Date Seeds as a Nutrient-Rich Source: Analysis of Macro and Micronutrient Content

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ABSTRACT:

Date seeds, often discarded as agricultural waste, possess significant untapped nutritional value. This study aims to thoroughly examine their macro- and micronutrient composition to evaluate their potential as a nutrient-rich food source. The analysis reveals high levels of key macronutrients, including carbohydrates $(74.27 \pm 2.25 \text{ gm})$, protein $(7.81 \pm 1.5 \text{ gm})$, fat $(8.19 \pm 0.8 \text{ gm})$, and crude fat $(8.01 \pm 0.85 \text{ gm})$, along with essential micronutrients such as vitamin C (19.16 ± 1.75 mg), insoluble dietary fiber ($7.59 \pm NA$ mg), total sugar (2.3%), moisture content (6.83 \pm 0.6%), pH, viscosity, water absorption capacity, and various minerals. Among the minerals, date seeds contain sodium (0.79 ± 0.22 mg), zinc (0.33 ± 0.02 mg), phosphorus (82.00 ± 2.25 mg), copper (0.10 ± 0.02 mg), manganese (8.5 ± 0.03 mg), lead (0.172 ± 0.01 mg), and chromium (0.00135 ± 0.03 mg). Additionally, the seeds are rich in important micronutrients such as potassium (11.32 \pm 1.2 mg), magnesium (54.02 \pm 0.04 mg), calcium (6.38 \pm 1.24 mg), and iron (0.88 \pm 0.02 mg), as well as vitamins like vitamin B and antioxidants. The study also highlights the high fiber content, which can contribute to better digestive health. The presence of bioactive compounds with antioxidant and anti-inflammatory properties underscores the potential therapeutic benefits of date seeds in preventing chronic diseases. These findings position date seeds as a valuable, sustainable resource for dietary supplements, nutraceuticals, and functional foods, offering an innovative approach to improving global nutrition while reducing food waste.

Keywords: Dates seeds powder, Macronutrients, Micronutrients.

1. INTRODUCTION:

There was historical significance to the date palm. Around 4000 BC, this plant is believed to have originated on the plains of Mesopotamia, Palestine, or northern Africa (Morocco). Since 3000 BC, it has expanded into parts of Egypt, Africa, Central Asia, and the surrounding regions. The date palm is a really meaningful location to be in terms of religion. However, Egypt produces 1.5 million tons of dates a year, which accounts for an average of 18 percent of the 7.5 million tons produced worldwide, **El-Sharabasy** *et al.*, (2019).[22]

The production and use of Iranian dates (Phoenix dactylifera L.) dates back to approximately 4000 BC. The Iranian community consumes the more than 400 distinct kinds of dates that are available. The purpose of this research was to create an exhaustive list of the items frequently found in Iranian cuisine that are made from dates and their fruits. The world's largest producer of dates is Egypt, followed by Saudi Arabia,



Iraq, Iran, Algeria, and Pakistan. The amount of dates produced worldwide increased from 6.7 million tons in 2004 to over 7.5 million tonnes in 2014. Iran produced more than 1.15 million tons of dates, ranking first among Asian nations, according to the U.N. Food and Agriculture Organization. (Http: //www.fao.org/faostat/en/#data in 2014). [19]

Given that the world produced 8 million tons of dates in 2018 (FAOSTAT 2018), date seed constitutes a substantial amount of trash. As a result, more than 800,000 tons of date might be made. Traditionally, date fruits are either utilized as soil fertilizer or as feed for animals and poultry. **(Vandepopuliere et al., 1995). [44]**

In the country of Iran or as pronounced in Chinese language "Bousi" is referred to as the Persian jujube, or country of date palm and 1,000-year-old jujube in their language. In the late 9th century, the date palm was taken to China from Iran and was planted there. Amongst European countries, Spain has a longer history in growing date palms. The food eat of the Iranian humans they can eat an average 7 kg of dates per year. The Each year by head eat dates in southern district of Iran is 25 kg, at the same time the estimated value of 100 gm is reported for the European Union in 2012. The 2nd Aim is the humans got smart to use the traditional medicine that they refer to eat dates in daily meal. The next suggestion of the Iranian humans used in Islamic society. The population of Iranians are Muslim-98% Approximately 80 million people. (Al-Mamary. M. *et al.*, 2014). [7]

The Dates is the one of most famous fruits in Iran and the world. Dates planting dates back to over 5000 years ago and however, it is written in religious books like Bible & Quran. People that are connected to the Kingdom of Saudi Arabia have a general understanding of the date palm. The humans are using to eat date as main dish. In the India date fruit are mostly available in the local shops, In the Ramadan untill Eid Hajj's month that its consumption tend to increase. The mature date fruits are Arrange into 3 groups its quality depends on the various parameters like its moisture content i.e., soft date type (>50% moisture) semi dry type (24-50% moisture) and dry type (<24% moisture) according to AI-Shahib and Marshall, (2003). [9]

A popular fruit tree, date palms are grown around the world, but particularly in the Middle East. They also significantly effect on the economics, environment, and society of many people who reside in arid areas of the globe (Mustafa A. I. *et al.*, 1983). [32] The fruit of the date palm is composed of a seed and a thick pericarp. Ten to fifteen percent of the date fruit is made up of the date seed, sometimes known as a pit or stone. Since date seeds were discovered to be beneficial for business, the economy, and nutrition. (S. Sirisena. S, Ng, K *et al.*, 2015) & A. Golshan Tafti, N. *et al.*, (2017). [36, 1]

The date tree, which may reach a height of 21 to 23 meters, is a flowering plant that is mostly planted for its edible fruit. Its leaves have about 150 leaflets and can grow up to 4 or 6 meters in length. AL Mahmoud *et al.*, (2020). [4] Date trees typically have a single root system and can grow alone or in clusters. Globally, some 100 million date trees are grown, the most of which are in the Middle East. Al-Shwyeh *et al.*, (2019) and AL Mahmoud *et al.*, (2020). [4 and 10]

In female date trees, the fruit stalk, occasionally known as a flat, tapering peduncle or rachis and bears the dates. A number of unbranched rachillae, or strands, are organized in a spiral arrangement along the rachis of the inflorescence. Three petals and three sepals are common in both men and women flowers. Male blooms are usually waxy white, In contrast, women blooms are often yellowish-green in color. Just the area of the rachilla with the blossoms is visible. About fifty to sixty days after anthesis, the fruit stalk lengthens and extends the inflorescence's non-flowering portion to a length of 60 to 120 cm. One of each pistillate flower's three carpels produces fruit following fertilization. 25 to 35 days after the spathe cracks,



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fruit naturally drops, and some cultivars see a second drop about 100 days later. Chao.C.T. et al., (2007). [17]

Since the Iranian dates palm is mostly grown in Iran, India is the world's largest consumer of Iranian dates, purchasing a sizable amount of Iran's exports. Although India produces its own dates, mostly in Gujarat and Rajasthan, they are not regarded as Iranian dates because of their varied origins and variety. India doesn't manufacture.

The seeds of the date According to a chemical composition investigation, date seeds have a low protein content, 4–14% oil, and 60–80% fiber by weight A multitude of compounds can be found in date seeds, including terpenoids, alkaloids, flavonoids, anthraquinone, saponin, and tannin, is known as vital minerals like calcium and potassium. (Al-Farsi and Lee 2008). [5]

The Date is the traditional crop, highly nutrients rich component for people daily mile in the Arab world. Because is rich in (vitamins, minerals, carbohydrates, fibers and it has health benefits. (Ava a. amin et al., 2020). [15] It has always play the importance role in economic and social life of the inhabitants of the oases. (Al-Mssallem et al., 2020). [8]

Iranian dates are exported in significant quantities to over 70 nations worldwide each year. You should contact a trustworthy business to place an order for dates and find out more about the current cost of Iranian dates. Every year, Crystal Dates, a well-known and trustworthy company, produces, packs, and distributes large quantities of Iranian dates and their byproducts, such as chopped dates, to customers worldwide. Iranian national style dates are readily available. The date palm is one of the most significant fruit crops among the world's sweltering sand dunes. It has a high nutritional value. (Abbes F, et al., 2011

& Sawava W.N. et al., 1983). [2, 38]

The Date seeds are reported that the contain are present such as like minerals, sodium as Na, potassium as K, magnesium as Mg, calcium, phosphorus, iron as Fe, manganese as Mn, zinc as Zn, copper as Cu, nickel, cobalt, chromium as Cr, lead as Pb and cadmium (Abdillah and Andriani, 2012). [3]

In the Quran, dates are mentioned in a number of places. Given the high production of dates and their popularity among consumers, many foods prepared using dates are produced. These include date juice, date seed flour, and fermented date concentrate etc. (Jridi. M. et al., 2015 & aya a. amin. et al., 2020). [26, 15]

The date that is safe for consumption its utilization to manufacture many products, like date juice concentrates (spread, syrup, and liquid sugar, the most common in bakery and confectionary), the production of fermented products like wine, alcohol, vinegar and organic acids (Chandrasekaran and Bahkali 2013). [16]

2. MATERIALS AND METHODS:

2.1 Materials

All the Raw material Dates seeds was purchased from the local Market at Beed, Maharashtra. The research that was proposed was conducted in MGM Institute of Biosciences & Technology. N-6, CIDCO, Chhatrapati Sambhajinagar (Aurangabad), Maharashtra, India.

2.2.1. Preparation process of Dates Seeds Powder:

Iranian finest dates are local quality dates which are buyed from local market at Beed, Maharashtra. Due to the fact that those dates are readily available in the local market for residents who are part of middle class families.

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Fig: 1. Flow chart of Preparation of date seed powder

2.3. Proximate analysis:

2.3.1. Estimation of moisture content:

The Estimation of moisture content by using Methods (AOAC, 2000). [11] Among oven-drying methods for moisture determination, sterile empty petri dish and lid were dried in the oven at 105°C for 3hours and transferred to desiccator to cool. Weight of empty petri dish and lid to be noted. About 5 grams of the sample was weighed in the dish. The dish was placed in the hot air oven at 105°C for 3hours. After drying, the petri dish was cooled in the desiccator. The dish containing the dried sample was again weighed till we achieved constant weight followed with 1 hour interval. Then calculate the moisture content using formula of moisture content.

Calculation:

(%) Moisture = [Wt. of sample before drying – Wt. after drying] \times 100

[Wt. of sample]

2.3.2. Determination of ash content:

Using gravimetric techniques, the amount of ash was determined (AOAC, 2000). [11] The inorganic residue that remains in food after organic matter has been completely oxidized or ignited is referred to as ash. A steady weight was achieved by heating, cooling, and weighing the crucible. The crucible was filled with 5–10 grams of the food sample. A modest Bunsen flame was used to heat the crucible. After the vapors stopped being created, the crucible was heated to 525°C for four to six hours in a muffle furnace. After cooling in a desiccator, the crucible was weighed. The crucible was once more heated in the muffle furnace for an hour, cooled, and weighed to guarantee full ashing.



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Calculation:

The amount of ash (g/100g sample) =

 $\frac{Weight of the ash}{Weight of the sample taken} \times 100$

2.3.3. Estimation of Fat content:

The Evaluation of Fat content by solvent extraction Technique is using Soxhlet Apparatus (AOAS, 2000). [13] Take 10 gm of the food sample is wt. and transferred to a 250ml Erlenmeyer flask is full filled with the hexane till the food sample was completely submerged. The mouth of the Erlenmeyer flask is covered with aluminum foil. The Erlenmeyer flask is properly mixed a minute, every half an hour. The next day, the hexane in Erlenmeyer flask is slowly decanted in a pre-weighed beaker. The beaker is stored open, for the hexane to get evaporated. Hexane was refilled into the conical flask and the repeated for 3 days. After 3 days, when the hexane had completely evaporated from the beaker, the wt. of beaker along with the fat was noted.

Calculation:

weight of beaker with fat-Fat $(g/100g \text{ of sample}) = \frac{weight \text{ of empty beaker}}{amount \text{ of sample taken}} \times 100$

2.3.4. Evaluation of protein:

The Micro-Kjeldahl aperture method was used to measure the protein concentration (Waterborg, J. H., 2009).[46] The mixture was centrifuged for 15 minutes at 5000 rpm after 1 gram of powdered material and 4 milliliters of potassium phosphate buffer were combined. A volume of one milliliter of the supernatant was used for protein estimation. A succession of test tubes were used to pipette out the working standard solution in increments of 0.2, 0.4, 0.6, 0.8, and 1 milliliter. In each test tube, distilled water was added until the volume reached one milliliter. The blank was a test tube filled with one milliliter of purified water. A solution of alkaline copper sulphate (5 ml) was added to each test tube, stirred well, and allowed to stand for 10 minutes. The Folin-Ciocalteau Reagent (0.5 ml) was added to each test tube, mixed well, and allowed to sit at a spectrophotometer was used to measure the absorbance at 660 nm and calculate the concentration.

2.3.5. Estimation of carbohydrate:

The Estimation of *carbohydrate by using the Anthrone method* (Sadasivam, S., 1996).[37] Together, let's For three hours, a test tube with 100 mg of powdered material was submerged in a boiling water bath with five milliliters of 2.5N HCl to hydrolyze it. After that, the tube was allowed to cool to room temperature. The effervescence was neutralized with solid sodium carbonate until it ceased. A 100 ml volume was added, and the mixture was centrifuged. The supernatant was taken in 1 milliliter for analysis. Transferring 0.2–1.0 milliliters of the standard solution via pipette into several tubes. Each tube was filled to the brim with distilled water. A test tube containing one milliliter of distilled water served as the blank. There were four milliliters of the Anthrone reagent in each test tube. Eight minutes passed while the test tubes.

2.3.6. Determination of mineral contents:

The estimation of mineral contents by using standard methods (AOAC). [23 & 14] For the macro-elements (potassium and sodium) and micro-elements (lead, cadmium, zinc, copper, and chromium), seed samples were prepared. Five milliliters of 0.1 N nitric acid were added to two grams of seed samples that had been turned to ash. To get the required volume, distilled water is added to the chemical. The concentrations of lead, cadmium, zinc, copper, and chromium were determined using an atomic absorption spectrophotometer, whereas the amounts of sodium and potassium were determined using flame atomic



emission. The elements' concentration was then ascertained by measuring the emission intensity and constructing a calibration curve.

2.3.7. Estimation of phosphorus:

The Estimation of phosphorus by using atomic absorption spectroscopy (AAS).Methods. The method prescribed by (Raghuramulu *et.al.* 2003). [35] Was altered and put to use. The volume was adjusted to 4 ml using double-distilled water after various aliquots of the standard phosphorus solution (0.5 ml, 1 ml, 2 ml, and 4 ml) were taken. One milliliter of the test sample was taken, and double-distilled water was added to bring the volume up to four milliliters. 0.4 Ml of the aminonaphtholsulphonic acid reagent and 1 ml of 2.5% ammonium molybdate were applied all test tube. Four milliliters of double-distilled water, one milliliter of 2.5% ammonium molybdate, and 0.4 milliliters of aminonaphtholsulphonic acid reagent is add to create the blank. After 10 minutes of room temperature incubation, the absorbance at 660 nm was measured, and the concentration A spectrophotometer was used to determine it.

2.3.8. Determination of sodium & potassium content:

The Determination of sodium & potassium content by using Whatman filter paper & Flame photometer for the analysis (AOAC 2016).[40] Take 1 gm of sample in tubes. Added 50 ml Ammonium Oxalate. Then Filter the sample solution by Whatmaan filter paper No.1 in Beaker and Read the sample ton Flame photometers.

2.3.9. Estimation of Insoluble Dietary fiber:

The Estimation of Insoluble Dietary fiber by using enzymatic-gravimetric method and liquid chromatography (Raghuramulu *et al.*, 2003). [29] Weighing two grams of the substance was done in a 500 ml conical flask. A precise half-hour was spent boiling it after 200 milliliters of 0.255N sulfuric acid were added and cooked gradually on a hot plate. In a separate conical flask, the mixture was filtered using a funnel covered with a muslin cloth. 200 - 300 milliliters of hot water were used to wash the residue off the cloth until no more acid was present. The substance was moved to the same beaker from the cloth. After adding 200 milliliters of 0.313N sodium hydroxide, the mixture was precisely cooked for half an hour. Using a funnel, the mixture was filtered through the same fabric. 200–300 milliliters of hot water were used to a crucible, the residue was cooked in a hot air furnace for at least four hours at 150–200 degrees Celsius. After cooling, it was weighed.

Calculation:

 $Crude fiber (g/100g sample) = \frac{weight of the crucible with contents before ashing}{weight of the crucible with contents after ashing} sample weight (grams)$

2.3.10. Estimation of calcium (AOAC 1980):

The Estimation of calcium by using titration with a standardized solution of ethylenediaminetetraacetic acid (EDTA). In a sanitized Erlenmeyer flask, a 25 ml aliquot of the ash solution was pipetted out. Doubledistilled water is used to dilute the chemical to 150 milliliters. After adding a few drops of methyl red indicator, the liquid was neutralized with ammonia until the light pink hue turned yellow. Ten milliliters of ammonium oxalate were added after the solution had reached a boiling point. A couple more minutes were spent boiling the mixture Glacial acetic acid was added until the color of the solution turned distinctly pink. They allowed the mixture to stand for four hours, or even better, overnight. The filtrate was run through Whatman No. 42 filter paper and then washed with warm water until the oxalate was gone. Using AgNO3 to check for the presence of chloride was simple because the ash solution had been made with



HCl. Five to ten milliliters of diluted H2SO4 were added to the filter paper, and the point of the paper was broken with a pointed glass rod. They put the filter paper into the Erlenmeyer flask. Titrating the solution against 0.01N KMnO4 after it had been heated to 70°C produced a permanent pale pink tint. Determine: 10.04 milligrams of calcium in 1 ml of 0.01N KMnO4

Calcium (mg)/ 5g food sample =

2.3.11. Estimation of total energy content:

It was approximated using the factorial approach to get the overall energy content.

Energy (kcal) = $(4 \times \text{protein}) + (9 \times \text{fat}) + (4 \times \text{carbohydrate})$

2.3.12. Determination of pH:

By using (AOAC, 2005) it was directly measured by using digital pH meter. PH meter was standardized by using buffer solution pH 7 and 4 at temperature required.

2.3.13. Titrable Acidity Test:

Titration techniques are employed in the Titrable Acidity Test (Parmar, 2003). [33] Using a volumetric pipette, 10 ml of the material was extracted and transferred into a beaker. Following the addition of phenolphthalein indicator, 1N NaOH solution was used to titrate it until a constant pink color is achieved. Titrable with 0.1 N NaOH, note the titrate value and compute the result as a percentage using a few drops of 1% phenolphthalein solution as an indicator.

3. RESULT AND DISCUSSION:

The nutritional properties of the date seed powder were examined, according to the proximate analysis of date's seeds. It has excellent nutritional qualities. Similar to the macronutrients found in powdered dates seeds Carbohydrates_74.27 \pm 2.25 gm, protein_7.81 \pm 1.5 gm, fat_8.19 \pm 0.8 gm, Crude Fat_8.01 \pm 0.85 gm and the Micronutrients are also good source of present Ascorbic Acid Vit-C_19.16 \pm 1.75 mg, Insoluble Dietary fiber_7.59 \pm NA mg, Total Sugar _2.3 \pm 1.1 %, Total Energy Kcal _367.43 \pm 1.15, Moisture_6.83 \pm 0.6 %, Ash_2.89 \pm 0.58 gm, Acidity_5.6 \pm NA %, PH_6.14 \pm 0.4, Viscosity_ N/A %, Water absorption Capacity_109.02 \pm NA % and the Minerals contents also present is good sources of amount Sodium_0.79 \pm 0.22 mg, Potassium K_11.32 \pm 1.2 mg, Calcium_6.38 \pm 1.24 mg, Zinc as Zn_0.33 \pm 0.02 mg, Magnesium as Mg_54.02 \pm 0.04 mg Iron as Fe_0.88 \pm 0.02 mg, Phosphorus_82.00 \pm 2.25 mg, Copper as Cu_0.10 \pm 0.02 mg, Manganese as Mn_08.5 \pm 0.03 mg, Lead as Pb_0.172 \pm 0.01 mg, Chromium as Cr_0.00135 \pm 0.03 mg and Respectively.

Sr. No.	Test Specification	Unit of Measurements	Test Outcome
1.	Carbohydrate content	gm./100gm	74.27 ± 2.25
2.	Protein content	gm./100gm	7.81 ± 1.5
3.	Fat content	gm./100gm	8.19 ± 0.8
4.	Crude Fat	mg/100gm	8.01 ± 0.85

Table: 3. Nutritional Analysis of Dates Seeds Powder (Macronutrients):-



Chart: 1. Nutritional Analysis of Dates Seeds Powder (Macronutrients):-



Table: 4. Nutritional Analysis of Dates Seeds Powder (Micronutrients):

Sr. No.	Test Specification	Unit of	Test Outcome
		Measurements	
1.	Ascorbic Acid [Vit-C]	mg/100g	19.16 ± 1.75
2.	Fibre	%	$7.59 \pm NA$
3.	Total Sugar	%	2.3 ± 1.1
4.	Total energy	Kcal	367.43 ± 1.15
5.	Total Moisture	%	6.83 ± 0.6
6.	Ash	gm./100gm	2.89 ± 0.58
7.	Acidity	%	$5.6 \pm NA$
8.	PH		6.14 ± 0.4
9.	Viscosity	%	N/A
10.	Water absorption capacity	%	$109.02 \pm NA$

Chart. 2. Nutritional Analysis of Dates Seeds Powder (Micronutrients):-



Table: 5. Nutritional Analysis of Dates Seeds Powder (Minerals):-

Sr. No.	Test Specification	Unit of Measurements	Test Outcome
1.	Sodium as Na	mg/100gm	0.79 ± 0.22



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2.	Potassium as K	gm./100gm	11.32 ± 1.2
3.	Calcium content (mg/100 g)	mg/100gm	6.38 ± 1.24
4.	Iron as Fe	mg/100gm	0.88 ± 0.02
5.	Zinc as Zn	mg/100gm	0.33 ± 0.02
6.	Magnesium as Mg	mg/100gm	54.02 ± 0.04
7.	Phosphorus	mg/100gm	82.00 ± 2.25
8.	Copper as Cu	mg/100gm	0.10 ± 0.02
9.	Manganese as Mn	mg/100gm	08.5 ± 0.03
10.	Lead as Pb	mg/100gm	0.172 ± 0.01
11.	Chromium as Cr	mg/100gm	0.00135 ± 0.03

Chart. 3. Evaluate physicochemical properties of Dates Seeds Powder (Minerals):



4. SUMMARY & CONCLUSION:

This study investigates the macro- and micronutrient content of date seeds (Phoenix dactylifera), highlighting their potential as a nutrient-dense and underutilized resource. Date seeds, typically discarded as agricultural waste, were analyzed for their content of carbohydrates, proteins, fats, fibers, and essential vitamins and minerals. The results show that date seeds are rich in carbohydrates 74.27 ± 2.25 gm, making them an excellent source of Energy Kcal $_367.43 \pm 1.15$. They also contain significant amounts of protein $_7.81 \pm 1.5$ gm and healthy fat $_8.19 \pm 0.8$ gm, Crude Fat $_8.01 \pm 0.85$ gm, including polyunsaturated fatty acids. In addition, date seeds are an excellent source of Insoluble Dietary fiber $_7.59 \pm$ NA mg, which may contribute to improved digestive health. Micronutrient analysis reveals a notable presence of essential Minerals contents also present is good sources of amount Sodium $_0.79 \pm 0.22$ mg, Potassium K_11.32 \pm 1.2 mg, Calcium_ $_6.38 \pm 1.24$ mg, Zinc as Zn_ $_0.33 \pm 0.02$ mg, Magnesium as Mg_54.02 \pm 0.04 mg Iron as Fe_0.88 \pm 0.02 mg, Phosphorus $_82.00 \pm 2.25$ mg, Copper as Cu_0.10 \pm 0.03 mg as well as Vit-C_19.16 \pm 1.75 mg, Furthermore, the seeds contain bioactive compounds such as antioxidants, including flavonoids and phenolic acids, suggesting potential health benefits like anti-inflammatory and antioxidant properties.



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The findings from this analysis demonstrate that date seeds are a rich source of essential nutrients, presenting a promising opportunity to repurpose them as a functional food ingredient. Their high carbohydrate content, along with significant amounts of protein, healthy fats, and micronutrients, positions date seeds as a valuable resource for enhancing human nutrition. Additionally, the presence of bioactive compounds suggests that date seeds may offer therapeutic benefits, such as supporting cardiovascular health and combating oxidative stress.

Given their nutritional profile and sustainability as an agricultural byproduct, date seeds can be explored further for use in nutraceuticals, dietary supplements, and functional foods. Future research should focus on the optimization of processing methods to enhance the bioavailability of these nutrients and the development of innovative food products derived from date seeds, contributing to both global nutrition and environmental sustainability.

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