaccharides, and bioactive compounds such as carotenoids, flavonoids, phenolics, anthocyanins, and sterols. Notably, the polysaccharides in dates exhibit prebiotic properties, supporting beneficial gut microbiota. Research highlights that dates promote the growth of helpful bacteria, including *Bifidobacterium* and *Lactobacillus*, which enhance intestinal health, improve barrier function, and increase the production of short-chain fatty acids. Beyond gut health, dates offer additional benefits, including anti-inflammatory, antioxidant, cardiovascular, neuroprotective, and blood sugar-regulating effects. This review synthesizes recent findings on the prebiotic effects and broader health impacts of dates, suggesting their potential in dietary strategies for promoting health and preventing gastrointestinal disorders.

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Introduction

The date palm belongs to the *Palmaceae* family, and *Phoenix dactylifera L.* is the scientific name for this plant, comprising two parts: seeds and edible fruit. The date palm is a valuable crop cultivated in different regions across the world, particularly in the Middle East desert areas, it had a major impact on the residents' ways of living, particularly the ancient nomads, as noted by Al-Hooti et al. (1997) and Karthishwaran et al. (2020).Due to their prebiotic properties, sugars and polysaccharides, which make up the majority of the date fruit's mesocarp, may be beneficial to gut microbes. Furthermore, date fruit contains a significant quantity of beneficial compounds including anthocyanins, phenolics, sterols, carotenoids, and flavonoids. The edible date fruit ripens through several stages before reaching its final, soft and delicious condition. The date fruit has a rich tradition in natural healing and holds significant potential for improving health (Blanco-Pérez et al., 2021; Noorbakhsh & Khorasgani, 2022).

The fiber content in date seeds ranges from 60 to 80% by weight (Al-Farsi et al., 2007). Iron, potassium, calcium, vitamin A, vitamin B3, and folic acid are among the vital components found in dates. Proteinogenic and non-proteinogenic amino acids, as well as fatty acids like oleic and linoleic acids, are abundant in dates (Ali et al., 2014; Mallhi et al., 2014). A recent study found that consuming date fruit can decrease the levels of inflammatory, oxidative, and apoptotic molecules in the body (Al-Yahya et al., 2016). In experiments involving animals, date fruits have been found to have protective effects on the liver, indicating their potential therapeutic value for a range of health issues (El Arem et al., 2014), nephroprotective kidney-protective (Al-Qarawi et al., 2008), antibacterial (Al-Shwyeh, 2019), antiviral (Ghanem et al., 2015), antioxidant and antifungal (Noshirvani et al., 2017) properties.

Over the past few years, there has been an increasing trend appreciation for the intricate relationship between diet and gut health, with particular attention given to the influence of food components on the intestinal microbiota's makeup and operation. The gut, often commonly known as the "second brain", is essential in multiple physiological functions beyond digestion, that includes immune function, metabolism, and even mood regulation (Mayer, 2011; Ross et al., 2024). Within the gut resides a complex ecosystem of trillions of microbes, generally referred to as gut microbiota, which interact with the host and with each other in a dynamic and mutually beneficial manner (Thursby & Juge, 2017).

A study revealed that natural polysaccharides show positive effects on the gut microbiome because of their prebiotic characteristics (Blanco-Pérez et al., 2021). The results of research indicate that natural polysaccharides have prebiotic properties that can beneficially influence gut microbiota (Liang et al., 2018).

This review explores the prebiotic properties of dates and their impact on intestinal microbiota, highlighting their implications for gut and overall health.

Nutritional Profile of Dates

Date palms offer notable advantages in terms of nutrition, the environment, the economy, and aesthetics. Date fruits provide abundant macro- and micronutrients at a low cost (Al-Farsi & Lee, 2008; Biglari et al., 2009). European guidelines highlight that consuming carbohydrate-rich foods with a low glycemic index is permissible when taken with suitable foods, as they can enhance blood sugar levels, such as date fruits (Alsarayrah et al., 2023).

Resh dates have a moisture content of 42.4g per 100g, whereas dried dates have a moisture content of 15.2g per 100g. Drying dates under the sun decreases moisture levels and helps to keep them fresh. The quality of drying is influenced by both humidity and temperature (Ashurst PR., 1996). Fresh dates have 54.9g of carbohydrates per 100g, while dried dates have 80.6g. Both contain high fiber and sugar content, which providing energy (Al-Farsi et al., 2005; USDA. 2023). Dates are high in ash, fat, and protein. Higher protein content is seen in dry dates (2.45g /100g) and fat (0.39g/100g) compared to fresh dates as a result of water evaporation. Values can be influenced by factors such as the conditions during drying (Table 1). The ash content is 1.67 grams per 100 grams (Al-Farsi et al., 2005; Al-Farsi & Lee, 2008; USDA. 2023).

The main sugars found in dates that are fresh and dates that are dried consist of fructose, sucrose, and glucose. Fresh dates contain a total sugar content of 43.4g per 100g, including 4.03g of sucrose, 19.4g of fructose, and 22.8g of glucose. The sugar levels in dried dates increase to 64.1g/100g, with 30.4g/100g of glucose, 29.4g/100g of fructose, and 11.6g/100g of sucrose (Ismail et al., 2006; Yousif A et al., 1982). Dates contain a range of essential minerals like iron, calcium, phosphorus, magnesium, potassium, copper, selenium, and manganese. Eating 100g of dates can supply around 15% of the recommended daily consumption of minerals. Dates are advantageous for those who have hypertension due to their reduced sodium and elevated potassium levels (Appel et al., 1997). Dried dates offer a reasonable quantity of vitamins B2, B3, B6, and B9, meeting approximately 9% of the daily allowance suggested intake per 100g. They have low levels of vitamins A, C, and B1, offering approximately 7% per 100g (Table 2) (Al-Farsi & Lee, 2008; USDA. 2023).

Research indicates that dates contain insoluble fiber. The fiber content rises from 7.5g/100g to 8g/100g during the drying process of dates. Growth in ripeness through decrease in moisture or breakdown by enzymes into soluble compounds (Thier, 1976). On average, dates contain 0.84g/100g of soluble dietary fiber, 5.76g/100g of insoluble dietary fiber, and a total dietary fiber 8g/100g (Al-Shahib & Marshall, 2002; Myhara et al., 1999; USDA. 2023). The suggested daily consumption of dietary fiber is approximately 25 grams per day (Marlett et al., 2002). Dates contain high levels of fiber, as 100g of dates can provide around 32% of the fiber that should be consumed daily. Insoluble dietary fiber has a major physiological impact on our body. Increasing stool weight can have a laxative effect, protecting our bodies from illnesses like colon cancer and diverticular disease (Marlett et al., 2002).

Phases of Dates Ripening

Date fruits undergo several developmental phases referred to as Kimri, Khalal, Rutab, and Tamar (Al-Farsi & Lee, 2008). Numerous researches has documented the chemical and physical transformations that dates experience while they progress through these phases (Table 3) (Figure 1) (Al-Farsi & Lee, 2008; Al-shahib & Marshall, 2003).

Kimri Phase

During the kimri Phase, dates have a high moisture content, typically around 85%. During this period, the date fruit grows larger, heavier, and sweeter. The fruit's color changes to yellow or red towards the phase's ending, based on the kind of date (El-Gioushy et al., 2022).

Khalal Phase

At this point, dates have a red, pink, or yellow color and a firm texture. The moisture level in fruit decreases over time, causing sucrose to be transformed into reducing sugars like fructose and glucose. Fruit typically has a Total Soluble Solids (TSS) ranging from 30 to 45 °Brix, with a slow weight gain and a reduction in astringency while they ripen. In certain cultivars, sucrose transformation occurs rapidly, and the fruit becomes tasty during the khalal phase (Al-Farsi & Lee, 2008).

Rutab Phase

The date tip begins to brown as it transitions into the rutab phase. fruits become lighter as they lose moisture. The fruit's current moisture level is 35%. Softening of tissues and browning of the skin also takes place during this phase. Sucrose is further converted into glucose and fructose. Dates are available without astringency and have a total soluble solids (TSS) measurement of 55 - 60 °Brix (El-Sharnouby GA et al., 2009).

Tamar Phase

Dates are completely dried when they reach the tamar stage and have a moisture content of 20%, while also being completely mature with a sugar content measuring between 60 and 84° Brix (El-Sharnouby GA et al., 2009).

Prebiotics and Their Role in Gut Health

Prebiotics, classified as non-digestible food components such as fibers and certain carbohydrates, are essential for promoting a healthy gut microbiome. Through selectively stimulating the development and activity of good bacteria, prebiotics contribute significantly to gut health maintenance. Recent research Merlo et al. (2024); Zhou et al. (2024) has shed light on their pivotal influence on modifying the makeup and activity of the gut

microbiota, impacting essential aspects of human health such as immune response, metabolism, and mental well-being. Evidence suggests that regular use of prebiotic-rich foods can enhance gut barrier function, mitigate inflammation, and boost the synthesis of short-chain fatty acids, all crucial factors for optimal gut health (Holscher, 2017; Rinninella et al., 2019). Furthermore, prebiotics have demonstrated potential in alleviating indications of gastrointestinal diseases like inflammatory bowel disease (IBD) and irritable bowel syndrome (IBS), as well as aiding in the management of obesity (Gibson et al., 2017).

Prebiotics are essential elements of the diet that specifically promote the development and function of helpful gut bacteria, thereby conferring numerous health benefits. These non-digestible fibers and carbohydrates serve as substrates for the fermentation process carried out by beneficial gut microbes, leading to the process that yields butyrate, propionate, and acetate, three short-chain fatty acids (SCFAs). SCFAs operate as pivotal role in maintaining gut barrier integrity, regulating immune function, and modulating energy metabolism (Du et al., 2024; Hill et al., 2014). Furthermore, prebiotics encourage the development of particular advantageous bacterial strains, such as *Lactobacilli* and *Bifidobacteria*, which are renowned for their anti-inflammatory and immunomodulatory characteristics (Gibson et al., 2017).

Recent research has highlighted the possibility of dates (*Phoenix dactylifera*) as a prebiotic source, which are able to beneficially influence digestive system health by modulating intestinal microbiota. Dates are rich in dietary fibers, particularly non-digestible oligosaccharides, which can act as the basis for beneficial gut microbe, encouraging their development and activity (Al-Farsi & Lee, 2008). This prebiotic effect can lead to improved gut barrier function and enhanced production of (SCFAs), which play an essential role in maintaining gut health and reducing inflammation (Chandrasekaran & Bahkali, 2013). Furthermore, research conducted by Eid et al., (2014) demonstrated that regular consumption of dates significantly increased the profusion of good bacterial strains like *Lactobacillus* and *Bifidobacterium* in the gut, suggesting a beneficial link between date consumption and enhanced intestinal microbiota composition. These findings support the potential role of dates as a natural dietary component for promoting gut health through prebiotic mechanisms.

Impact of Dates on Gut Microbiota

The human gastrointestinal system can accommodate billions of microbes, with over 1014 bacteria of 2000 different species residing within it (Kau et al., 2011). The human intestinal microorganisms are made up of over. There are fifty bacterial phyla, the most common being *Firmicutes* and *Actinobacteria* (gram positive), *Bacteroidetes* (gram negative), *Proteobacteria*, and *Verrucomicrobia* (D'Aversa et al., 2013). Food primarily has an impact on the gut microbiome (Turnbaugh et al., 2009). Alterations in the makeup of the gut bacteria (dysbiosis) are linked to inflammation and health issues related to aging. Hence, regulating the gut microbiota is seen as a crucial strategy for managing age-related inflammation (D'Aversa et al., 2013). With high levels of carbohydrates, fiber, protein, fat, and vitamins and minerals ranging from 44–88%, 6.4–11.5%, 2.3-5.6%, 0.2-0.5%, and 15 grams, respectively, dates are a nutrient-dense and energy-boosting meal (Khan et al., 2016). Dates are rich in phenolic compounds, with high antioxidant and flavonoid levels observed across various types and ripening stages (Singh et al., 2012). Consuming dates directly or with polyphenol-rich extracts led to alterations in gut bacteria. Consuming dates can support gut health by promoting the growth of beneficial microorganisms and suppressing harmful bacteria linked to metabolic disorders (Eid et al., 2014).

The research done by Karim et al. (2024) assessed the impact of Ajwa date extract (ADE) on the Sprague Dawley rats' intestinal microbiota after they were fed a high-fat diet (HFD). Findings indicated that ADE significantly increased the prevalence of good bacteria, includes *Lactobacillus* and *Bifidobacterium*, while reducing harmful microorganisms like *Clostridium* and *Escherichia coli*. Additionally, ADE administration resulted in decreased blood glucose levels and body weight, demonstrating its potential to modulate gut microbiota and mitigate metabolic disorders associated with obesity. And in another study Eid et al. (2015) conducted in random, controlled human intervention research to investigate the effects eating palm dates on the development of microbiota and the health of the large intestine. Despite no significant changes in choose bacterial group or (SCFA) levels, dates increased bowel movements, reduced stool ammonia concentration, and decreased faecal water genotoxicity. The study suggests that date consumption may mitigate colon cancer risk without altering the microbiota significantly.

Potential Health Benefits of Dates Beyond Gut Health

Dates (*Phoenix dactylifera L.*) are not only known for their prebiotic effects and positive impact on gut health but also for a wide range of medicinal benefits that extend well beyond the digestive system. Rich in essential nutrients, antioxidants, carotenoids, procyanidins, flavonoids, phenolics, anthocyanins, and sterols, dates offer several potential health benefits that contribute to overall health (Al-Alawi et al., 2017; Baliga et al., 2011; Vayalil, 2012).

Anti-inflammatory and Antioxidant Properties

The potential antioxidant properties of date palm seeds and leaves are of particular interest due to the effectiveness of phenolic compounds in naturally combating reactive oxygen species and free radicals. These compounds help reduce oxidative damage to proteins, nucleic acids, and lipids, which lowers the risk of illness by minimizing free radical production and its harmful effects (Shahidi, 2000). Several phenolic substances, such as epicatechin, catechin, and proanthocyanidin dimers, and ferulic acid, were identified in the seeds and leaves in research by John & Shahidi (2019). The date palm (*Phoenix dactylifera L.*) was examined for its phenolic content and antioxidant activity in its seeds and leaves. The leaves had greater phenolic concentration than the seeds. Extracts demonstrated strong radical scavenging activity and inhibited cooked ground meat oxidation. Seed extracts notably inhibited DNA strand scission, while leaf extracts inhibited LDL

cholesterol oxidation. In another study by Begum et al. (2024), the pharmacological potential of date seeds was explored. Activities of Pain relief, inflammation reduction, and muscle spasm prevention were evaluated using acetic acid-induced writhing, carrageenin-induced edema, and charcoal-induced spasm tests. The seeds' organic components effectively reduced pain in a dose-dependent manner, with n-hexane partition achieving notable results. In the anti-inflammatory test, the Ajwa seeds methanol extract displayed the most significant decrease in paw edema, closely following the standard drug. The examination of plant chemicals showed the existence of flavonoids, glycosides, carbohydrates, and fats, with each extract having distinct dominant compounds. These results suggest the seeds' potential as a source of natural therapeutic agents. Butler et al. (2022) carried out a randomized controlled experiment to evaluate the impact of eating three dates every day for 16 weeks on blood sugar levels, body mass index (BMI), quality of life, and lipid levels in individuals with T2DM. The research involved 100 T2DM subjects divided into two groups: one consuming dates and the other avoiding them. Results showed that date consumption significantly improved the lipid profile by reducing total cholesterol and LDL levels. However, BMI and HbA1c levels remained unchanged. Additionally, quality of life improved significantly due to enhanced mental health. The study suggests that dates can benefit lipid profiles without impacting glycemic index because of their low glycemic content.

Cardiovascular Health

The benefits of dates for cardiovascular health are renowned. They contain important levels of potassium, magnesium, and antioxidants, which are essential for promoting heart health. Grazioli et al. (2022) has demonstrated that dates can decrease blood pressure and enhance lipid profiles, ultimately lowering the chances of developing cardiovascular diseases. Moreover, dates' high fiber content also helps in lowering cholesterol levels, promoting better heart health. Recent studies have shown that eating dates regularly can enhance vascular function and decrease inflammation, which can help maintain heart health (Barakat & Alfheeaid, 2023; Butler et al., 2022). The research carried out by Alsaif et al. (2007) aimed to assess the impacts of dates, gahwa (Arabian coffee), and their impact on lipid metabolism in hamsters with high cholesterol levels. Six groups from Golden Syrian hamsters were fed different diets, including a control chow, dates, dates with gahwa, and high cholesterol with combinations of dates and gahwa for a duration of 13 weeks. The diet heavy in cholesterol significantly increased body and organ weights and plasma lipids, while the dates diet notably reduced these increases. However, dates combined with a high-cholesterol diet elevated hepatic TC levels. Gahwa alone did not significantly impact lipid parameters. The findings suggest that dates may have beneficial effects on lipid metabolism and body weight, potentially reducing atherosclerosis risk. Another study done by Alalwan et al. (2020) carried out a controlled, randomized experiment to evaluate the impacts of consuming 3 dates a day for 16 weeks on blood sugar levels, weight-to-height ratio, overall well-being, and fat content in the bloodstream of individuals with type 2 diabetes subjects. The study involved 100 T2DM subjects divided into two groups: one consuming dates and the other avoiding them. Results showed that date consumption significantly improved the lipid profile by reducing total cholesterol and LDL levels. However, BMI and HbA1c levels remained unchanged. Additionally, quality of life improved significantly due to enhanced mental health. The study suggests that dates can benefit lipid profiles without impacting blood sugar levels because of low glycemic index.

Neuroprotective Effects

Dates *(Phoenix dactylifera L.)* exhibit neuroprotective effects because of their anti-inflammatory and rich in antioxidant capabilities. Studies show that the polyphenols and flavonoids in dates can mitigate oxidative stress and inflammation, important elements in neurological conditions like Parkinson's and Alzheimer's. Recent research suggests that date consumption can protect neurons from neurotoxicity and promote cognitive health, highlighting their potential role in preventing and managing neurodegenerative conditions(Baliga et al., 2011; Vayalil, 2012; Al-Alawi et al., 2017). Essa et al. (2015) conducted research on effects of dietary supplementation with date palm fruits, rich in antioxidants and phenolic compounds, on Alzheimer's disease (AD) progression in transgenic mice. Mice fed with 2% and 4% date supplementation showed improved memory, reduced anxiety, and enhanced motor skills compared to standard diet-fed AD mice. Levels of amyloid beta proteins, associated with AD, were significantly lower in supplemented groups. Findings suggest date fruit supplementation may mitigate AD risk or progression. The 4% supplementation demonstrated greater neuroprotective effects (Alkaabi et al., 2011; Rock et al., 2009).

Blood Sugar Regulation

Consuming dates in moderation can be beneficial for individuals who have diabetes. Dates possess a glycemic index that is relatively low and are rich in fiber, which helps to slow glucose absorption into the bloodstream, preventing significant spikes in blood sugar levels. They are also high in antioxidants, vitamins, and minerals, contributing to overall health. Research suggests that different varieties of dates have varying effects on blood sugar levels, but generally, it is recommended to limit intake to 2-3 dates per day for diabetic individuals to maintain stable blood sugar levels (Rock et al., 2009; Alkaabi et al., 2011; Vayalil, 2012; Alalwan et al., 2020). In the last in vivo research Butt (2020) research at the Postgraduate Medical Institute in Lahore investigated the antihyperglycemic and nephroprotective effects of Ajwa seed and fleshy part in rats with diabetes. The study found that the Ajwa pit significantly reduced blood glucose, urea, creatinine, and microalbuminuria markers, while also improving urine creatinine and creatinine clearance. However, the effect of Ajwa pulp was less pronounced. These results suggest that the Ajwa pit may possess strong antihyperglycemic and renal protective properties, likely because of its high level of polyphenols, bioflavonoids, and antioxidants. Abdullah & Al-boka (2022) study assessed the effects of date palm seed methanolic extract (PDS) on diabetes induced by dexamethasone in rabbits.

The research involved seven groups of rabbits receiving different treatments orally for 30 days. Results indicated significant anti-diabetic effects of PDS extract, potentially attributed to its flavonoid and fatty acid content. Pancreas tissue regeneration was observed histologically. While suggesting the extract's hypoglycemic potential, further investigation is necessary to identify its bioactive compounds and mechanisms of action (Abdullah & Al-boka 2022).

Future Trends and Perspectives on Gut

Recent research on the effects of dates fruit consumption on gut health reveals promising trends and perspectives. Studies indicate that dates possess prebiotic properties, promoting the development of advantageous gut flora like *Lactobacillus* and *Bifidobacterium* (Al-Farsi & Lee, 2008). These fruits are rich in fiber, particularly soluble fiber, which aids in digestion and contributes to a healthy gut microbiome (Sekirov et al., 2010). Furthermore, dates contain polyphenols, antioxidants that may exert anti-inflammatory effects in the gut, potentially reducing the risk of gastrointestinal disorders (Vayalil, 2012). However, more clinical trials are needed to validate these findings and elucidate the mechanisms behind the observed benefits (Bagherzadeh Karimi et al., 2020). Incorporating dates into the diet as a natural source of prebiotics may offer a feasible strategy for improving gut health and overall well-being (Fekete et al., 2024). Further investigation of the varied viral environment in the human gut offers the potential to discover new ways to comprehend gut health and disease. As our knowledge of the gut microbiome keeps developing, exploring therapeutic potential of dates fruit represents an intriguing avenue for future research (Fekete et al., 2024; Leviatan et al., 2022).

Conclusion

Dates *(Phoenix dactylifera L.)* hold significant promise as a natural dietary component for enhancing gut health and overall well-being. Rich in fibers, polysaccharides, and various beneficial compounds, dates exhibit prebiotic properties that promote beneficial gut microbiota, improve gut barrier attribute, and enhance (SCFAs) production. Beyond gut health, dates offer anti-inflammatory, antioxidant, cardiovascular, neuroprotective, and blood sugar regulation benefits. Future research should focus on clinical trials to further validate these findings and uncover the underlying mechanisms. Incorporating dates into the diet represents a feasible strategy for improving health and managing gastrointestinal disorders.

Declarations

Ethical Approval Certificate

None

Author Contribution Statement

Please indicate how each author contributed to this work and at what stage. For example:

A.A.: Literature review, investigation, conceptualization, and writing the original draft, review and editing.

M.K.B.: Supervision, conceptualization, visualization, review and editing.

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Conflict of Interest

"The authors declare no conflict of interest."

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