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Comprehensive Evaluation of Nutritional Quality, Phytochemical Profile, Antioxidant Activity, and Microbial Safety of Date Palm Sap from Different Cultivars

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Abstract

This study evaluated the nutritional quality and health safety of date palm sap from four Libyan cultivars (Amy, Bekrari, Dokar, and Tabony) and one Tunisian Bekrari sample. Chemical analyses showed significant variation among samples, with Dokar sap recording the highest total solids content (27.55 °Brix), while exhibiting the lowest total acidity (0.065%) and pH (7.00). Phytochemical screening revealed high levels of glycosides, phenols, and flavonoids in all samples. The Libyan Bekrari sap contained the highest total polyphenol content (10.81 mg GAE/g). Mineral analysis demonstrated that date sap is a rich source of essential minerals, particularly potassium, calcium, and phosphorus. Microbiological examination detected coliform bacteria (45–551 × 10^2 CFU/ml) and yeasts and molds (2–73 × 10^2 CFU/ml) in the analyzed samples, whereas Escherichia coli was absent in all cases. These findings highlight the nutritional and functional value of date sap but also indicate concerns regarding microbial contamination. The study emphasizes the need for improved hygienic practices during sap collection, handling, and packaging to enhance product safety and shelf life. Furthermore, the results provide important baseline data that may support the development of quality standards and safety regulations for date palm sap intended for human consumption in Libya.

Keywords: date sap, flavonoids, chemical composition, nutritional value, functional foods.

Introduction

The date palm tree (*Phoenix dactylifera* L.), often referred to as the "Tree of Life," has been cherished since ancient times as one of the earliest fundamental natural foods. The date palm is a source of many food products, such as dates, sugar, date kernel oil, and date sap (Mahomoodally et al., 2023). Date palm sap juice (known as Lagmi in Libya) is a natural drink rich in energy and nutrients and has many health benefits. It is also a value-added palm tree product. Global production of date sap has seen rapid growth in recent years due to its distinctive sensory properties and high sugar content. Date sap juice is rich in natural sugars, minerals, phenolic compounds, and antioxidants, which contribute to its nutritional value and potential health benefits, including energy provision and antioxidant activity (Aparnna, et al., 2023). Furthermore, date palm sap is a naturally renewable resource that can be processed with minimal industrial input, supporting sustainable food production systems (Ansar et al., 2021; Saputro et al., 2017). In Arab nations, especially in the northwest region of Africa, date sap is a vital and revitalizing beverage in the summer months, when it is traditionally harvested by slicing the stem of a date palm tree. The date palm produces about 8-10 liters of date sap per day (Sarkar et al., 2023, Sarma et al., 2022). The amount of production varies depending on the types of palm trees, the season, and the time of extraction (morning and evening). The period of collecting date sap may extend from one month to 6 months from the same palm tree (Sarma, et al., 2022). Although date sap is extracted and consumed as a refreshing natural juice in Libya, there are several research gaps that need to be addressed, such as investigating the chemical properties, nutritional value, and microbial content of date sap extracted from different Libyan date varieties. The date sap juice is negatively affected by the microbial population, especially bacteria and yeasts. The microbiological quality of date palm sap plays a decisive role in determining its suitability for consumption as a fresh beverage. Date sap is highly susceptible to microbial contamination due to its high sugar content and near-neutral pH, which favors the growth of bacteria, yeasts, and molds (Djemal, et al., 2025). The rapid fermentation of date sap juice by natural microorganisms and the lack of modern technical methods for collecting and preserving, in addition to the lack of people’s knowledge of its nutritional value and health benefits, are among the most important reasons for not getting the maximum benefit from this beverage (Aparnna et al., 2024). Although date sap has been collected and consumed as fresh natural juice for many decades in Libya, and

despite the technological and marketing progress in the field of food manufacturing, there have not been many recent studies on date sap in Libya in order to value this nutritious natural product.

This study aimed to evaluate the chemical, phytochemical, mineral, and microbiological characteristics of date palm sap from different cultivars to assess its nutritional value, safety for human consumption, and potential use in developing quality standards.

Materials and Methods

Traditional date palm sap extraction method (cutting stem method):

In this traditional method, the farmer makes an incision at the upper part of the date palm trunk to allow the sap to flow, which is then collected in a container attached to the tree. This technique is considered efficient, as it yields substantial quantities of date sap without causing significant damage to the palm. After collecting sap from several date palm trees of the same cultivar, the sap is pooled into a single container, then filtered and manually filled into plastic bottles, and finally stored under freezing conditions, and subsequently sold at local points of sale as a fresh, refreshing beverage.

Sample collection

Date palm sap samples were collected from local retail outlets in the Zliten region (150 km away from the capital, Tripoli, on the western coast of Libya), where the sap is traditionally extracted by farmers and sold chilled or frozen at points of sale. To ensure sample integrity, only freshly refrigerated samples were selected at the time of purchase. The samples were transported to the laboratory in insulated and ice-cooled containers to minimize temperature fluctuations and microbial changes. Upon arrival, samples were kept under refrigerated conditions (4 °C) and analyzed at the same day. All samples were handled under hygienic conditions throughout transportation and preparation to prevent external contamination. As for the Tunisian date sap sample, it was purchased from Gabes, Tunisia, and it is also transported under the same isolated and refrigerated conditions and kept refrigerated during analysis.

Chemical analysis:

All chemical analysis was determined using standard analytical procedures described by (AOAC, 2023).

Total Soluble Solids (TSS): The Rhino Brix refractometer HR-150N/Rhino technology (Brix scale 0-80%) was used to determine TSS date sap samples.

Titratable acidity (TA): was determined by the titration method using NaOH (0.1 N) and phenolphthalein as indicators.

pH: pH measurement was conducted using calibrated digital pH meter (SensoDirect 150, Multi-Parameter Meter, Tintometer GmbH. United Kingdom).

Moisture Content: Determined using an ATG high-temperature oven (Shanghai, China). 5 g of the sample was dried at 135 °C for 2 hours until a constant weight was reached.

Ash Content: Determined using a ZE electric muffle furnace (Italy). 5 g of the sample was placed in a pre-weighed crucible and incinerated at 550 °C for 6 hours. After cooling in a desiccator, the residue was weighed, and ash content was expressed as (%).

Protein content was determined using the micro Kjeldahl method, which involves three main steps: digestion, distillation, and titration. Protein content was calculated using a conversion factor of 6.25.

Fat content: was determined using the Soxhlet extraction method. Fat content was expressed as grams of fat per 100 g of sample (g/100 g).

Fibers: Crude fiber content was determined using the acid–alkali digestion method. Crude fiber content was calculated as a percentage of the original sample weight.

Carbohydrate: the percentages of moisture, crude protein, crude fat, fiber and ash were determined using standard analytical procedures (AOAC, 2023). The total carbohydrate content was then calculated by subtracting the sum of these components from 100, according to the following equation:

Total carbohydrates (%) =100− (% moisture + % protein + % fat + % ash + % fiber)

Mineral concentrations: were determined using a flame photometer (BWB Technologies, England). Quantification was carried out by comparing sample readings with calibration curves constructed from standard solutions of each mineral (according to Harborne, 1998).

Phytochemical Identification Tests: Qualitative phytochemical screening was carried out using the methanolic extract of the samples to identify major bioactive constituents as follows:

Alkaloids: Two milliliters of the extract were mixed with 2 mL of dilute hydrochloric acid and heated in a water bath. The mixture was filtered, and a few drops of Mayer's or Wagner's reagent were added to the filtrate. The formation of a white or brown precipitate indicated the presence of alkaloids.

Flavonoids: Two milliliters of the extract were treated with 1 mL of 10% sodium hydroxide solution. The appearance of a yellow coloration that disappeared upon the addition of diluted hydrochloric acid confirmed the presence of flavonoids.

Tannins: A few drops of 1% ferric chloride solution were added to 2 mL of the extract. The development of a blue-black or green coloration indicated the presence of tannins.

Saponins: Two milliliters of the extract were vigorously shaken with 5 mL of distilled water for 30 seconds. The persistence of stable froth for at least 10 minutes indicated the presence of saponins.

Glycosides: The extract was treated with glacial acetic acid containing ferric chloride, followed by the careful addition of concentrated sulfuric acid along the side of the test tube. The formation of a brown ring at the interface indicated the presence of glycosides.

Determination of Total Polyphenol Content

Total polyphenols were determined using the Folin–Ciocalteu method. Polyphenolic compounds were extracted using methanol. An aliquot (0.5 mL) of the extract was mixed with 2.5 mL of diluted Folin–Ciocalteu reagent (1:10, v/v). After 5 minutes, 2 mL of 7.5% sodium carbonate solution were added. The mixture was incubated at room temperature in the dark for 30 minutes. Absorbance was measured at 695 nm using a spectrophotometer. Total polyphenol content was calculated from a standard calibration curve (gallic acid) and expressed as mg gallic acid equivalents (GAE) per gram of sample (Gutfinger, 1981).

Determination of Total Antioxidant Capacity (Phosphomolybdenum Assay)**:** Total antioxidant capacity was evaluated using the phosphomolybdenum method. The reagent solution consisted of 0.6 M sulfuric acid, 28 mM sodium phosphate, and 4 mM ammonium molybdate. One milliliter of the extract was combined with 3 mL of the reagent and incubated in a water bath at 95°C for 90 minutes. After cooling to room temperature, absorbance was measured at 695 nm. Antioxidant capacity was expressed relative to a standard calibration curve prepared using ascorbic acid.

Energy content: The energy content was determined via a CALO-3 bomb calorimeter, which is used to measure the heat of combustion when placed in a reaction container surrounded by water, where the substance and oxygen gas are placed and heated until the substance combusts, as the

temperature of the water surrounding the reaction container increases; then, the combustion temperature is calculated according to the following equation:

$Q = mCp\Delta T$

Where

Q = heat absorbed by water, m = mass of water in grams, Cp = 1 Cal/g °C, ΔT = change in temperature

Microbiological analysis:

Microbiological analysis was performed using Compact Dry™ plates (Nissui Pharmaceutical Co., Japan) a rapid ready-to-use test system for the enumeration of aerobic colony count (TC), coliforms, *E. coli*, yeasts, and molds according to (Mizuochi, et al., 2016). One ml of each sample was aseptically homogenized with 9 ml of sterile buffered peptone water to obtain a 10^{-1} dilution, followed by preparation of appropriate serial dilutions. One ml of each dilution was inoculated onto Compact Dry Total Count (TC), Compact Dry Coliforms/ *E. coli* (CF/EC), and Compact Dry Yeast and Molds (YM) plates. The plates were incubated according to the manufacturer's instructions at 35–37 °C for 24–48 h for TC, coliforms, and *E. coli*, and at 25 ± 1 °C for 3–5 days for yeasts and molds. After incubation, characteristic colonies were counted, and microbial loads were expressed as colony-forming units per ml (CFU/ml) of sample.

Statistical analysis: In this study, ANOVA table and LSD test was used. Chemical analysis results of this study (for 3 replicates) were subjected to statistical analysis using the SPSS program (version 21). An LSD test was conducted at a significant level of $p \leq 0.05$ to identify statistically significant differences among the mean values. The results were expressed as mean ± standard deviation.

Results and Discussion

Quality characteristic:

The percentage of total solids reflects the concentration of sugars in the date sap juice, which is an indicator of the degree of sweetness and nutritional value, while the acidity and pH affect the sensory properties, especially the taste, as well as the microbial quality characteristics and fermentation speed. The findings presented in Table (1) illustrate the chemical quality attributes of the date sap juice samples. Significant variations exist due to genetic differences (cultivars).

Sample D showed the highest sugar concentration, likely due to superior photosynthetic efficiency. It was found that the Dokar sample had the highest percentage of total solids (27.55±0.071) and the lowest percentage of acidity (0.06±0.007) and was characterized by a neutral pH of (7.00±0.007), while the Tunisian date sap sample showed the highest average acidity and a low pH (0.22±0.007 and 5.02±0.007, respectively). Date sap samples in this study had pH values near neutral except Tabony and Tunisian sample (Bekrari) as shown in table (1).

Table (1) Quality characteristics of date palm sap samples

Sample	TSS (Brix^0)	pH	Acidity% (as malic acid)
A	22.10±0.141^c	6.12±0.000^c	0.15±0.028^b
B	25.05±0.071^b	7.30±0.021^a	0.04±0.020^d
D	27.55±0.070^a	7.00±0.007^b	0.08±0.021^c
T	18.60±0.142^d	5.84±0.042^d	0.13±0.026^b
T0	24.75±0.072^b	5.05±0.035^e	0.22±0.029^a
P-value	0.000	0.000	0.000
Comment	S	S	S

The ANOVA test (F test) was used at the 0.05 significant level, with * meaning significantly different and ** highly significantly different. P-value ≥ 0.05. A, B, D, T, T0 are date palm sap samples (according to variety) where: A: Amy, B: Bekrari, D: Dokar (male date tree), T: Tabony (Libyan varieties), T0: Bekrari sample from Qabes/ Tunisia

The pH values recorded in this study showed a broader variation compared to the results of Zango et al. (2020), who reported a pH of 6.55. This divergence is likely due to differences in cultivar characteristics, soil composition, and the environmental conditions. It is also obvious that there is a significant difference between samples in the mean of TSS, pH, and Acidity all p-values are equal to 0.000 less than 0.05. According to Shanta et al. (2021), the total soluble solids (TSS) and acidity of fresh date palm juice were found to be 9.0 and 0.12, respectively. From the results obtained in the above table it is evident that Dokar and Bekrari samples are characterized by the super quality attributes among the samples under study.

Chemical composition

A significant difference between samples in the means of chemical composition was observed; all p-values ≥0.001. The date sap sample was characterized by moderate high-water content. It was found that the moisture content ranged between 69.89±0.014 and 81.11±0.007%. For ash content, the Amy date sap sample recorded the highest reading (3.50±0.007%), which is considered an indicator of the content of date sap of minerals and salts. The results further indicated that Dokar sample recorded the highest carbohydrate, fiber, and energy content (24.47%, 1.53%, and 108.32 kcal/100ml, respectively). The Dokar sample (D) is the sweetest sample among the tested samples. The Bekrari sample from Tunisia was distinguished by the highest protein content (6.02%) (Table 2).

Table (2) Chemical composition and total energy content of date sap samples

Sample	Moisture%	Ash%	Carbohydrate %	Protein%	Fat%	Fiber%	Total energy (kcal/100 ml)
A	77.00±0.007^{b}	3.50±0.007^{a}	14.61±0.049^{d}	3.54±0.035^{b}	0±0	1.35±0.014^{b}	72.60±0.057^{d}
B	72.70±0.007^{d}	1.30±0.014^{e}	22.92±0.028^{b}	1.91±0.014^{e}	0±0	1.17±0.007^{c}	99.32±0.057^{b}
D	69.89±0.014^{e}	1.51±0.007^{d}	24.47±0.049^{a}	2.60±0.007^{c}	0±0	1.53±0.035^{a}	108.28±0.17^{a}
T	81.11±0.007^{a}	2.93±0.021^{b}	13.02±0.035^{e}	2.22±0.021^{d}	0±0	0.72±0.028^{d}	60.96±0.226^{e}
T0	73.53±0.014^{c}	1.57±0.021^{c}	17.77±0.057^{c}	6.02±0.007^{a}	0±0	1.11±0.014^{c}	95.16±0.198^{c}
P-value	0.000	0.000	0.000	0.000		0.000	0.000
Comment	S	S	S	S		S	S

ANOVA test (F test) was use at 0.05 significant level, S ≡significant different, NS ≡Non- significance differences A, B, D, T, T0 are date palm sap samples where: A: Amy, B: Bekrari, D: Dokar (male date tree), T: Tabony, T0: (Bekrari sample) from Qabes, Tunisian.

As is known, water is very important in diets as it is a natural source for hydrating the body, maintaining its vital functions, transporting nutrients, and eliminating waste. It also helps regulate body temperature, which is what makes date juice a refreshing drink, especially in the scorching summer heat. In terms of ash content, the results of this study (ranging from 1.30% to 3.50%) were higher than the findings reported by Sarkar et al. (2023), who found an ash content of 1.8%.

This discrepancy is particularly evident in the Amy cultivar, which recorded the highest ash content at 3.50%. Such variations likely arise from differences in soil mineral composition, cultivar types, and geographical locations. According to Dirkes et al. (2021), the sweetness of date sap is primarily due to its high sugar content, which constitutes a major portion of its total carbohydrates. From a nutritional point of view, date palm sap is a natural beverage rich in sugars, which are a major source of immediate energy for the body; essential minerals that help balance electrolytes in the body; soluble fiber, which improves digestive health and bowel movements; and proteins, which play a crucial role in building and repairing tissues and cells and producing enzymes and hormones (Mahomoodally et al., 2023; Hai et al., 2024).

Phytochemical screening:

The phytochemical compounds present in date sap samples were examined to gain insights into their characteristics. Although some differences were observed during qualitative evaluation, the analysis showed strong positive results for some active chemical compounds, especially glycosides (+++). Compared to the other samples in this study, Amy's date sap sample exhibited medium and strong values of flavonoids, phenols, and alkaloids (Table 3).

Table (3) Preliminary phytochemical screening of active chemical components of date sap samples

Samples	Flavonoids	Phenols	Alkaloids	Glycosides	Saponins	Tannins
A	+++	++	++	+++	+	-ve
B	++	++	-ve	+++	+	++
D	-ve	++	-ve	+++	+	+++
T	++	-ve	+	+++	++	++
T0	-ve	-ve	-ve	+++	++	+++

(−ve, +, ++, +++) represent qualitative intensity levels of active phytochemical compounds.

Flavonoids have anti-inflammatory and antioxidant properties, which improve cognitive function and contribute to cardiovascular health (Li et al., 2018).The strength of antioxidant activity is

linked to the presence of phenolic compounds, flavonoids, and tannins, as the removal of free radicals is directly linked to these compounds (Kruk et al, 2022). It should be noted that environmental conditions at the time of sap collection such as temperature, humidity, and seasonal variations, can influence the concentration and activity of these phytochemicals. For example, higher temperatures and prolonged exposure during collection may lead to slight degradation of sensitive compounds, whereas cooler conditions may help preserve antioxidant constituents. Flavonoids are known for their anti-inflammatory and antioxidant properties, contributing to cardiovascular health and cognitive function (Ben Rawat et al., 2025). The strength of antioxidant activity is closely linked to the presence of phenolic compounds, flavonoids, and tannins, as these compounds play a direct role in free radical scavenging (Kruk et al., 2022).

4. Polyphenols and antioxidants:

The results presented in Table (4) demonstrate a highly significant variation ($p<0.000$) in the total polyphenol content among the investigated date sap samples. Sample B exhibited the most robust phenolic profile (10.817±0.741 mg GAE/g), which was significantly higher than all other treatments. This diversity in TPC can be attributed to the genetic variation between cultivars, physiological maturity of the palm at the time of tapping, and potential environmental stressors that stimulate the phenylpropanoid pathway, leading to increased secondary metabolite production. In contrast, the antioxidant activity showed no statistically significant differences across all samples ($p=0.072$). Although Sample B had a nominally higher value (0.28±0.03), the lack of significance (NS) suggests that the antioxidant capacity in date sap may be influenced by a complex synergistic effect of various bioactive constituents beyond just total phenols. These constituents may include melanoidins formed during sap handling or water-soluble vitamins. Furthermore, this outcome implies that while the quantity of polyphenols varies significantly by variety, the fundamental antioxidant potential remains relatively stable, ensuring a consistent functional value for the sap regardless of the source cultivar.

Table (4) Determination of polyphenols and antioxidants

	Polyphenols (mg/ GAE/g)	**Antioxidants (mg/GAE/g)**
A	2.017±0.341[d]	0.20±0.03
B	10.817±0.741[a]	0.28±0.03
D	0.090±0.025[c]	0.23±0.02
T	6.876±0.544[b]	0.23±0.02
T0	4.563±2.220[c]	0.25±0.05
P-value	0.000	0.072
Comment	S	NS

ANOVA test (F test) was use at 0.05 significant level, S ≡significant different, NS ≡ non-significant different

Date sap is known to contain chemically active compounds such as flavonoids and polyphenols, which are known for their health benefits in improving cardiovascular health (Jim et al., 2025). Al-Shwyeh, (2019), showed that the high levels of flavonoids in date sap were accompanied by high antioxidant activity and free radical inhibition, this result making date sap a promising drink for fighting cancer. Antioxidants and polyphenols are of great importance in promoting human health due to their ability to combat oxidative stress, which is the main cause of many diseases (Rudrapal, et al., 2022). Many studies have indicated that antioxidants and polyphenols are linked to reducing the risk of many chronic diseases such as cardiovascular disease, improving levels of beneficial HDL cholesterol, and preventing the formation of blood clots. Some types of antioxidants also help reduce the mutation of cells into cancerous cells, combat aging, and support digestive health through their positive effect on the gut microbiome, which in turn converts it into more effective bioactive compounds (Giurranna et al., 2024; Feldman et al., 2021; Serino & Salazar, 2018).

Mineral content:

The mineral composition of date sap samples (Table 5) revealed significant diversity ($p<0.000$) across all tested elements. Potassium was the most abundant mineral, ranging from 435.00 to 585.50 ppm. This aligns with previous studies on Phoenix dactylifera products, which typically identify potassium as the primary inorganic constituent. Notably, the negligible concentrations of sodium across most samples (specifically A, D, and T) result in a high K:Na ratio, a key metric for evaluating the cardioprotective potential of functional foods. Furthermore, the variation in Magnesium levels—peaking at 86.50 ppm in Sample (T) suggests that different date varieties or sap collection methods significantly influence the micronutrient density. The high Phosphorus content in Sample T0 (539.50±0.71 ppm) further distinguishes it as a potential source of dietary minerals compared to refined sweeteners. These results indicate that date palm sap is not merely a source of carbohydrates (as shown in Table 2) but also a complex matrix of essential minerals, particularly for potassium and magnesium. Significant differences ($P\geq0.05$) were detected between samples in term of mineral content, this difference may be due to the difference in varieties, environmental conditions and soil type.

Table (5) Minerals content (ppm)

Sample	P	K	Mg	Na	Ca
A	476.50±0.707^{b}	435.00±2.828^{d}	16.00±1.414^{d}	0.00±0.000^{c}	70.25±0.04^{a}
B	471.00±2.828^{c}	581.50±2.121^{a}	17.50±0.707^{d}	1.75±0.071^{b}	51.34±0.34^{e}
D	381.50±2.121^{d}	585.50±0.707^{a}	66.50±2.121^{b}	0.00±0.000^{c}	61.77±0.67^{b}
T	252.00±4.243^{e}	442.00±2.828^{c}	86.50±2.121^{a}	0.00±0.000^{c}	60.03±0.03^{c}
T0	539.50±0.707^{a}	499.50±0.707^{b}	18.00±1.414^{c}	3.30±0.141^{a}	56.79±0.09^{d}
P-value	0.000	0.000	0.000	0.000	0.000
Comment	S	S	S	S	S

ANOVA test (F test) was use at 0.05 significant level, * ≡significant different, ** ≡ Highly significant differences

The high K:Na ratio is highly desirable in modern diets. High potassium intake is linked to reduced blood pressure and lower cardiovascular risk, mention that date sap acts as a "natural

electrolyte" source (Souza et al., 2025). The mineral profile is characterized by an exceptionally high potassium-to-sodium ratio. This suggests that date sap could serve as a functional ingredient in hypertension-friendly diets, where low sodium and high potassium are essential for osmotic balance. Magnesium is a cofactor for over 300 enzyme systems. Phosphorus is vital for ATP production and bone health. Compare these to other saps (like maple or coconut sap). Usually, date sap is richer in phosphorus than many other palm saps, which adds to its value as a nutrient-dense beverage (Barbagallo et al., 2023). Calcium is often a limiting factor in plant-based diets. Even at ppm levels, the presence of calcium in a liquid sweetener adds to the "ash content," representing higher overall mineral density compared to refined sugars. Date sap juice contains a group of minerals necessary for human health as it is rich in potassium, which is necessary for muscle contraction and heart health, and calcium. Date sap is also abundant in phosphorus and magnesium (Al-Okbi, 2022).

Microbiological contamination:

The microbiological profile (Table 6) highlights a significant disparity in the microbial load among the samples. The absence of *E. coli* across all treatments is a crucial indicator of the biological safety of the sap for human consumption. However, the high Total Colony Count (TCC) in Sample B (415×10^2 CFU/ml) suggests a high susceptibility to microbial proliferation, likely due to its high nutrient density. Regarding Yeasts and Molds, Sample T0 exhibited the lowest microbial density (0.02×10^2 CFU/ml). This observation correlates strongly with the physicochemical findings in Table 1, where T0 showed the lowest pH and highest acidity. This acidic environment likely acted as a bio-preservative, inhibiting the growth of acid-sensitive microorganisms.

Table (6) Microbiological analysis: (CFU/ml, 10^2)

Sample	Total Colony Count	Total Coliforms	Yeasts and Molds	E. coli
A	1.03	0.69	0.73	N.D.
B	415.00	1.03	0.36	N.D.
D	21.00	5.51	0.24	N.D.

T	1.12	0.45	0.51	N.D.
T0	1.25	N.D.	0.02	N.D.

Harper et al. (2022) and Reuben et al. (2019) confirmed that *Leuconostoc spp*, (one of the fermenting lactic acid bacteria strains) showed anti-E. coli activity, which may explain the absence of it in the date sap samples under study. Since the presence of bacteria and yeasts has a significant impact on the fermentation of date sap and the conversion of sugars into alcohol, it can be confirmed that contamination of date sap with bacteria and yeasts has a significant impact on its chemical and sensory quality and suitability for consumption. According to international guidelines for fresh juices and beverages, the absence of *E. coli* is a key requirement for consumer safety, whereas elevated total microbial and yeast counts may limit shelf life and marketability unless appropriate hygienic controls are applied. It should be noted that date sap in Libya collected and packaged using traditional, non-sterilized containers, which likely contributed to the observed microbial loads and may not fully reflect the intrinsic microbial quality of freshly exuded sap. Therefore, under current traditional handling practices, fresh date sap may pose quality and safety challenges for direct commercialization. However, the implementation of improved hygienic collection methods, use of sterilized containers, rapid cooling, or mild preservation treatments could significantly reduce microbial contamination and enhance its potential as a safe and marketable fresh beverage.

Conclusion

This study has proven that date sap is a rich source of easily absorbed carbohydrates, proteins, and essential minerals like potassium and calcium, in addition to its good content of chemically active compounds such as phenolic compounds and antioxidants. From all of this, we conclude that date sap juice is a unique beverage that is more than just a refreshing summer drink; it extends to form a functional product that offers health advantages, positioning it as a potential choice in the sustainable food and beverage industry. The study recommends the development of strict protocols for the safety of date sap to ensure its continued production as a high-quality and safe product for consumers, thus strengthening its position as a sustainable product with high nutritional and functional value. Rather, it extends to form a functional product with health benefits, making it a promising option in the sustainable beverage market. This supports its

position as a sustainable product with high nutritional and functional value, while emphasizing the development of effective extraction methods that do not harm the palm tree.

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تقييم شامل للجودة الغذائية والمحتوى الكيميائي والنشاط المضاد للأكسدة والسلامة الميكروبية لعصارة نخيل التمر من أصناف مختلفة

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الخلاصة

قيم هذا البحث الجودة الغذائية والسلامة الصحية لعصارة نخيل التمر من أربعة أصناف ليبية (Amy و Bekrari و Dokar و Tabony) وعينة واحدة من صنف Bekrari التونسي. أظهرت التحاليل الكيميائية تبايناً ملحوظاً بين العينات، حيث سجلت عصارة صنف Dokar أعلى محتوى من المواد الصلبة الكلية (27.55 درجة بريكس)، في حين أظهرت أدنى قيم للحموضة الكلية (0.065%) ودرجة الحموضة (7.00). وكشفت الفحوصات الكيميائية النباتية عن مستويات مرتفعة من الغليكوسيدات والفينولات والفلافونويدات في جميع العينات. كما احتوت عصارة صنف Bekrari الليبي على أعلى محتوى من متعددات الفينول (10.81 ملغم/GAE غم). وأوضحت التحاليل المعدنية أن عصارة التمر تُعد مصدراً غنياً بالعناصر المعدنية الأساسية، ولا سيما البوتاسيوم والكالسيوم والفوسفور. وأظهرت الفحوصات الميكروبيولوجية وجود بكتيريا القولون (45–551 × CFU/10² مل) والخمائر والعفن (2–73 × CFU/10² مل) في العينات المدروسة، في حين لم يتم الكشف عن الإشريكية القولونية في أي منها. وتبرز هذه النتائج القيمة الغذائية والوظيفية لعصارة التمر، لكنها تشير أيضاً إلى مخاوف تتعلق بالتلوث الميكروبي. كما تؤكد الدراسة على ضرورة تحسين الممارسات الصحية أثناء جمع العصارة ومعالجتها وتعبئتها لتعزيز سلامة المنتج وإطالة مدة صلاحيته. إضافة إلى ذلك، توفر النتائج بيانات أساسية مهمة يمكن أن تدعم تطوير معايير الجودة ولوائح السلامة الخاصة بعصارة نخيل التمر المخصصة للاستهلاك البشري في ليبيا.

الكلمات المفتاحية: عصارة التمر، الفلافونويدات، التركيب الكيميائي، القيمة الغذائية، الاغذية الوظيفية.