DOI: https://doi.org/10.4314/njbmb.v40i2.14 NJBMB (2025) 40(2) 234-239

Nigerian Journal of Biochemistry and Molecular Biology

The Official Publication of the Nigerian Society of Biochemistry & Molecular Biology (NSBMB). Journal homepage: https://www.nsbmb.org.ng/journals/

e-ISSN: 2659-0042

Research Article

Comparative Evaluation of the Nutritional Composition and Antioxidant Activity of Roasted and Unroasted Date Seed *(Phoenix dactylifera)* Powder Extracts

Jamila A. Omale,[1,3,*] Bintu M. Mofio[1], Aminu Omale[2], Funmilola Audu[1], Palmah M. Nyadar[1], Suleiman M. Salisu[3], Sonia O. George[3], Godwin O. Mohammed[3], Wisdom O. Oniwon[3], Samuel A. Egu[2],

[1] *Department of Biochemistry, Faculty of Sciences, University of Abuja. Nigeria*
[2] *Department of Pure and Industrial Chemistry, Faculty of Natural Sciences, Prince Abubakar Audu University, Anyigba. Nigeria*
[3] *Department of Biochemistry, Faculty of Natural Sciences, Prince Abubakar Audu University, Anyigba. Nigeria*

OPEN ACCESS

CORRESPONDENCE
Omale J. A.
omale.aj@ksu.edu.ng
jjamie4u@gmail.com
+234-806-568-7761

ARTICLE HISTORY
Received: 29/07/2025
Reviewed: 26/10/2025
Revised: 24/09/2025
Accepted: 0404/2026
Published: 05/08/2026

CITATION
Omale J. A., Mofio B. M., Omale, A., Audu F., Oniwon W. O., Nyadar P. M., Egu S. A., Salisu S. M., George S. O., & Mohammed G. O. (2025). Comparative evaluation of the nutritional composition and antioxidant activity of roasted and unroasted date seed *(phoenix dactylifera)* powder extracts. *Nigerian Journal of Biochemistry and Molecular Biology*. 40(2), 234-239 https://doi.org/10.4314/njbmb.v40i2.14

ABSTRACT

The date seed *(Phoenix dactylifera* L.*),* a member of the *Arecaceae* family, produces seeds rich in dietary fiber, phenolics and essential nutrients. This study investigated the nutritional composition and antioxidant potential of roasted and unroasted *Phoenix dactylifera* seed powder extracts. Proximate, vitamin and mineral analyses were conducted using standardized methods. Roasting decreased moisture, and protein while carbohydrate and fat increased (carbohydrate: 73.92 ± 0.13 to 76.80 ± 0.06 %; fat: 5.54 ± 0.02 to 5.90 ± 0.04 %). while ash and crude fiber showed minor variations. Roasting reduced vitamins C, B1, B2, B3 and A. Mineral analysis showed high potassium in both samples, while roasted samples had more iron and zinc; with magnesium, sodium, calcium and phosphorus also well represented. Antioxidant activity by DPPH assay revealed an IC_{50} of 26.91 ± 0.68 µg/ml (unroasted) and 44.97 ± 0.63 µg/ml (roasted), while standard ascorbic acid showed 1.62 ± 0.04 µg/ml. FRAP peaked at 93.60 ± 0.46 % (unroasted), 92.00 ± 0.28 % (roasted) and 98.40 ± 0.27 % (ascorbic acid). Unroasted seed powder retained more nutritional and antioxidant value, supporting its use in functional foods and nutraceuticals.

Keywords: *Phoenix dactylifera; Antioxidant activity; Proximate composition; Vitamins; Minerals; Roasting.*

INTRODUCTION

In recent decades, the increasing emphasis on sustainable nutrition and functional foods has shifted attention toward the re-evaluation of agro-industrial by-products for their potential health benefits. Among these, date seeds, the hard endosperm of *Phoenix dactylifera L.*, commonly known as the date palm, are gaining recognition for their rich composition of dietary fiber, essential fatty acids, polyphenols, and natural antioxidants (Al-Farsi *et al*., 2005; Habib & Ibrahim, 2009). Although date fruits are widely consumed in various cultures, their seeds are often discarded, despite mounting evidence suggesting that they may be a valuable source of bioactive compounds with nutritional and therapeutic relevance (Baliga *et al*., 2011). Date palm cultivation spans across the Middle East, North Africa and parts of Sub-Saharan Africa and Asia, with millions of tons of date fruits harvested annually. It is estimated that there are 150 million date palms worldwide and 75% of these are found in the Near East and North African Region (Faleiro & Kumar, 2024). According to

the Food and Agriculture Organization (FAO) of the United Nations, the global production of dates has increased from just 1.8 million tons in 1962 to nearly 9.75 million tons in 2022 (Faleiro & Kumar, 2024). Given the volume of seeds generated as waste, their conversion into value-added products presents a compelling case for food sustainability and waste reduction strategies. Recent studies have highlighted that powdered date seed extracts possess notable antioxidant properties, largely due to their phenolic and flavonoid constituents, which have been associated with reduced risk of oxidative stress-related conditions, including cardiovascular diseases, type 2 diabetes, neurodegenerative disorders and some cancers (Allaith, 2008; Borochov-Neori *et al*., 2015).

Processing methods significantly influence the nutritional and functional properties of plant-based materials. Roasting, a traditional and cost-effective method, has been shown to induce Maillard reactions that can enhance antioxidant activity by increasing the availability of certain phenolic compounds or by generating new antioxidant substances (Shahidi & Naczk, 2004; Ahmed *et al*., 2024). However, excessive heat may also degrade heat-sensitive micronutrients and diminish total antioxidant capacity. In the context of date seeds, some preliminary investigations suggest that roasting may affect not only the sensory qualities but also the chemical composition and biological activities of the seed powder (Fikry *et al*., 2019). Despite this, a detailed comparison of the nutritional and antioxidant profiles of roasted versus unroasted date seed powder has not been adequately explored.

This study aims to fill this gap by conducting a comparative analysis of roasted and unroasted date seed powder extracts, focusing on their antioxidant activities and nutritional composition. Specific parameters to be evaluated include vitamin and mineral content determination, proximate composition (including crude fat, protein, fiber, ash, carbohydrate and moisture content) and also DPPH radical scavenging activity. By understanding how roasting alters the functional and nutritional qualities of date seed powder, this work may support the integration of this by-product into functional food systems and nutraceutical formulations

The broader implications of this research extend beyond food science. It intersects with public health, environmental sustainability and the economy, particularly in regions where date palm agriculture is prevalent. The findings could inform efforts to utilize low-cost, locally available resources in health promotion and disease prevention, while also contributing to the circular bioeconomy and food system resilience.

MATERIALS AND METHODS

Sample preparation

Date seeds were obtained from mature *Phoenix dactylifera* fruits, thoroughly washed and air-dried to remove adhering fruit pulp. The seeds were then divided into two batches: one batch was roasted in a hot air oven at 180°C for 15 minutes, while the other remained unroasted. Both batches were ground into a fine powder using a Buchymix blender and stored in airtight containers at 4°C until analysis.

Vitamin analysis

Vitamin C determination

Vitamin C content was determined by titration with 2,6-dichlorophenolindophenol dye solution (AOAC, 2016). The extract was titrated with the dye until a light pink endpoint persisted for 15 seconds.

Vitamin A determination

Vitamin A and beta-carotene content was quantified spectrophotometrically after extraction with cold acetone and partitioning into petroleum ether. Absorbance was read at 450 nm. The method of Rodriguez-Amaya and Kimura (2004) was followed.

B-complex vitamin (B1, B2, B3) determination

Thiamine (B1), riboflavin (B2), and niacin (B3) content was analyzed using high-performance liquid chromatography (HPLC), following the revised method of Ndaw *et al*. (2000). Samples were acid-hydrolyzed and enzymatically treated before filtration and HPLC analysis.

Mineral content determination

Mineral content was determined using Atomic Absorption Spectrophotometry (AAS) after wet digestion with a nitric-perchloric acid (HNO_3-$HClO_4$) mixture, following AOAC Method 968.08:

Calcium (Ca), Magnesium (Mg), Iron (Fe) and Zinc (Zn) were quantified using AAS. Phosphorus (P) was determined calorimetrically using the molybdovanadate method. Sodium (Na) and Potassium (K) were measured using a flame photometer

Determination of proximate composition

All proximate analyses were conducted following AOAC (2016) standard methods:

Moisture content was determined by oven-drying at 105°C until constant weight (AOAC Method 925.10). Ash content was measured by incineration in a muffle furnace at 550°C for 5 hours (AOAC Method 923.03). Crude lipids were extracted using the Soxhlet extraction method with petroleum ether (AOAC Method 920.39). Crude fiber was determined using acid and alkali digestion (AOAC Method 962.09). Crude protein was estimated using the Kjeldahl method with nitrogen content multiplied by a factor of 6.25 (AOAC Method 984.13). Carbohydrate content was calculated by difference: Carbohydrate (%) = 100% - (% Moisture + % Ash + % Protein + % Fat + % Fiber)

Antioxidant activity determination

DPPH Radical scavenging activity

The antioxidant activity was evaluated using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging method as described by Brand-Williams *et al*. (1995). A volume of 1 mL of extract was added to 2 mL of 0.1 mM DPPH methanolic

solution. The mixture was incubated in the dark at room temperature for 30 minutes and absorbance was measured at 517 nm using a UV–V is spectrophotometer. The percentage inhibition and IC_{50} values were calculated accordingly.

Ferric reducing antioxidant power (FRAP) Assay

The FRAP assay was carried out according to the method described by Benzie and Strain (1996), with slight modifications. The working FRAP reagent was prepared by mixing 300mM acetate buffer (pH 3.6), 10mM TPTZ (2,4,6-tripyridyl-s-triazine) solution in 40mM HCl and 20mM $FeCl_3.6H_2O$ in a 10:1:1 ratio.

A volume of 100 µL of the sample extract was mixed with 3 mL of freshly prepared FRAP reagent and incubated at 37°C for 4 minutes. The increase in absorbance was measured at 593 nm using a spectrophotometer. Ascorbic acid was used as the standard and results were expressed as a percentage of ascorbic acid activity.

RESULTS

Figure 1a. shows a clear decline in vitamin content post-roasting. Vitamin C content dropped significantly from 12.29 mg/100g in unroasted to 7.98 mg/100g in roasted.

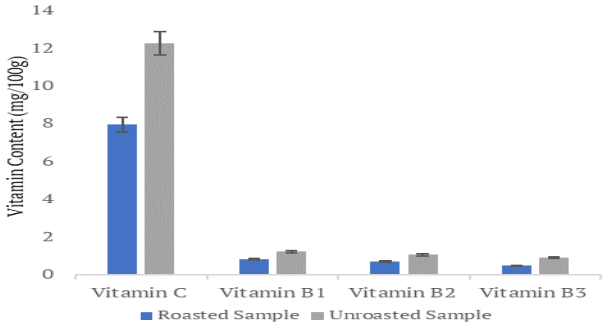

Figure 1a. Determination of B-Vitamin Contents in Roasted and Unroasted Date Seed Powder Extract

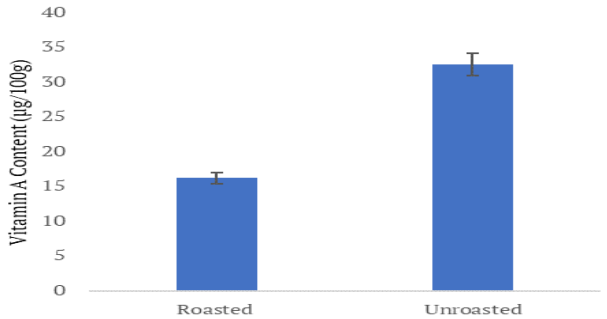

Figure 1b. Determination of Vitamin A Content in Roasted and Unroasted Date Seed Powder Extract

Mineral content determination

Table 1 reveals significant differences in the mineral composition of roasted and unroasted date seed powder extract. In the displayed result, Potassium (K) was found to be the most abundant mineral in both roasted (229.00 mg/kg) and unroasted (232.10 mg/kg) samples, with a slightly higher concentration in the unroasted form. Magnesium (Mg) and Calcium (Ca) are relatively similar between treatments, with unroasted having a marginally higher Mg content and roasted showing slightly higher Ca. Phosphorus (P) content is notably higher in roasted seeds (115.50 mg/kg) compared to unroasted (107.10 mg/kg), suggesting enhanced availability due to roasting-induced breakdown of phytates. Sodium (Na) and Zinc (Zn) also showed a slight increase in roasted samples. Iron (Fe) content decreases notably from 5.20 mg/kg (roasted) to 3.70 mg/kg (unroasted), indicating that roasting might enhance bioavailability or extractability of iron or may be due to the release or concentration of bound iron forms during heating.

Table 1. Analysis of Mineral Composition in Roasted and Unroasted *Phoenix dactylifera* Seed Powder Extracts

Mineral (mg/kg)	Roasted Extract	Unroasted Extract
Sodium (Na)	20.2±0.02	18.3±0.02
Potassium (K)	229.0±0.10	232.1±0.10
Magnesium (Mg)	71.3±0.01	73.0±0.22
Calcium (Ca)	70.1±0.03	68.3±0.10
Iron (Fe)	5.2±0.01	3.7±0.10
Phosphorus(P)	115.5±0.10	107.1±0.03
Zinc (Zn)	13.05±0.05	11.2±0.20

Values are reported as mean ± standard deviation of triplicate values

The table showed that minerals like Fe, Zn and P were slightly higher in roasted seeds, possibly due to water loss concentrating these nutrients. Other minerals like K, Mg and Ca were found to be higher in the unroasted seeds.

Proximate composition analysis

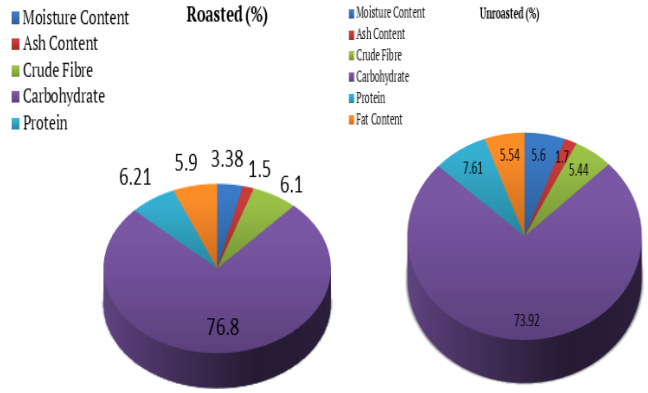

Figure 2. Pie Charts Showing the Proximate Composition of Roasted and Unroasted Date Seed Powder Extracts

Figure 2: above displays the proportional distribution of nutrients in the sample extracts. It can be observed that in both samples, carbohydrate dominates the composition but is higher in the roasted sample.

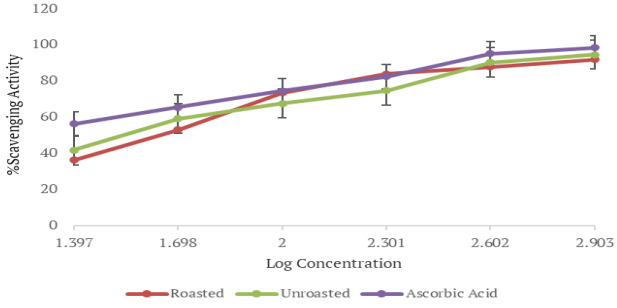

Figure 3. DPPH Radical Scavenging Antioxidant Activity of Roasted and Unroasted Date Seed Extracts

Both the roasted and unroasted date seed extracts have significantly higher IC_{50} values compared to the standard ascorbic acid, indicating that a much larger concentration of the date seed extracts is required to achieve the same level of DPPH radical scavenging activity as the Ascorbic Acid. Therefore, both date seed extracts are less potent antioxidants than the Ascorbic Acid used in this assay.

Table 2. IC_{50} of Roasted and Unroasted Date Seed Powder Extract and Standard Ascorbic Acid for DPPH Radical Scavenging Activity

Sample	IC_{50} (µg/ml)
Roasted Extract	44.97±0.63
Unroasted Extract	26.91±0.68
Ascorbic Acid	1.62±0.04

Values are reported as mean ± standard deviation of triplicate values

The results, displayed in Table 3, are expressed as percent reduction compared to the standard antioxidant, ascorbic acid. The roasted seed extract exhibited a FRAP value of 92.00 ± 0.28 % which is slightly lower than the unroasted seed extract with a value of 93.60 ± 0.46 %. The standard ascorbic acid recorded a significantly higher reducing power at 98.40 ± 0.27 %. These findings indicate that both extracts possess considerable ferric reducing ability, with the unroasted seed powder demonstrating a marginally superior antioxidant potential.

Table 3. FRAP of Roasted and Unroasted Date Seed Powder Extract and Standard Ascorbic Acid

Sample	FRAP (%)
Roasted Extract	92.00±0.28
Unroasted Extract	93.60±0.46
Ascorbic Acid	98.40±0.27

Values are reported as mean ± standard deviation of triplicate values

DISCUSSION

This decrease is likely due to the known thermal lability of ascorbic acid during heat treatment (Davey *et al*., 2000). Vitamin B1, B2 and B3 also decreased by approximately 33–45%, confirming the partial degradation of water-soluble B vitamins and reflecting thermal damage (Fennema, 1996). Vitamin A, measured in µg/100g (Fig 1b), was also significantly higher in the unroasted sample (32.57 µg) than in the roasted (16.28 µg), reinforcing the notion that roasting causes losses in certain micronutrients, possibly due to oxidative degradation (Rodriguez-Amaya, 2001). This loss in Vitamin A content was reduced by about 50%. This result shows that unroasted date seed powder preserves more of the vitamins and may be preferable when vitamin retention is desired. These findings agree with those reported by Rodriguez-Amaya, (2001) and Bhanu *et al.* (2024). It underscores the potential negative impact of roasting on the vitamin profile of date seed powder, suggesting that unroasted powder may be a better source for these nutrients.

Ali-Mohamed & Khamis (2004), reported potassium to be the most abundant mineral in date seed followed by phosphorus, this is in agreement with the observation in this study. This abundance of potassium and magnesium in both samples, is consistent with the role of date seeds as rich sources of electrolytes.

This analysis suggests that roasting modestly alters the mineral profile, with specific increases in P, Fe and Zn, which may be nutritionally significant (Institute of Food Technologists, 2006). Result obtained here shows that roasting is likely to affect mineral distribution, which has implications for the nutritional use of date seed products.

It can be observed that in both samples, carbohydrate dominates the composition but is higher in the roasted sample. This observed increase may be due to the reduction in moisture content during roasting, which concentrates the dry matter (including carbohydrates). Additionally, heat may breakdown complex polysaccharides into more extractable forms. Also, the analytical methods performed might detect Maillard reaction products as carbohydrates, leading to an overestimation of carbohydrate content as observed in Figure 2. This finding is in agreement with those reported by Oboh *et al*. (2010) and Nooshkam, (2019).

Protein content is higher in the unroasted seed due to degradation upon heating. Proteins participate in Maillard reactions with reducing sugars, potentially leading to the formation of complex, less extractable compounds or the loss of some amino acids through volatilization or cross-linking. Heat can cause protein denaturation, leading to changes in solubility and extractability during proximate analysis. Extreme roasting conditions could also potentially lead to some protein degradation, thereby reducing its composition in the roasted sample.

Moisture content is also higher in the unroasted seed most likely due to heat-induced water loss during roasting (Al-Juhaimi *et al*., 2018). Ash content, which is an indicator of mineral content, is also slightly higher in the unroasted sample. This slight decrease in ash content after roasting could be attributed to minor losses of volatile minerals during the heating process. However, the difference is relatively small, suggesting that the overall mineral composition is largely preserved.

Meanwhile, the roasted sample shows a slightly increased share of crude fiber and fat content. This could be because, with reduced moisture and protein contents, there would be concentration effects due to water loss (Elleuch *et al*., 2011). Roasting itself, is capable of causing some structural changes in the fiber components, potentially making them slightly more or less extractable. Fats are generally more stable to moderate heat compared to some other organic components. Roasting can also aid in the extraction of some lipids from the seed matrix leading to the increase in its composition as seen with the roasted samples.

Ascorbic Acid (Vitamin C) is the most potent antioxidant based on its IC_{50} value (Table 2). This means that a much smaller concentration of ascorbic acid is needed to scavenge 50% of the DPPH radicals compared to both the roasted and unroasted date seed extracts. This is expected, as Vitamin C is a well-known and potent antioxidant.

The IC_{50} values for the roasted (44.97 µg/mL) and unroasted (26.91 µg/mL) date seed extracts suggest that the roasting process, under the conditions tested, can

significantly alter the overall antioxidant potency of the date seed extract as measured by the DPPH assay. This is because, there might be changes in the specific antioxidant compounds due to roasting, thereby affecting the overall potency and the ability of the extract to scavenge DPPH radicals at the 50% inhibition level (Yousif *et al*., 2018). This is seen from the significant difference between the two extracts used.

Although, variations in antioxidant levels are expected due to difference in extraction methods, maturity stage and date cultivar, the values obtained in this study are comparable to those in previous reports and support the claim that date seeds possess considerable antioxidant potential. Al- Farsi and Lee (2008), also reported that date seed extracts exhibit notable DPPH radical scavenging properties, making them promising candidates for natural antioxidant sources in food systems.

The ferric reducing antioxidant power (FRAP) assay was employed to evaluate the electron- donating capacity of both roasted and unroasted *Phoenix dactylifera* seed powder extracts, served as a measure of antioxidant potential. The decrease in the FRAP value upon roasting may be attributed to thermal degradation of heat- labile antioxidant compounds, such as vitamin C and certain phenolics (Peng *et al*., 2021; Ghafoor *et al* 2022). Despite the reduction in the roasted sample, the antioxidant constituents are relatively stable under moderate roasting conditions (Muñoz-Tebar *et al*., 2024). These findings thereby support the potential application of *Phoenix dactylifera* seed powders, particularly the unroasted form, as functional ingredients in antioxidant-enriched nutraceutical formulations (Ghafoor *et al*., 2022; Himanshu *et al.,* 2024).

CONCLUSION

The roasting process significantly alters the nutritional composition of date seed powder extract, leading to a notable decrease in the content of several important vitamins, particularly Vitamin A and the B-complex vitamins, as well as Vitamin C. While the mineral content shows more subtle changes, with some minerals appearing to be slightly more concentrated, the overall findings suggest a trade-off between the potential flavor and textural benefits of roasting and the retention of certain micronutrients. These results highlight the importance of considering the processing methods when evaluating the nutritional value of date seed powder. Further research could explore the specific roasting conditions such as temperature and time that minimize nutrient loss while optimizing other desired qualities.

AUTHORS' CONTRIBUTIONS

Conceptualization: JAO, AO and PMN
Methodology: JAO, AO, FA, WOO, SMS, SOG, and GOM
Writing: Draft - JAO, BMM and ESA. All authors have read and agreed to the published version of the manuscript.

FUNDING STATEMENT

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest

ACKNOWLEDGEMENT

We thank the laboratory staff of both Prince Abubakar Audu University, Anyigba and University of Abuja, Nigeria.

REFERENCES

Ahmed, I. A. M., Al- Juhaimi, F., Karrar, E., Uslu, N., & Özcan, M. M. (2024). The effect of roasting on bioactive properties, phenolic compounds and fatty acid profiles of pumpkin *(Cucurbita spp.)* seeds. *Journal of Oleo Science*, 73(12), 1457-1465. https://doi.org/10.5650/jos.ess24153

Al-Farsi, M., Alasalvar, C., Morris, A., Baron, M., & Shahidi, F. (2005). Comparison of antioxidant activity, anthocyanins, carotenoids, and phenolics of three native fresh and sun-dried date *(Phoenix dactylifera L.)* varieties grown in Oman. *Journal of Agricultural and Food Chemistry*, 53(19), 7592 – 7599. https://doi.org/10.1021/jf050579q

Al-Farsi, M., & Lee, C. Y. (2008). Nutritional and Functional Properties of Dates: A Review. *Critical Reviews in Food Science and Nutrition*, 48(10), 877-887. https://doi.org/10.1080/10408390701724264

Al-Juhaimi, F. Y., Ghafar, A. A., & Özcan, M. M. (2018). Effect of roasting on physical properties and fatty acid composition of date *(Phoenix dactylifera L.)* seeds. *Food Science and Technology*, 38(suppl 1), 146-151.

Ali-Mohamed, A. Y., & Khamis, S. H. (2004). Mineral ion content of the seeds of six cultivars of Bahraini date palm *(Phoenix dactylifera)*. *Journal of Agricultural and Food Chemistry,* 52(21), 6522-6525. https://doi.org/10.1021/jf030518x

Allaith, A. A. A. (2008). Antioxidant activity of Bahraini date palm *(Phoenix dactylifera L.)* fruit of various cultivars. *International Journal of Food Science & Technology*, 43(6), 1033–1040. https://doi.org/10.1111/j.1365-2621.2007.01558.x

AOAC. (2016). Official Methods of Analysis of AOAC International (20th ed.). Association of Official Analytical Chemists. Method 920.39. AOAC International.

Baliga, M. S., Baliga, B. R. V., Kandathil, S. M., Bhat, H. P., & Vayalil, P. K. (2011). A review of the chemistry and pharmacology of the date fruits *(Phoenix dactylifera L.)*. *Food Research International*, 44(7), 1812–1822. https://doi.org/10.1016/j.foodres.2010.07.004

Benzie, I. F. F., & Strain, J. J. (1996). The ferric reducing ability of plasma (FRAP) as a measure of "antioxidant power": The FRAP assay. *Analytical Biochemistry*, 239 (1), 70-76. https://doi.org/10.1006/abio.1996.0292

Bhanu, L., Goudar, G., Gogoi, P., Mahajan, A., Subhah, K., Chandragiri, A. K., Sreedhar, M., Dutta, H., Roy, A., Hmar, B. Z., Sharma, P., Sasikumar, R., & Longvah, T. (2024). Effect of roasting on nutritional composition, polyphenols and antioxidant properties of chironji *(Buchanania lanzan* Spreng) kernels. *Journal of Food Measurement and*

Characterization, 18, 7003-7018. https://doi.org/10.1007/s11694-024-02710-8

Borochov-Neori, H., Judeinstein, S., Greenberg, A., Volkova, N., Rosenblat, M., & Aviram, M. (2015). Antioxidant and antiatherogenic properties of phenolic acid and flavonol fractions of date (*Phoenix dactylifera* L., Medjool and Hallawi varieties) fruit at different degrees of ripening. *Journal of Agricultural and Food Chemistry*, 63(12), 3189–3195. https://doi.org/10.1021/jf506489p

Brand-Williams, W., Cuvelier, M. E., & Berset, C. (1995). Use of a free radical method to evaluate antioxidant activity. LWT - *Food Science and Technology*, 28(1), 25–30. https://doi.org/10.1016/S0023-6438(95)80008-5

Davey, M. W., Montagu, M. V., Sanmartin, Kanelis, A., Smirnoff, N., Benzie, J. J. JStrain, J. J., Favel, D., & Fletcher, J. (2000). Plant L-ascorbic acid: chemistry, function, metabolism, bioavailability and effects of processing. *Journal of the Science of Food and Agriculture*, 80(7), 825-855.

Elleuch, M., Besbes, S., Roiseux, O., Blecker, C., Deroanne, C., & Attia, H. (2011). Date seeds and kernels: Chemical composition and potential applications. *Comprehensive Reviews in Food Science and Food Safety,* 10(4), 264-277.

Faleiro, J. R., & Kumar, N. K. K (2023). Date palm- A gift for health and nutrition: National and International scenario. *Journal of Horticultural Sciences,* 18(2). Food and Agriculture Organization of the United Nations. https://doi.org/10.24154/jhs.v18i2.2508

Fennema, O. R. (1996). *Food Chemistry (*Vol. 76*)*. CRC press.

Fikry, M., Yusof, Y. A., M. Al-Awaadh, A., Abdul Rahman, R., Chin, N. L., Ghazali, H. M. (2019). Antioxidative and quality properties of full-fat date seeds brew as influenced by the roasting conditions. *Antioxidants*, 8(7), 226.

Ghafoor, K., Sarker, M. Z. I., Al-Juhaimi, F. Y., Babiker, E. E., & Alkaltham, M. S., Almubarak, A. K. (2022). Extraction and evaluation of bioactive compounds from date (Phoenix dactylifera) seed using supercritical and subcritical CO2 techniques. *Foods*, 11(12), 1806.

Habib, H. M., Ibrahim, W. H., Jafar, T. T., Rizk, E. M., & Kamal-Eldin, A. (2013). Nutritional quality of date seeds as affected by variety. *Emirates Journal of Food and Agriculture,* 25(7), 516-522.

Himanshu, K. N., Khangwal, I., & Ashutosh, U. (2024). Assessment of nutritional composition, phytochemical screening, antioxidant and antibacterial activities of date palm *(Phoenix dactylifera)* seeds. *Discover Food*, 4, Article 151.https://doi.org/10.1007/s44187-024-00234-0

Morgan, M. T., Ismail, B., & Hayes, K. (2006). Relative importance of the Institute of Food Technologists (IFT) core competencies—A case study survey. *Journal of Food Science Education,* 5(2), 35-39.

Muñoz-Tebar, N., Candela-Salvador, L., Pérez-Álvarez, J. Á., Lorenzo, J. M., Fernández-López, J., & Viuda-Martos, M. (2024). Date (Phoenix dactylifera L. cv. Medjool) seed flour, a potential ingredient for the food industry: effect of particle size on its chemical, technological, and functional properties. *Plants*, 13(3), 335.

Ndaw, S., Bergaentzlé, M., Aoudé-Werner, D., & Hasselmann, C. (2000). Extraction procedures for the liquid chromatographic determination of thiamine, riboflavin and vitamin B6 in foodstuffs. *Food Chemistry,* 71(1), 129–138. https://doi.org/10.1016/S0308-8146(00)00142-7

Nooshkam, M., Varidi, M., & Bashash, M. (2019). The Maillard reaction products as food-born antioxidant and antibrowning agents in model and real food systems. *Food Chemistry,* 275, 644-660. https://doi.org/10.1016/j.foodchem.2018.09.083

Oboh, G., Ademiluyi, A.O., & Akindahunsi, A. A. (2010). The effect of roasting on the nutritional and antioxidant properties of yellow and white maize varieties. *International Journal of Food Science & Technology,* 45(6), 1236-1242.https://doi.org/10.1111/j.1365-2621.2010.02263x

Peng, M., Lu, D., Liu, J., Jiang, B., & Chen, J. (2021). Effect of roasting on the antioxidant activity, phenolic composition, and nutritional quality of pumpkin (Cucurbita pepo L.) seeds. *Frontiers in Nutrition, 8*, 647354.

Rodriguez-Amaya, D. B. (2001). A guide to carotenoid analysis in foods. Washington, DC: *International Life Sciences Institute* (ILSI) Press. 41 - 47

Rodriguez-Amaya, D. B., & Kimura, M. (2004). HarvestPlus Handbook for Carotenoid Analysis. International Food Policy Research Institute (IFPRI). https://hdl.handle.net/10568/157384

Shahidi, F., & Naczk, M. (2004). Phenolics in food and nutraceuticals. *Boca Raton*, FL: CRC Press. https://doi.org/10.1201/9780203508732Yousif, G. J., Al-ghamdi, S. S., & Ghnimi, S. (2018). Effect of roasting on the antioxidant activity and total phenolic content of different date seed varieties. *Journal of Food Measurement and Characterization,* 12(4), 2549-2557.