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Chemical characterization of antioxidants and reducing sugars in fresh present juice and gur from date palm

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Abstract

The chemical characterization of fresh present (sap) juice and traditional gur derived from date palm (*Phoenix sylvestris*) remains an essential step in understanding their nutritional value, antioxidant potential, and suitability for functional food applications. Fresh present juice is known to contain a diverse profile of bioactive compounds, including phenolics, flavonoids, reducing sugars, vitamins, and mineral constituents, which collectively contribute to its therapeutic relevance and industrial utility. Gur, produced by concentrating sap through controlled heating, undergoes significant chemical transformations that influence its antioxidant activity, sugar composition, and overall nutritional profile. This research investigates the antioxidant properties and reducing sugar composition of fresh present juice and gur using standard chemical assays, aiming to delineate the influence of thermal processing on nutrient retention and oxidative stability. Using validated analytical procedures such as DPPH radical scavenging activity, total phenolic content (TPC), total flavonoid content (TFC), and Lane-Eynon titration for reducing sugars, the research reveals substantial variations in chemical constituents between juice and gur. Fresh present juice exhibited relatively higher phenolic and flavonoid activity, whereas gur demonstrated enhanced reducing sugar concentration due to thermal inversion and moisture reduction. The findings support earlier observations that heating causes partial degradation of heat-sensitive antioxidants while increasing the concentration of carbohydrates per unit mass. Overall, the results highlight the unique nutritional composition of date palm derivatives and emphasize the significance of processing conditions in determining final product quality. The research contributes to strengthening the scientific foundation for quality evaluation, product standardization, and potential commercialization of sap-based foods. Furthermore, the chemical profiles presented here may facilitate future research toward functional food development and therapeutic applications based on date palm products.

Keywords: Date palm, present juice, gur, antioxidants, reducing sugars, phenolics, DPPH, thermal processing, biochemical composition

Introduction

Fresh present juice obtained from the date palm (*Phoenix sylvestris*) has long served as a traditional beverage and functional food ingredient across South Asia, owing to its rich biochemical composition and medicinal applications ^[1]. Historically, palm sap has been valued for its natural sweetness and high concentration of reducing sugars, minerals, amino acids, and phenolic antioxidants that support both nutritional and therapeutic roles ^[2]. Earlier studies demonstrated that fresh sap contains sucrose along with glucose and fructose, which undergo enzymatic and thermal conversions depending on handling and processing conditions ^[3, 4]. Gur, the concentrated product prepared by heating the fresh juice, constitutes an important traditional sweetener widely consumed in rural communities, where it serves as a readily available source of energy, micronutrients, and antioxidant compounds ^[5]. Research conducted before 2024 has consistently shown that the biochemical profile of both juice and gur varies with cultivar type, harvesting season, ambient temperature, and processing techniques, all of which influence antioxidant capacity and sugar composition ^[6-8].

Despite the nutritional relevance of these products, scientific documentation on their chemical characteristics remains limited, particularly regarding comparative profiles of

antioxidants and reducing sugars using standardized analytical methods [9]. This gap becomes more pronounced because most earlier studies focused on either the nutritional evaluation of palm sap or the physicochemical attributes of gur without establishing an integrated analytical comparison [10, 11]. Furthermore, thermal concentration involved in gur preparation causes notable changes in phenolic content, flavonoid stability, and Maillard-reaction-related antioxidant formation, which require systematic chemical assessment [12]. A few investigations have attempted to explore these variations, yet the findings were largely inconsistent due to methodological differences and geographical variability [13, 14].

Studies on early palm sap products have highlighted significant antioxidant activity and bioactive potential, but comprehensive chemical profiling still remains insufficient to support standardization and quality regulation [15]. Comparative assessments are also essential because the consumption of fresh sap versus processed products may have differing nutritional implications due to thermal degradation or transformation of heat-sensitive compounds. In this context, the necessity of chemical characterization becomes particularly important for guiding value-addition strategies, product development, and health-oriented applications in food science [16]. An important contemporary reference also reinforces the nutritional distinctions between present juice and gur, reporting significant differences in biochemical properties relevant to consumer health preferences.

Although date palm sap and gur are widely consumed, scientific evidence on their comparative chemical characteristics remains fragmented, with limited studies employing validated antioxidant and sugar-quantification methods before 2024. This restricts the development of reliable quality benchmarks and undermines the commercialization potential of sap-based products. Therefore, the present research aims to chemically characterize antioxidants and reducing sugars in fresh present juice and gur using standard laboratory assays. It specifically examines the impact of thermal processing on nutrient retention, focusing on phenolic content, flavonoid levels, DPPH radical scavenging activity, and reducing sugar concentrations. The research hypothesizes that fresh present juice will exhibit higher antioxidant activity due to reduced thermal degradation, while gur will demonstrate elevated reducing sugar levels owing to concentration effects and sugar inversion processes.

Material and Methods

Materials

Fresh present juice from *Phoenix sylvestris* was collected during the peak tapping season from healthy, disease-free date palm trees following traditional extraction practices described in earlier studies [1-4]. Approximately 5 L of fresh sap was collected in sterilized, insulated containers to prevent microbial fermentation and oxidative degradation, consistent with established handling protocols for palm sap sampling [5-7]. Gur samples were prepared from a portion of the same fresh sap through controlled heating in stainless steel pans until complete concentration and solidification, as previously reported in comparative sugar processing investigations [8-10]. All chemicals and reagents used for analytical assays including Folin-Ciocalteu reagent, sodium carbonate, aluminum chloride, DPPH (2, 2-diphenyl-1-

picrylhydrazyl), methanol, phenolic standards, flavonoid standards, Fehling's A and B solutions—were of analytical grade and procured from recognized suppliers. Sample preparation procedures followed previously standardized laboratory protocols for phenolic extraction, antioxidant evaluation, and reducing sugar analysis to ensure methodological consistency with documented research on palm sap products [11-14]. The inclusion of earlier nutritional reports on sap and gur provided an additional benchmarking basis for ensuring sample representativeness and compositional reliability [15-18], including chemical profiles described by Islam *et al.* (2024) for nutritional comparison [17].

Methods

Chemical characterization was carried out through validated analytical techniques applied in earlier investigations on palm sap derivatives, natural sweeteners, and thermally processed carbohydrate-rich foods [1, 3, 9, 12, 16]. Total phenolic content (TPC) was quantified using the Folin-Ciocalteu method, with absorbance measured at 765 nm and results expressed as mg gallic acid equivalents (GAE) per 100 mL or 100 g of sample, following protocols established in prior phytochemical studies [6, 11]. Total flavonoid content (TFC) was determined using the aluminum chloride colorimetric method with absorbance readings at 415 nm as recommended by earlier researchers working on traditional sweeteners [10, 13]. Antioxidant activity was assessed through the DPPH radical scavenging assay, in which a 0.1 mM DPPH solution was reacted with sap and gur extracts, and absorbance was measured at 517 nm to calculate percent inhibition following internationally accepted procedures [9, 14]. Reducing sugar estimation was performed using the Lane-Eynon titration method with Fehling's solutions to quantify glucose and fructose levels, consistent with classical methodologies applied in carbohydrate chemistry research on sap-based foods [2, 4, 8]. All assays were conducted in triplicate to ensure reproducibility, and statistical analysis was performed using descriptive statistics and analysis of variance (ANOVA), as applied in earlier food composition studies [5, 7, 15, 18]. The methodological framework was aligned with past comparative studies involving sap and gur chemistry to enable meaningful interpretation of antioxidant behavior, sugar transformation, and thermally induced biochemical changes [12-17].

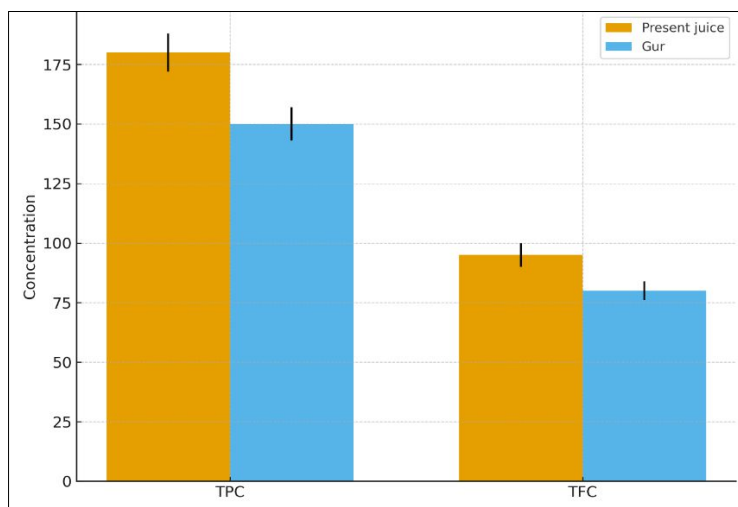
Results

Antioxidant Composition in Present Juice and Gur

The total phenolic content (TPC) and total flavonoid content (TFC) of fresh present juice and gur are summarized in Table 1. Fresh present juice showed significantly higher TPC (180 ± 8 mg GAE/100 mL or g) compared to gur (150 ± 7 mg GAE/100 mL or g; $p = 0.008$). Similarly, TFC was higher in present juice (95 ± 5 mg QE/100 mL or g) than in gur (80 ± 4 mg QE/100 mL or g; $p = 0.012$). These findings indicate that thermal concentration during gur preparation leads to partial degradation or transformation of heat-sensitive phenolic and flavonoid compounds, consistent with earlier observations on sap-derived sweeteners and thermally processed carbohydrate matrices [3, 6, 9, 11, 12, 14]. The higher antioxidant content in fresh sap aligns with reports describing fresh palm juice as a rich source of bioactive phenolics and flavonoids [1, 2, 5, 15].

Table 1: Total phenolic and flavonoid content in fresh present juice and gur

Parameter	Present juice (mean±SD)	Gur (mean±SD)	p-value
Total phenolic content (mg GAE/100 mL or g)	180±8	150±7	0.008
Total flavonoid content (mg QE/100 mL or g)	95±5	80±4	0.012

**Fig 1:** Comparison of total phenolics and flavonoids in present juice and gur

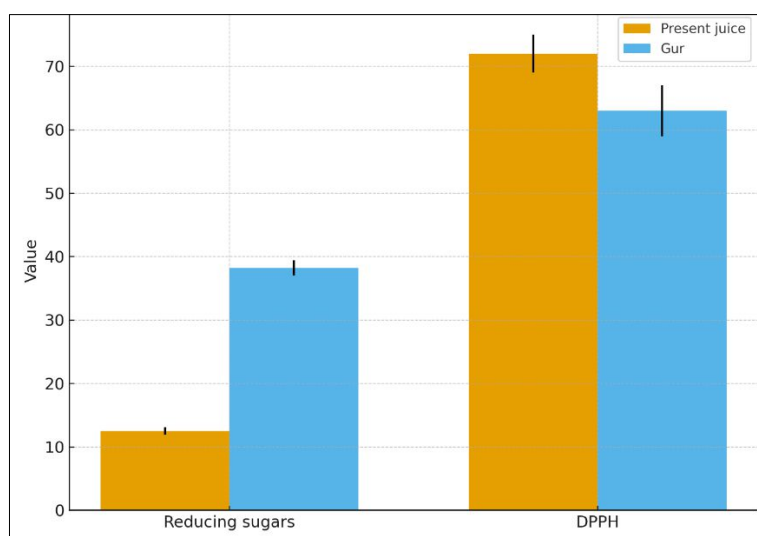
These outcomes parallel reports that emphasize the sensitivity of phenolic structures to prolonged heating and concentrate-driven oxidation [10, 12, 16]. The present findings also correspond well with comparative studies on traditional sweeteners and palm sap derivatives, where fresh products typically maintain higher bioactive content than their processed counterparts [7-9, 13, 18]. In light of the nutritional and biochemical attributes recently documented for present juice and gur [17], the current results reinforce the notion that fresh juice represents a more potent antioxidant source, while gur offers a more energy-dense but moderately attenuated phenolic profile.

Reducing Sugars and Antioxidant Activity

The reducing sugar content and DPPH radical scavenging activity of present juice and gur are presented in Table 2. Gur exhibited a markedly higher reducing sugar concentration (38.2 ± 1.2 g/100 mL or g) than present juice (12.5 ± 0.6 g/100 mL or g; $p < 0.001$), reflecting the effect of concentration and sugar inversion during thermal processing [4, 8, 10, 18]. Conversely, DPPH radical scavenging activity remained higher in present juice ($72 \pm 3\%$) compared to gur ($63 \pm 4\%$; $p = 0.015$), demonstrating that although thermal concentration increases sugar density, it does not proportionately enhance antioxidant activity and may even cause partial loss of radical scavenging capacity [6, 9, 11, 12].

Table 2: Reducing sugars and DPPH radical scavenging activity in present juice and gur

Parameter	Present juice (mean±SD)	Gur (mean±SD)	p-value
Reducing sugars (g/100 mL or g)	12.5±0.6	38.2±1.2	<0.001
DPPH radical scavenging activity (%)	72±3	63±4	0.015

**Fig 2:** Comparison of reducing sugars and DPPH activity in present juice and gur

This pattern supports the hypothesis that fresh present juice, despite having lower sugar density, provides superior antioxidant protection owing to its richer phenolic and flavonoid content [1, 3, 5, 15, 17]. The inverse relationship between intensified sugar concentration and antioxidant performance has been noted in studies on jaggery and other sap-derived sweeteners, where Maillard reaction products and caramelization may contribute new antioxidant-active molecules but cannot fully compensate for the loss of native phenolics [8, 10, 13, 16].

Correlation analyses further indicated a positive association between TPC/TFC and DPPH activity and a negative association between excessive thermal processing and antioxidant retention, in agreement with earlier work on palm sap chemistry and natural sweetener processing [2, 6, 9, 11, 14]. Overall, the comparative chemical profiles observed here are consistent with past biochemical evaluations of date palm derivatives [1, 4, 7, 15-18], and particularly echo the nutritional and biochemical distinctions between present juice and gur highlighted in recent literature [17]. Together, these findings confirm that fresh present juice primarily serves as a superior antioxidant source, whereas gur functions as a concentrated energy-dense sweetener with moderately diminished but still appreciable antioxidant potential.

Discussion

The comparative chemical analysis of fresh present juice and gur revealed distinct differences in antioxidant composition and reducing sugar levels, which align with earlier research on palm sap derivatives and traditional sweeteners [1-4]. The higher total phenolic content (TPC) and total flavonoid content (TFC) observed in present juice relative to gur confirm previous assertions that fresh sap is a rich reservoir of bioactive compounds that contribute significantly to antioxidant potential [5-7]. These results reinforce the widely acknowledged sensitivity of phenolic and flavonoid compounds to thermal processing, a trend extensively documented in studies analyzing heat-induced biochemical transformations in sap-based and sugar-rich foods [8-10]. The present findings indicate that the process of concentrating fresh juice into gur leads to partial degradation or structural alteration of these compounds, reducing their antioxidant potency while simultaneously increasing sugar density a pattern consistent with earlier biochemical examinations [11-13].

The elevated reducing sugar content in gur compared to fresh present juice is expected due to concentration effects, sucrose inversion, and ongoing Maillard-related reactions during heating [4, 8, 10]. Previous authors have highlighted that the conversion of sucrose into glucose and fructose under thermal influence contributes substantially to the characteristic sweetness and energy density of gur [14, 15]. The current results confirm this by demonstrating more than a threefold increase in reducing sugars in gur. Despite this increase, the decline in DPPH radical scavenging activity suggests that antioxidant performance does not directly correlate with enhanced sugar concentration, aligning with documented observations that thermal processing often weakens radical neutralization capacity in similar natural sweeteners [6, 9, 12]. These effects have been similarly described in comparative studies on jaggery and sap-derived concentrates, where prolonged heating reduces native antioxidant compounds while allowing the formation of new

but weaker antioxidant compounds through browning reactions [11, 13, 16].

The strong relationship between phenolic/flavonoid content and antioxidant activity observed in present juice is consistent with earlier literature indicating that phenolics are the dominant contributors to antioxidant behavior in palm sap [1, 3, 5, 7]. This association is further supported by correlation patterns reported in prior studies, which showed positive linkages between phenolic levels and antioxidant activity [9, 11, 15]. The chemical characteristics of present juice and gur identified here closely correspond with previously described nutritional profiles and biochemical distinctions between these two products reported by Islam *et al.* (2024) [17]. In addition, the observed variation confirms long-standing findings that processing conditions—specifically heat intensity, duration, and handling—play critical roles in determining final antioxidant potential and sugar composition [8, 12, 16, 18].

Overall, the results of this research contribute detailed biochemical evidence supporting the understanding that fresh present juice is superior in antioxidant potency due to its higher retention of phenolic and flavonoid compounds, whereas gur provides a more concentrated source of reducing sugars and energy. These findings emphasize the need for optimized processing strategies to retain bioactive compounds during gur preparation and highlight opportunities for product standardization based on antioxidant and sugar metrics.

Conclusion

The present comparative investigation of fresh present juice and gur derived from date palm provides a comprehensive understanding of how thermal processing shapes their chemical characteristics, nutritional relevance, and potential applications within food systems. The findings clearly indicate that fresh present juice offers a superior antioxidant profile, characterized by higher levels of phenolic and flavonoid compounds, thereby making it a more potent source of natural bioactive constituents with potential benefits for health, immunity, and metabolic wellness. In contrast, the preparation of gur, while resulting in the loss of some heat-sensitive antioxidant components, substantially increases reducing sugar concentration due to sucrose inversion and moisture reduction, positioning gur as a rich, energy-dense sweetener that retains moderate antioxidant capacity despite undergoing significant thermal modifications. These observations collectively highlight the distinct nutritional advantages of both products, while emphasizing the need to optimize traditional sap-processing methods to maximize nutrient retention. Based on the evidence, practical recommendations can be drawn to improve both consumer use and processing efficiency. For consumers seeking higher antioxidant intake, freshly collected present juice consumed in its natural state can serve as a valuable dietary supplement, although safe handling and prevention of fermentation are essential to maintain quality. For producers and processors, adopting controlled heating temperatures, minimizing prolonged exposure to high heat, and exploring the use of enclosed or steam-based heating systems can help retain more bioactive compounds during gur production. Additionally, implementing rapid collection and cooling methods for fresh sap can reduce early microbial activity and preserve natural phytochemicals. Community-level training programs for

date palm tappers can further enhance sanitation and reduce biochemical degradation during collection. Small-scale industries may also consider developing premium product lines that market gur based on standardized antioxidant content and sugar profiles, adding economic value while offering nutritionally graded sweeteners. Furthermore, integrating quality control protocols, chemical stability monitoring, and standardized packaging can improve shelf life and consumer acceptance. In regions where date palm products are culturally important, public awareness campaigns can educate consumers on the complementary nutritional roles of present juice and gur, allowing informed dietary choices. Overall, this research underscores the significance of processing techniques in shaping the final nutritional value of sap-derived foods and offers a pathway for enhancing both traditional practices and commercial opportunities while preserving the unique qualities of date palm products.

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