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Antioxidant Capacity and Sensory Evaluation of Date (*Phoenix dactylifera L.)* Fruit and Its Products.

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Abstract

The growing demand for healthier diets has increased interest in fruits with high nutritional and antioxidant value. Date fruit (Phoenix dactylifera) is rich in macro- and micronutrients and possesses notable antioxidant properties. This study evaluated the antioxidant capacity and sensory attributes of date fruit and its processed products, including powder, syrup, puree, and syrup supplemented with ginger or garlic. Total phenolic content, total flavonoids, flavones, vitamin E, total antioxidant capacity, and DPPH radical scavenging activity were determined using standard analytical methods. Total phenolic content ranged from 5.36 ± 0.25 to 7.80 ± 0.55 mg GAE/100 g, while total antioxidant capacity ranged from 1041.66 ± 43.68 to 1413.33 ± 91.57 mg GAE/gDW, with ginger-supplemented syrup showing the highest values. Sensory evaluation revealed that ginger-enriched date syrup was most preferred in terms of flavor and overall acceptability. The results indicate that date fruit and its products are valuable sources of antioxidants, and supplementation with ginger enhances both antioxidant potential and consumer acceptability.

Keywords: date fruit; antioxidant capacity; phenolic compounds; sensory evaluation; ginger supplementation

1. Introduction

Since the beginning of human history, natural medical materials have been utilized to prevent and treat illness (WHO, 2023). Although many traditional remedies have been replaced by conventional pharmaceuticals, renewed scientific interest has emerged in nutritherapy, which emphasizes the health-promoting role of food-derived bioactive compounds (Arshad *et al*., 2025). In particular, plant-based foods rich in antioxidants have gained attention for their ability help lessen oxidative stress linked to long-term illnesses viz cancer, diabetes, cardiovascular, neurodegenerative, as well as inflammatory disorders (Muscolo *et al*., 2024).

Fruits are essential elements of a nutritious diet because of their rich nutrient and bioactive composition, especially in developing countries such as Nigeria, where they contribute significantly to nutrition and food security (Obiageli, 2025). Among these fruits, date fruit (*Phoenix dactylifera* L.) is an economically and nutritionally important crop grown in arid and semi-arid areas of the Gulf Cooperation Council nations, the Middle East, and North Africa (Al-Karmad & Okoh, 2024).

Dates have been valued for their health-promoting properties since ancient and biblical times. Modern scientific studies have increasingly validated traditional claims regarding their nutritional and therapeutic benefits (Awan *et al*., 2025). Dates are widely consumed, particularly among Arabian populations, due to their high nutritive value, affordability, and ease of cultivation (Biglari, 2009). Fresh dates contain soft, easily digestible flesh rich in simple sugars, which provide rapid energy and contribute to physical revitalization (Mirghani, 2021). Beyond their energy-providing capacity, date fruits play significant social, economic, and environmental roles for communities living in areas that are dry or semi-arid, where they serve as a dietary staple (Al-Karmad & Okoh, 2024).

Despite numerous investigations on the nutritional constituents of date fruits, limited information exists on the combined effects of processing methods and spice supplementation on antioxidant capacity and consumer acceptability of date-based products. Therefore, this study aimed to evaluate the antioxidant features of date fruit and its processed products and to assess the sensory attributes of date syrup supplemented with ginger and garlic.

Specifically, the study examined total phenolic content, flavonoids, flavones, vitamin E, total antioxidant capacity, DPPH radical scavenging activity, and consumer sensory preferences.

2. Materials and Methods

2.1 Collection and Preparation of Date Fruits

Fresh date fruits (*Phoenix dactylifera* L.) were purchased in an indigenous market in Zaria, Kaduna State, Nigeria, in February 2025. Every chemical and reagent utilized was of analytical quality.
Also, seeds were manually removed from the fruits. The edible flesh was properly cleaned to get rid of dirt and debris with distilled water. A portion (100 g) of the cleaned flesh was soaked in distilled water for 2 h at room temperature prior to processing.

2.2 Preparation of Date Products

For date syrup preparation, the soaked date flesh was boiled for 5 min, filtered via a muslin cloth, and the filtrate was further boiled until a thick syrup was obtained. The syrup was allowed to cool at room temperature. Ginger- and garlic-supplemented syrups were prepared by adding 10 g of freshly prepared ginger or garlic paste to the syrup, respectively. Date puree (paste) was prepared by blending the soaked date flesh into a smooth paste using a laboratory blender. For date powder, the soaked date flesh was air-dried, ground manually into a uniform powder, and kept in sealed containers before being examined.

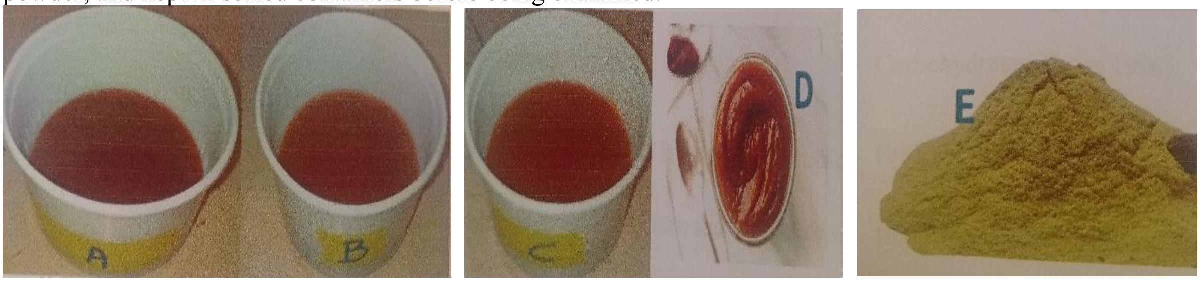

Figure 1: Pictures of date products (A is date syrup, B contains date syrup supplemented with 10g of ginger, C contains date syrup supplemented with 10g of garlic, D is date paste/puree and E is date powder).

2.3 Biochemical Analysis

2.3.1 Determination of Total Phenolic Content

The Folin–Ciocalteu method, as outlined by Dewanto et al. (2002), was used to calculate the total phenolic content. In short, 0.5 mL of each sample was combined with 6 mL of distilled water and 100 µL of Folin–Ciocalteu reagent. After a minute of vortexing the liquid, 2 mL of 15% sodium carbonate (Na_2CO_3) was added. The volume of the solution was adjusted to 10 mL using distilled water after it had been incubated for one hour and thirty minutes at room temperature. A UV-visible spectrophotometer was used to detect absorbance at 750 nm. Milligrams of gallic acid equivalents per 100 g dry weight (mg GAE/100 g DW) were used to express the results, which were calibrated using gallic acid.

2.3.2 Determination of Flavones (Luteolin)

The method of Struchkov et al. (2018) was used to determine the flavone (luteolin) content. 5 mL of distilled water and 0.3 mL of 5% sodium nitrite ($NaNO_2$) were added to 0.1 mL of the sample. 5 µL of acetic acid, 0.2 mL of 10% aluminum chloride ($AlCl_3$), and 1.5 mL of 1 M sodium hydroxide (NaOH) were added after 5 minutes. At 517 nm, absorbance was measured. A standard absorbance coefficient (E = 63.9) was used to compute the luteolin concentration, which was then represented as mg/mL.

2.3.3 Determination of Total Flavonoid Content

The aluminum chloride colorimetric method outlined by Ebrahimzadeh et al. (2008) was used to estimate the total flavonoid content. Five milliliters of sample extract were combined with five milliliters of 2% $AlCl_3$ in methanol. Absorbance was measured at 415 nm against a blank after 10 minutes of incubation. The standard calibration curve was created using rutin (0–100 mg/L), and the results were reported as mg rutin equivalents.

2.3.4 DPPH Radical Scavenging Activity

According to Mokoroane et al. (2020), the DPPH (2,2-diphenyl-1-picrylhydrazyl) assay was used to measure the extracts' capacity to scavenge free radicals. Three milliliters of ethanol and three milliliters of DPPH solution were combined with fifty micrograms (50 µg) of extract. After shaking the mixture, it was left in the dark for half an hour. At 517 nm, absorbance was measured in comparison to a blank. The following equation was used to express DPPH scavenging activity as IC_{50} values and % inhibition:

$$\%\text{Inhibition} = \frac{(A0-A1)}{A0} \times 100 \quad (1)$$

Where A0 is the absorbance of the blank and A1is the absorbance of the sample.

2.3.5 Determination of Total Antioxidant Capacity

The phosphomolybdenum method outlined by Prieto et al. (1999) was used to calculate total antioxidant capacity. 1 mL of reagent solution comprising 0.6 M sulfuric acid (H_2SO_4), 28 mM sodium phosphate (Na_3PO_4), and 4 mM ammonium molybdate was mixed with an aliquot (0.1 mL) of sample extract. For ninety minutes, the mixture was incubated at 95 °C. Absorbance was measured at 695 nm after cooling to ambient temperature. Gallic acid equivalents per gram dry weight (mg GAE/g DW) were used to express the results.

2.3.6 Determination of Vitamin E (α-Tocopherol)

Vitamin E (α-tocopherol) content was estimated following the process of Artuç (2020), according to Emmerie-Engel reaction. Sample aliquots (40 µL) and standard α-tocopherol solutions (20–100 µL) were diluted with chloroform to 30 mL. Subsequently, 1 mL of 2,2-dipyridyl and 1 mL of ferric chloride ($FeCl_3$) solution were added. The mixture was incubated at 37 °C for 15 min, and absorbance was read at 520 nm. Concentrations were calculated from the standard calibration curve.

2.4 Sensory Evaluation

The results were presented as mean ± standard deviation (SD), and all analyses were carried out in triplicate. One-way analysis of variance (ANOVA) was used to examine the data. The Least Significant Difference (LSD) post hoc test was used to identify significant differences between means at $p < 0.05$.

3. Results and Discussion

3.1. Results

3.1.1 Total Phenolic Content and Antioxidant Capacity

Table 1. Total phenolic content and antioxidant capacity of date powder and its derivatives

Sample	Total phenolic content (mg GAE/100 g)	Total antioxidant capacity (mg GAE/g DW)
Powdered extract	6.13 ± 1.20	1299.60 ± 20.51
Syrup	6.01 ± 0.52	1295.33 ± 50.00
Syrup + ginger	7.80 ± 0.55	1413.33 ± 91.57
Syrup + garlic	5.61 ± 1.80	1197.66 ± 15.27
Puree	5.36 ± 0.25	1041.66 ± 43.68

Values are presented as mean ± standard deviation (SD). GAE = Gallic Acid Equivalents DW = Dry Weight

Table 1 shows the total phenolic content and total antioxidant capacity of date powder and its processed derivatives. All samples exhibited measurable phenolic compounds and antioxidant activity, confirming antioxidants potential of date-based products. Among the samples, date syrup supplemented with ginger recorded the highest total phenolic content (7.80 ± 0.55 mg GAE/100 g) and antioxidant capacity (1413.33 ± 91.57 mg GAE/g DW), while date puree showed the lowest values. The enhanced antioxidant properties observed in the ginger-supplemented syrup may be ascribed to the phenolic compounds' synergistic impact naturally present in dates and bioactive constituents in ginger. This finding supports previous reports that processing and spice supplementation can improve the essential aspects of foods made from plants. The comparatively lower antioxidant values in puree suggest possible dilution effects and reduced concentration of bioactive compounds during processing.

3.1.2 Total Flavonoid and Flavone Content

Table 2. Total flavonoid and flavone levels of date powder and its derivatives

Sample	Total flavonoids (mg/L rutin)	Flavones (luteolin) (µg PNE/mg)
Powdered extract	5.00 ± 1.11	41.52 ± 0.46
Syrup	6.10 ± 0.38	43.15 ± 3.39
Syrup + ginger	6.28 ± 0.12	49.90 ± 0.90

Sample	Total flavonoids (mg/L rutin)	Flavones (luteolin) (µg PNE/mg)
Syrup + garlic	1.66 ± 0.11	46.82 ± 1.00
Puree	4.03 ± 1.13	47.33 ± 0.57

Values are presented as mean ± standard deviation (SD). Flavone content is expressed as µg p-nitrophenyl equivalents per mg sample (µg PNE/mg).

The total flavonoid and flavone contents of date powder and its derivatives are presented in Table 2. All samples contained detectable levels of flavonoids and flavones, indicating the presence of important antioxidant phytochemicals across all products. Syrup supplemented with ginger showed the highest flavonoid content (6.28 ± 0.12 mg/L rutin equivalent), followed by syrup and powdered extract, while syrup supplemented with garlic recorded the lowest value. For flavone (luteolin) content, syrup supplemented with ginger and garlic exhibited higher values compared to other samples, suggesting that thermal processing and spice incorporation influenced flavone retention. These results align with earlier studies reporting that flavonoids contribute significantly to antioxidant activity and health-promoting properties of functional foods.

3.1.3 Vitamin E Content and DPPH Radical Scavenging Activity

Table 3. Vitamin E content and DPPH radical scavenging activity of date powder and its derivatives

Sample	Vitamin E (µg/mL)	DPPH radical scavenging activity (%)
Powdered extract	44.39 ± 5.03	35.46 ± 0.15
Syrup	40.54 ± 4.56	39.43 ± 1.41
Syrup + ginger	31.22 ± 0.79	41.73 ± 1.88
Syrup + garlic	33.64 ± 3.53	37.13 ± 0.14
Puree	37.73 ± 0.35	39.10 ± 0.38

Values are presented as mean ± standard deviation (SD).

Vitamin E content and DPPH radical scavenging activity of the samples are indicated in Table 3. All samples demonstrated antioxidant scavenging ability, indicating their potential role in neutralizing free radicals. Powdered date extract contained the highest vitamin E concentration (44.39 ± 5.03 µg/mL), whereas ginger-supplemented syrup showed the lowest value. In contrast, DPPH scavenging activity was highest in ginger-supplemented syrup, suggesting that antioxidant effectiveness is not solely dependent on vitamin E content but also influenced by other phytochemicals such as phenolics and flavonoids. This observation highlights the importance of combined antioxidant mechanisms in processed date products.

3.1.4 Sensory Evaluation of Date Products

Table 4. Sensory evaluation scores of date powder and its derivatives

Sample	Colour	Flavour	Texture	Taste	General acceptability
Powdered extract	7.30 ± 1.00	6.90 ± 1.30	6.71 ± 1.55	7.40 ± 1.28	7.20 ± 1.89
Syrup	6.40 ± 1.26	8.40 ± 0.92	6.80 ± 1.19	7.70 ± 1.00	8.04 ± 1.35
Syrup + ginger	6.50 ± 1.57	9.10 ± 1.14	5.20 ± 1.66	6.80 ± 1.78	8.50 ± 2.15
Syrup + garlic	5.10 ± 2.57	5.10 ± 2.07	3.60 ± 2.06	5.50 ± 2.06	4.50 ± 1.80
Puree	3.20 ± 2.34	2.30 ± 1.20	3.50 ± 2.00	7.20 ± 1.16	4.30 ± 1.53

Values are presented as mean ± standard deviation (SD) based on a 5-point sensory evaluation scale.

Table 4 displays the findings of the sensory evaluation. The color, flavor, texture, taste, and general acceptance of the samples varied significantly. Syrup-based products generally received higher sensory scores compared to powdered extract and puree. Date syrup supplemented with ginger recorded the highest scores for flavor and overall acceptability, followed closely by plain syrup. In contrast, garlic-supplemented syrup had the lowest sensory ratings, possibly due to its strong flavor profile, which may not be widely acceptable to consumers. These findings suggest that ginger supplementation enhances both functional and sensory qualities of date syrup, making it a more acceptable functional food product.

3.2 Discussion

3.2.1 Total Phenolic Content and Antioxidant Capacity

The total phenolic content and antioxidant capacity of date powder and its processed derivatives are presented in Table 1. All samples contained appreciable levels of phenolic compounds and exhibited notable antioxidant activity, confirming inherent antioxidant potential of date-based products. Among the samples, date syrup supplemented with ginger recorded the maximum total phenolic content (7.80 ± 0.55 mg GAE/100 g) and antioxidant capacity (1413.33 ± 91.57 mg GAE/g DW), whereas date puree indicated minimum values.

The enhanced antioxidant properties observed in the ginger-supplemented syrup may be ascribed to the synergy interaction between phenolic compounds naturally present in dates and bioactive constituents such as gingerols and shogaols in ginger. Similar findings have been reported, indicating that spice incorporation can significantly enhance the functional properties of plant-based foods (Shahidi & Ambigaipalan, 2015; El-Saadony *et al*., 2025). The comparatively lower antioxidant values observed in date puree may be due to dilution effects and possible degradation of phenolic compounds during processing, as earlier studies have shown that processing conditions can influence phytochemical stability (Khosravi *et al*., 2024).

3.2.2 Total Flavonoid and Flavone Content

Table 2 presents the total flavonoid and flavone contents of date powder and its derivatives. Detectable levels of flavonoids and flavones were observed in all samples, indicating their contribution to the antioxidant potential of the products. Syrup supplemented with ginger exhibited the maximum total flavonoid content (6.28 ± 0.12 mg/L rutin equivalent), followed by plain syrup and powdered extract, while syrup supplemented with garlic showed the lowest flavonoid concentration.

Flavone (luteolin) content was comparatively higher in syrup supplemented with ginger and garlic, suggesting that spice addition and thermal processing may influence flavone retention. Flavonoids also possess strong free-radical scavenging and metal-chelating features, which contribute significantly to the health-promoting attributes of functional foods (Panche *et al*., 2016). The observed variation among samples highlights the impact of formulation and processing on phytochemical composition.

3.2.3 Vitamin E Content and DPPH Radical Scavenging Activity

The vitamin E content and DPPH radical scavenging activity of the samples are shown in Table 3. All samples proved appreciable free-radical scavenging ability, indicating their antioxidant effectiveness. Powdered date extract recorded the highest vitamin E concentration (44.39 ± 5.03 µg/mL), while ginger-supplemented syrup exhibited the lowest value.

In contrast, DPPH radical scavenging activity was highest in syrup supplemented with ginger (41.73 ± 1.88 %), suggesting that antioxidant activity is not solely dependent on vitamin E content but is also influenced by other bioactive compounds such as phenolics and flavonoids. This observation agrees with previous studies indicating that combined antioxidant mechanisms enhance overall radical scavenging efficiency in functional foods (Mustafa & Chin, 2023; Gulcin & Alwasel, 2023).

3.2.4 Sensory Evaluation of Date Products

The sensory evaluation scores of date powder and its derivatives are reported in Table 4. Significant variations were noticed among samples with respect to colour, flavour, texture, taste, and overall acceptability. Syrup-based products generally recorded higher sensory scores compared to powdered extract and puree. Date syrup supplemented with ginger achieved the highest flavour and overall acceptability scores, followed closely by plain syrup.

Conversely, garlic-supplemented syrup recorded the lowest sensory ratings, which may be attributed to the strong and distinctive flavour of garlic that may limit consumer acceptance. These findings indicate that ginger supplementation not only enhances the antioxidant properties of date syrup but also improves its sensory appeal, thereby increasing its potential as an acceptable functional food product (Karangiya *et al*., 2016).

4. Conclusion

In conclusion, date fruit and its processed products are valuable sources of natural antioxidants, with processing and formulation significantly influencing their functional and sensory qualities. Ginger supplementation notably enhanced antioxidant effectiveness while improving consumer acceptability, underscoring its practical relevance in functional food development. These results add to the increasing amount of data demonstrating the benefits of using plant-based components and natural spices in improving food quality and health value. The study highlights the potential application of ginger-enriched date products in health-oriented food formulations and provides a basis for further research on product optimization and nutritional functionality.

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