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ICP-OES-Based Determination of Mineral Content in Dates and Commercial Date Juices Available in Malaysia

Nur Syazwani Mohd Hanafiah[1], Nasrul Hisyam Nor Muhamad[1], Radhiahtul Raehan Mustafa[1], Faizuan Abdullah[2]

[1]Academy of Islamic Civilisation, Faculty of Social Sciences and Humanities, [2]Faculty of Science, Universiti Teknology Malaysia, 81310 Skudai, Johor, Malaysia

Email: nasrul@utm.my, radhiahtulraehan@utm.my, faizuan@utm.my

*Corresponding Author Email: nsyazwani33@graduate.utm.my

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Abstract

This study explores the rising consumption of functional beverages in Malaysia, particularly date juice, which is often associated with Sunnah foods. Dates (Phoenix dactylifera L.) are traditionally recognized for their historical, spiritual, and nutritional value. Today, they are processed into commercial juice products to meet modern consumer demands. However, this transformation raises questions about the preservation of nutritional integrity and the alignment of such products with the principles of halalan toyyiban, which emphasize safety, quality, and consumer well-being. The aim of this preliminary study is to critically evaluate and compare the mineral content of whole dates and commercial date juices available in the Malaysian market. Quantitative analysis was conducted using Inductively Coupled Plasma–Optical Emission Spectrometry (ICP-OES), a high-precision analytical method that allows comprehensive detection and quantification of mineral elements. The findings revealed that both categories of samples contained essential minerals such as zinc (Zn), phosphorus (P), iron (Fe), manganese (Mn), magnesium (Mg), calcium (Ca), copper (Cu), sodium (Na), and potassium (K), but with notable variations in concentration levels. These differences reflect the significant impact of industrial processing methods, which may lead to nutrient loss or, conversely, nutrient retention or enrichment. Among the samples, one commercial date juice product, referred to as Sample JB, consistently exhibited higher concentrations of minerals and was therefore considered the most nutritious among those tested. In conclusion, not all date juices result in reduced nutritional value. Some products retain or even enhance essential nutrients. This study provides an empirical foundation for better product selection and supports the scientific development of Sunnah-based functional foods.

Keywords: Date Juice, Halalan Toyyiban, ICP-OES, Mineral Analysis and Nutritional Content

Introduction

The date palm or Phoenix dactylifera, is considered one of the oldest and most valuable fruit plants due to its nutritional, medicinal, religious and socioeconomic significance (Ali et al., 2012). The increasing consumption of dates is closely related to their high nutritional content, particularly in terms of minerals. Minerals are a key nutrient in dates. Among the minerals found in dates are potassium, phosphorus, calcium, magnesium, sodium and zinc (Hamad et al., 2015; E.A. El-Nagga & Y.A. Abd El Tawab, 2012; Iman Ismail & Duaa Altuwairki, 2016).

In the study conducted by Hamad et al. (2015), the findings revealed that potassium was the highest mineral present in all types of dates studied, except for Nabtit Ali. The second highest mineral was phosphorus, followed by magnesium and sodium. The result indicating potassium as the highest mineral is consistent with the findings of Eman Abdul Rahman Assirey (2015) and E.A. El-Nagga and Y.A. Abd El Tawab (2012). However according to Eman Abdul Rahman Assirey (2015), the second highest mineral found in dates was calcium. This finding differs from the study by Hamad et al. (2015), which identified phosphorus as the second highest mineral.

The diverse mineral content clearly highlights the potential of dates as a nutritional source that contributes to health. The consumption of Sunnah foods such as dates provides various health benefits to its consumers. This is because dates are rich in various bioactive components that play important roles in the prevention and treatment of diseases.

Among the benefits of dates are their function as antioxidants that help combat free radicals in the body, antitumor agents that have the potential to prevent the growth of cancer cells and neuroprotective agents that protect nerve cells. Additionally, dates help improve male fertility, regulate cholesterol levels in the blood, act as antiatherogenic agents that prevent plaque formation on artery walls and possess antidiabetic and antilipidemic properties that aid in controlling blood sugar and fat levels.

With its numerous health benefits, dates possess high added value and should be fully utilized. Typically, after the month of Ramadan, there is an oversupply of dates in the market. To address this issue, dates can not only be consumed as dried fruits but also processed into other products such as date juice. Currently, the demand for health products like date juice is increasing. This is driven by the growing public awareness of the importance of consuming high-quality, safe, nutritious, and balanced food for overall health. According to Principato et al. (2025), public awareness of healthy eating and environmental sustainability has risen as a result of nutrition and environmental education. This awareness encourages consumers to make healthier, higher-quality, and safer food choices.

This is also in line with Allah's command in Surah Al-Mā'idah, verse 88, which calls upon Muslims to consume food that is halal and good (halalan tayyiban):

وَكُلُواْ مِمَّا رَزَقَكُمُ ٱللَّهُ حَلَٰلًا طَيِّبٗاۚ وَٱتَّقُواْ ٱللَّهَ ٱلَّذِيٓ أَنتُم بِهِۦ مُؤۡمِنُونَ

"And eat of what Allah has provided for you, [that which is] lawful and good (tayyib), and fear Allah in whom you are believers."

This verse emphasises that Muslims are required not only to consume halal food but also food that is tayyib, meaning that it does not cause harm or danger to health. In line with this, there has been a marked increase in the consumption of health-related products based on herbal ingredients, organic sources, and Sunnah foods. These products are widely used as complementary options for maintaining health and as adjuncts in the prevention and management of certain illnesses (Khadher Ahmad et al., 2016).

Therefore, the demand for date juice products is high as they are perceived to be beneficial for health. However, a critical question arises: do these products truly provide health benefits to consumers or otherwise? This is because food processing methods such as freezing, heating, and drying can lead to some loss of nutrients, even if minimal, as stated by Visioli et al. (2023).

This differs from natural Sunnah foods like whole dates, which are well known for their health benefits and are free from added additives (Naureen et al., 2022). Therefore, this study was conducted to examine whether there are differences in the nutritional mineral content between whole dates and commercial date juice, and whether date juice is suitable for regular consumption.

Methodology

Mineral Analysis

Mineral analysis provides essential information on the nutritional value and potential health benefits of date-based products. In this study, the mineral composition of whole dates and commercial date juices was determined using Inductively Coupled Plasma–Optical Emission Spectrometry (ICP-OES), a technique widely used in food research for multi-element analysis. The method enables accurate detection and quantification of essential minerals such as potassium, magnesium, calcium, and zinc.

Sample Preparation and Acid Digestion

0.5 g of date powder was accurately weighed and transferred into a digestion vessel. The sample was then treated with 5 mL of nitric acid and 2 mL of 30% hydrogen peroxide. For date juice, 12.5 mL of each sample was placed into a vessel and mixed with 2 mL of 30% hydrogen peroxide. All mixtures underwent acid digestion at approximately 250 °C and 160 bar for about 10 minutes to break down organic matter and release mineral elements. After digestion, the solutions were allowed to cool to room temperature and then diluted to a final volume of 25 mL with deionised water. The diluted samples were filtered to remove any remaining particulates prior to analysis.

ICP-OES Analysis

Mineral analysis was performed using ICP-OES. Instrumental parameters were adjusted to obtain stable and accurate signals, including an RF power of approximately 1150 W, a nebuliser gas flow rate of 0.4 L/min, and an auxiliary gas flow rate of 0.5 L/min. These settings were optimised to ensure efficient atomisation and excitation of mineral elements within the plasma. Figure 2 presents a simplified flowchart of the sample preparation and ICP-OES analytical procedure for mineral determination.

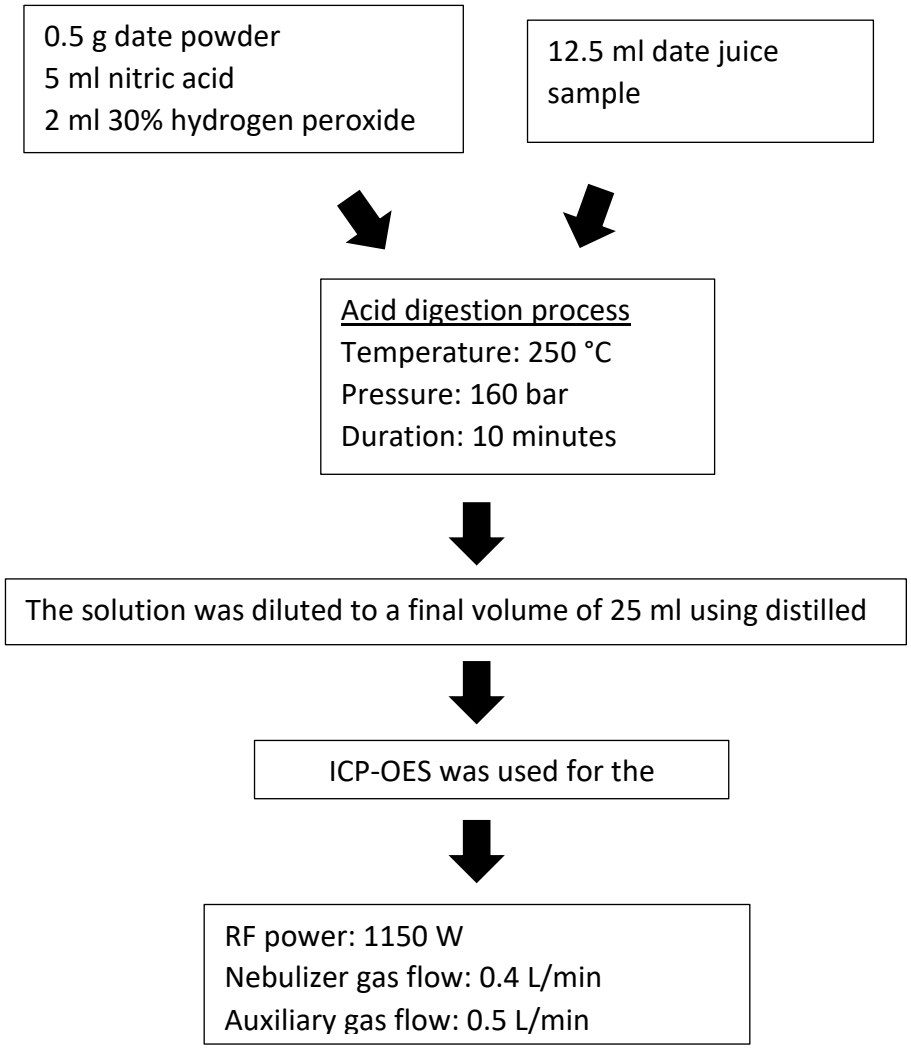

Figure 2. Flowchart of mineral analysis using ICP-OES

Results and Discussion

Mineral Profiles of Dates and Date Juices

Nine minerals were examined in this study: zinc (Zn), phosphorus (P), iron (Fe), manganese (Mn), magnesium (Mg), calcium (Ca), copper (Cu), sodium (Na), and potassium (K). Four date fruit samples were analysed: Mabroum (SA), Ajwa (SB), Safawi (SC), and Medjoul (SD). In addition, three commercial date juice samples were evaluated and labelled as JA, JB, and JC. The mineral content values were measured in mg/kg. The results of the nine types of minerals studied are shown in Table 1.

Table 1

Mineral content in date fruits and commercial date juices (mg/kg)

MINERAL (mg/kg)	SA	SB	SC	SD	JA	JB	JC
Zinc (Zn)	15.51	12.58	7.892	9.860	2.481	18.15	8.563
Phosphorus (P)	947.0	963.8	844.7	847.3	588.6	1644	1412
Iron (Fe)	5.804	17.61	23.03	5.769	2.716	23.25	6.059
Manganese (Mn)	2.551	4.938	4.981	3.192	1.246	7.330	3.572
Magnesium (Mg)	724.6	581.3	614.6	743.0	248.8	1409	876.1
Calcium (Ca)	984.0	403.5	380.2	396.9	290.9	1847	708.9

Copper (Cu)	5.963	4.105	3.765	4.092	1.668	3.314	2.526
Sodium (Na)	241.2	317.9	248.2	184.1	1542	802.2	4788
Potassium (K)	15110	11230	7757	8219	4535	19540	15970

From Table 1, seven of the nine minerals (Zn, P, Fe, Mn, Mg, Ca, and K) were present at the highest levels in Sample JB, indicating that this date juice product had the most enriched mineral profile among all samples analysed. Copper was highest in the Mabroum date sample (SA), while sodium was highest in the JC juice sample.

For most minerals (Zn, P, Fe, Mn, Mg, Ca, Cu, and K), Sample JA showed the lowest values among all samples, whereas sodium was lowest in the Medjoul date sample (SD). Across all samples, potassium was the most abundant mineral, consistent with previous reports that dates are naturally rich in potassium (e.g. Bano et al., 2022). Figures 3–11 further illustrate the variation in mineral contents across the different samples.

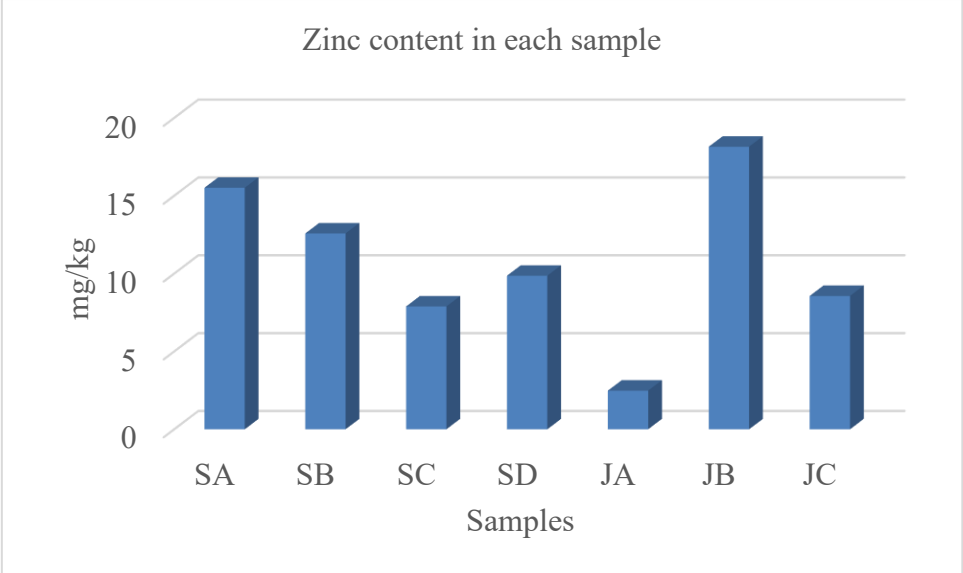

Figure 3. Graph of zinc content in each sample

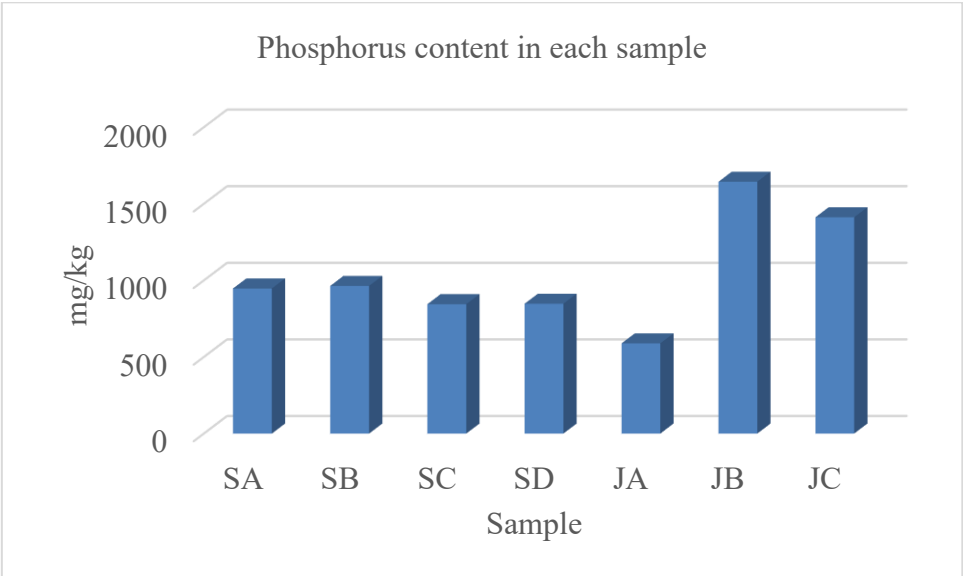

Figure 4. Graph of phosphorus content in each sample

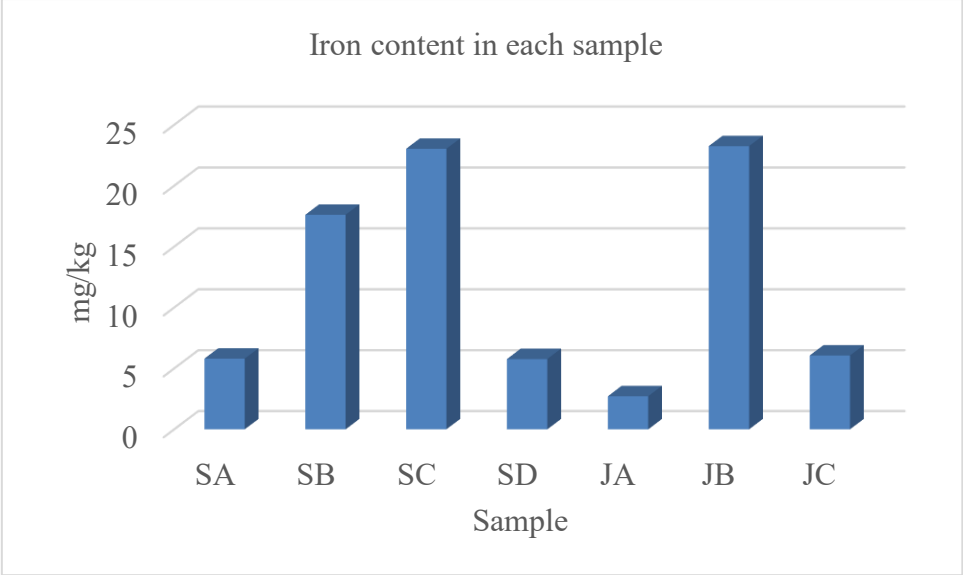

Figure 5. Graph of iron content in each sample

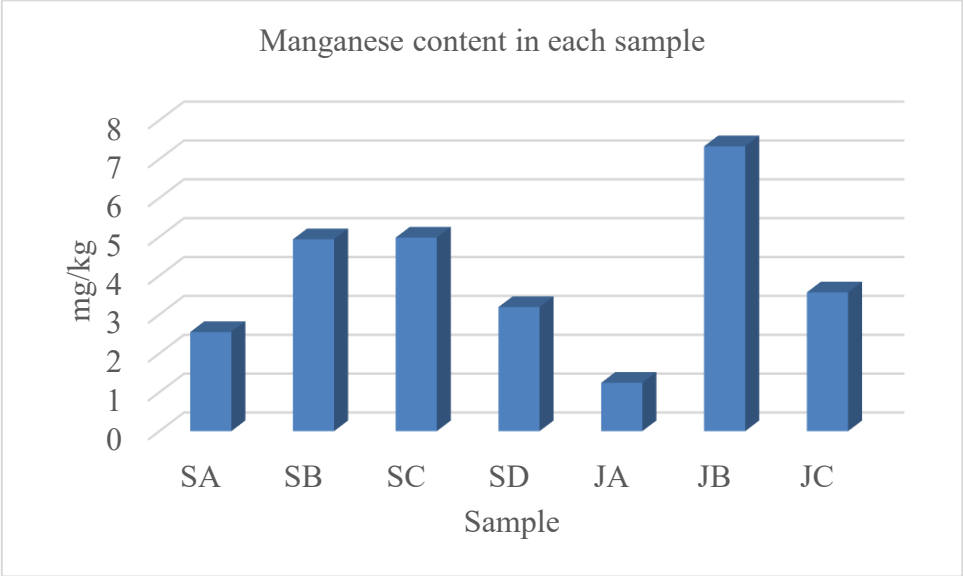

Figure 6. Graph of manganese content in each sample

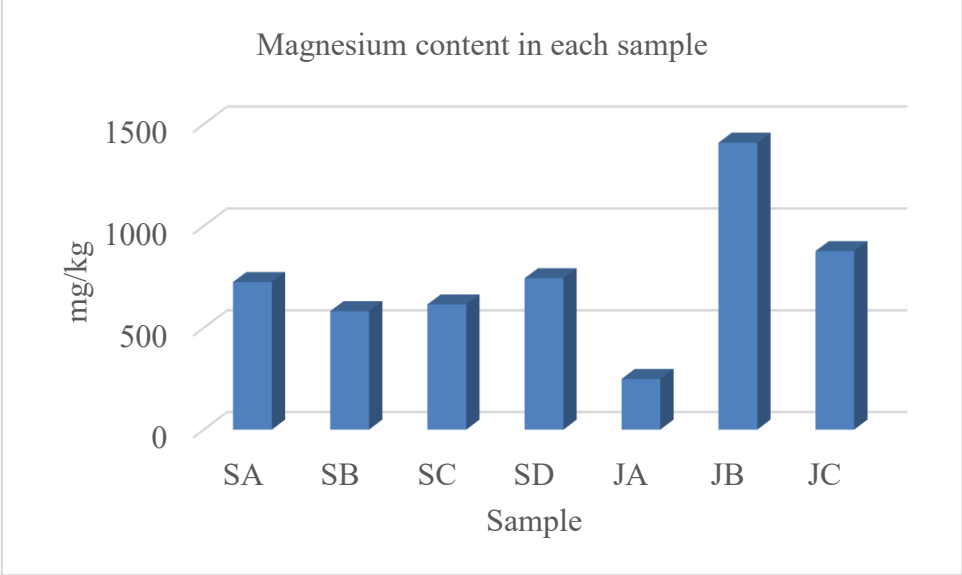

Figure 7. Graph of magnesium content in each sample

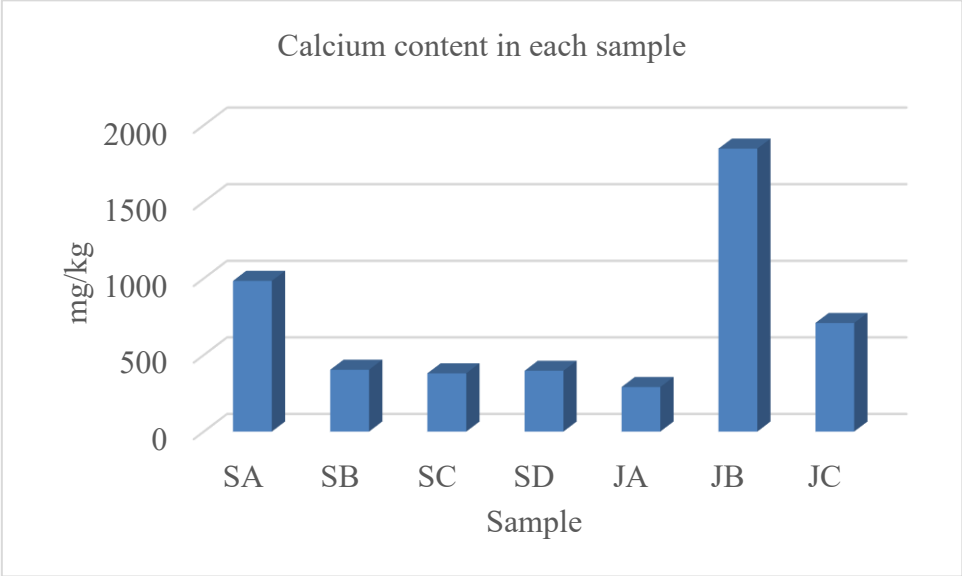

Figure 8. Graph of calcium content in each sample

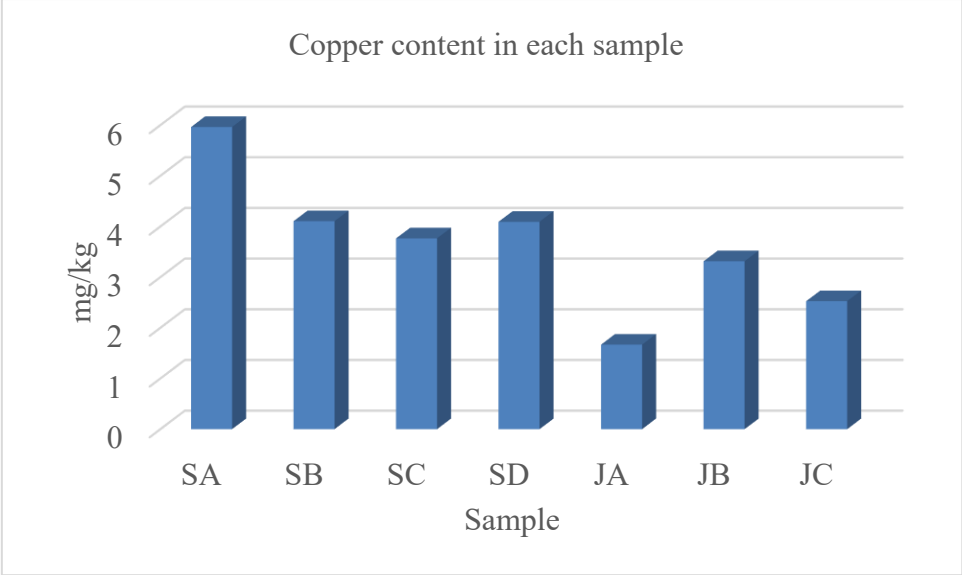

Figure 9. Graph of copper content in each sample

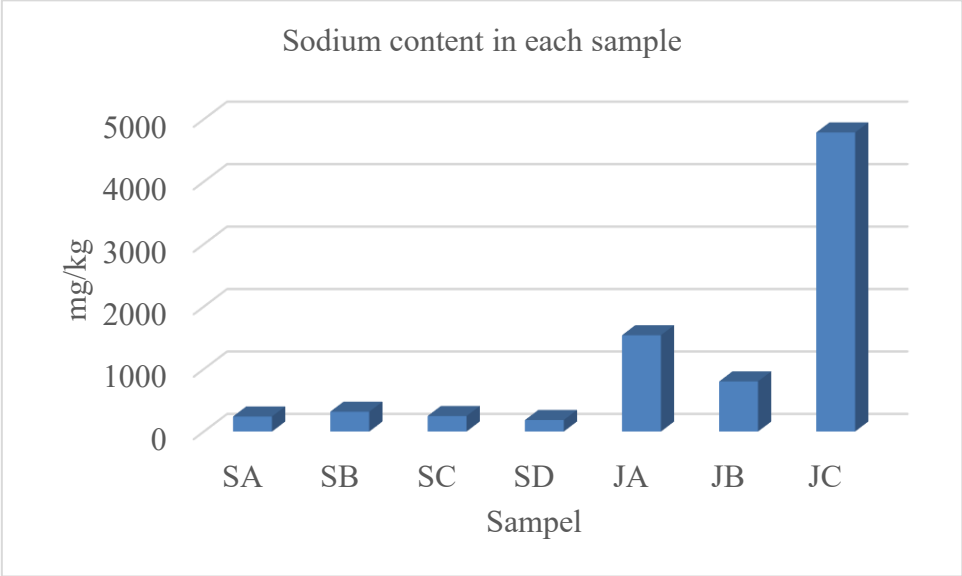

Figure 10. Graph of sodium content in each sample

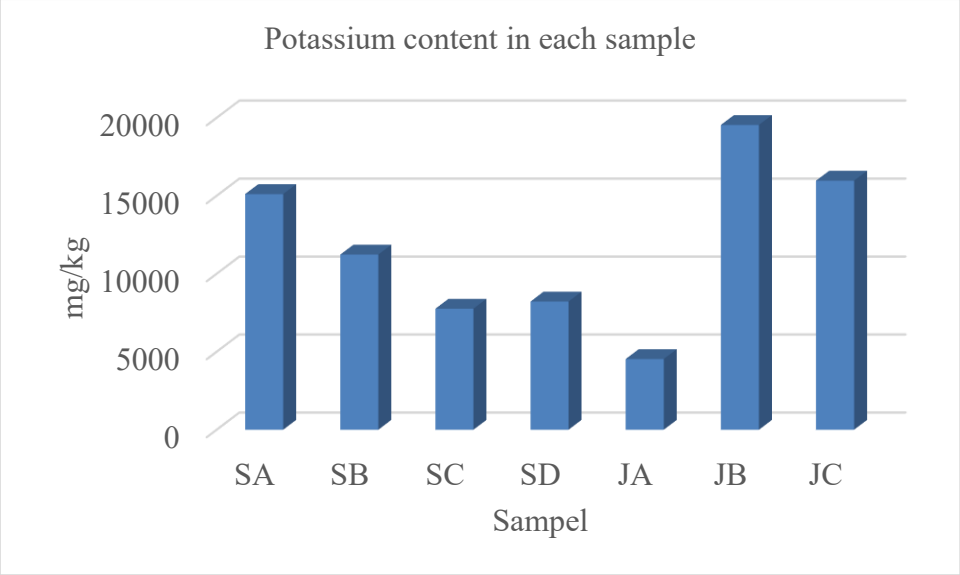

Figure 11. Graph of potassium content in each sample

Comparison between Whole Dates and Date Juices

The findings indicate notable differences in mineral content between whole dates and commercial date juices. These differences can largely be attributed to processing methods, including heating, filtration, concentration, and the addition of preservatives, flavourings, or mineral fortificants (Akonor et al., 2023).

Sample JA exhibited generally lower mineral concentrations (except sodium) compared to the whole date samples. This suggests that certain date juices may experience mineral losses during processing, as reported by Alshallash et al. (2023), who observed mineral reductions of 25–60% in thermally processed fruit juices compared to raw fruits due to filtration, heating, and dilution with sugar solutions.

Conversely, Sample JB demonstrated higher levels of eight out of nine minerals (excluding sodium) compared to all four date fruit samples. This pattern suggests that JB may have undergone fortification or nutrient restoration, resulting in elevated mineral content. Bhutto et al. (2025) similarly found that branded fruit juices often have higher mineral content than local or unbranded products, possibly due to differences in formulation and processing.

Regulatory Context and Nutritional Implications

Under the Malaysian Food Regulations 1985, there are no specific maximum limits for minerals such as Zn, P, Fe, Mn, Mg, Ca, Cu, Na, and K in fruit juices. The regulations focus more on product definitions, soluble solids, acidity, and permitted additives. However, P.U. (A) 209/2020 (amendment to the Food Regulations 1985) provides recommended maximum daily intakes for certain minerals (Schedule III, Regulation 26): Zn 15 mg, P 1,250 mg, Fe 20 mg, Mn 2 mg, Mg 250 mg, Ca 1,500 mg, and Cu 2 mg. For sodium and potassium, no general daily maximum is specified in these regulations, although WHO recommends that daily sodium intake should not exceed 2,000 mg.

From a nutritional perspective, Sample JB appears to be the richest in mineral content; however, selecting the “best” product should consider individual dietary needs and health

status, particularly in relation to sodium intake. Excessive sodium consumption is associated with hypertension and increased cardiovascular risk. While Sample JB has a relatively high sodium content (802.2 mg/kg), Sample JC exhibits a much higher sodium level (4,788 mg/kg), which may be of concern for individuals requiring salt restriction.

Therefore, the choice of date juice should not be based solely on total mineral content but should also take into account the balance of specific minerals in relation to individual health conditions. Within the halalan toyyiban framework, both the permissibility and the wholesomeness (nutritional safety and suitability) of products must be considered.

Conclusion

These findings suggest that commercial date juices can serve as sources of essential minerals such as iron, calcium, and potassium and may contribute to daily nutrient intake. However, differences in processing and formulation can lead to substantial variation in mineral content, including potentially high sodium levels. Within the framework of halalan toyyiban, consumers and regulators should not only assess the halal status of such products but also consider their nutritional quality and health implications.These findings demonstrate that date juice has the potential to serve as a valuable source of essential nutrients such as iron, calcium, and sodium, making it a beneficial product in supporting users' daily health needs.

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