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Original Article

Nutritional, Safety and Sensory Evaluation of Innovative Siwi Date Snacks with Flavors and Fillings

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Abstract

Background: Due to their nutritional benefits and economic importance, dates are essential for all ages, nations, and civilizations. Dates include some nutritional components that can boost their nutritious worth.
Objective(s): We aimed to assess the quality and safety attributes of Siwi semi-dry dates and their products with diverse tastes and fillings by measuring their chemical composition, safety features, and sensory aspects.
Methods: Eleven Siwi semi-dry date products were evaluated**.** The flavors were milk, coconut, Oreo, cinnamon, coffee, Nescafé, cappuccino, caramel, peanut butter, Lotus, and Nutella. Additionally, our study assessed their chemical composition, including vitamin and mineral content besides evaluating their quality, safety, and sensory characteristics. Statistical analysis was performed, with a 5% least significant difference calculated for each treatment.
Results: This study investigated Siwi semi-dry date snacks, revealing distinct nutritional profiles. Dark mix whole dates had the highest calorie, protein, and fat content; while plain whole dates had the lowest. Plain whole dates were rich in carbohydrates and sugars. Dark mix whole dates generally showed elevated vitamin and mineral levels. Quality attributes like texture favoured plain whole dates. Microbiological analysis confirmed safety, with no aflatoxins detected. Sensory evaluation ranked milk whole dates as the highest for colour, taste, odour, texture, and overall acceptance. These insights provide comprehensive overview, valuable information for both consumers and producers of Siwi semi-dry date snacks.
Conclusion: Dates are a significant food source for carbohydrates, fibres, minerals, and vitamins. The quality attributes of date-based products increase the potential of being nutritious snacks.

Keywords: Date fruit, nutritional value, health benefits, flavours, sensory assessment

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INTRODUCTION

Recently, date-based snacks, specifically Siwi semi-dry dates, have become a healthier snack option known for their natural sweetness and nutritional benefits. Accordingly, exploring innovative flavours and fillings that can enhance the sensory experience of these date snacks to diverse consumer preferences has become essential [(1)]. Comprehensively evaluating the nutritional content and safety aspects will ensure that these new variations maintain the high standards consumers expect. Blending dates with other crops, such as quinoa, oats, and wheat germ, offers numerous benefits, enhancing dietary value and sensory qualities. Quinoa, known for its richness in essential fatty acids, minerals, vitamins, dietary fibres, and gluten-free nature, has advantageous hypoglycaemic effects [(2)]. Oats have gained attention as a healthful food in reducing cardiovascular diseases, type 2 diabetes mellitus, gastrointestinal disorders, and cancer due to various bioactive compounds like β-glucan, avenanthramides, tocols, sterols, phytic acid, avenacosides [(3)]. Wheat germ is rich in bioactive compounds, including carotenoids, tocopherols, flavonoids, policosanols, phytosterols, and polyunsaturated fatty acids, with potent antioxidant and anti-inflammatory properties [(4)]. Additionally, Kumawat et al. [(5)] have emphasized the significant role of nuts in human health and a balanced diet by being a rich source of unsaturated fatty acids, protein, vitamins, minerals, and antioxidants. Moreover, Baliga et al. [(6)] highlighted the three stages of date fruit consumption–Khalal or Bisr (50% moisture), Rutab (30–35% moisture), and Tamr (10–30% moisture)–each offering a distinct nutritional benefit. Dates are a valuable food source of high

nutritional value, including carbohydrates, proteins, dietary fibres, minerals, and vitamin B complex [7,8]. Furthermore, dates are an essential source of potassium, magnesium, calcium, zinc, phosphorus, sodium, and iron [9].

Dates offer diverse vitamins crucial for various developmental stages and overall well-being. Vitamin A (50–100 IU/100 g of deseeded fruit) plays a vital role in vision, foetal development, protein synthesis, bone development, immune system support, and antioxidant activity [10]. Furthermore, dates contain vitamin B complex, which contribute to various physiological processes, such as blood vessel function, nervous system health, cardiovascular disease prevention, and immune system support [11,12]. Dates also contain vitamin C (3 mg/100 g of deseeded fruit), which reduces the risk of cardiovascular disease, stroke, and cancer while enhancing resistance against colds and flu. Although dates have a small amount of vitamin D, they are crucial in bone and tooth development, calcium and phosphorus balance, and rickets and cancer growth [13]. The antioxidant vitamin E (0.1 mg/100 g of deseeded fruit) protects against cardiovascular disease, aging, Alzheimer's disease, diabetes, cancer, and arthritis [14]. Vitamin K, found in dates (2.7 mg/100 g of deseeded fruit), is significant for various physiological processes, including fracture prevention, memory improvement, and blood pressure control [15]. Dates also contain vitamin B5 complex (pantothenic acid), contributing to respiratory system maintenance, allergy and asthma prevention, diabetes risk and anxiety reduction, immune function and hair quality improvement, and excessive shedding prevention. Additionally, dates offer 53 mg of vitamin B9 (folic acid) per 100 g of deseeded fruit, playing vital roles in preventing autism, cleft lip, and anaemia [11].

Herein, we aim to investigate the potential health advantages of consuming Siwi semi-dry date snacks. Additionally, we seek to evaluate the chemical composition, safety characteristics, and sensory attributes of dates and their various flavoured products. Our results will offer significant knowledge for consumers and manufacturers alike regarding developing healthier and more nutritious snack alternatives with Siwi dates.

METHODS

Siwi semi-dry dates (*Phoenix dactylifera* L.) were obtained from a private factory in Siwa (Matrouh Governorate, Egypt). Chocolate powder, plain scone, maple syrup, icing sugar, honey, and milk powder were purchased from Alexandria (Egypt) local markets. Flavouring agents, including milk, Oreo, cinnamon, peanut butter, Lotus, Nutella, coffee, Nescafé, cappuccino, caramel, and natural yeast, were obtained from a private factory in Dumyat , AFF company, Borg Al Arab, Alexandria, Egypt.

Eleven different samples from new date products were coated and stuffed with different flavours. Three key mixtures were used, including the coating mixture used for coating and covering the whole date products (**Figure 1**), the filling mixture employed for stuffing and filling the whole date products (**Figure 2**), and the flavours that were incorporated into three products: white, dark, and brown mixes (**Figure 3**). This meticulous categorization of mixtures and flavours ensured a systematic and standardized approach throughout the manufacturing.

Figure 1: The coating mix of Siwi semi-dry date snacks.

Figure 2: The stuffing mix of Siwi semi-dry date snacks.

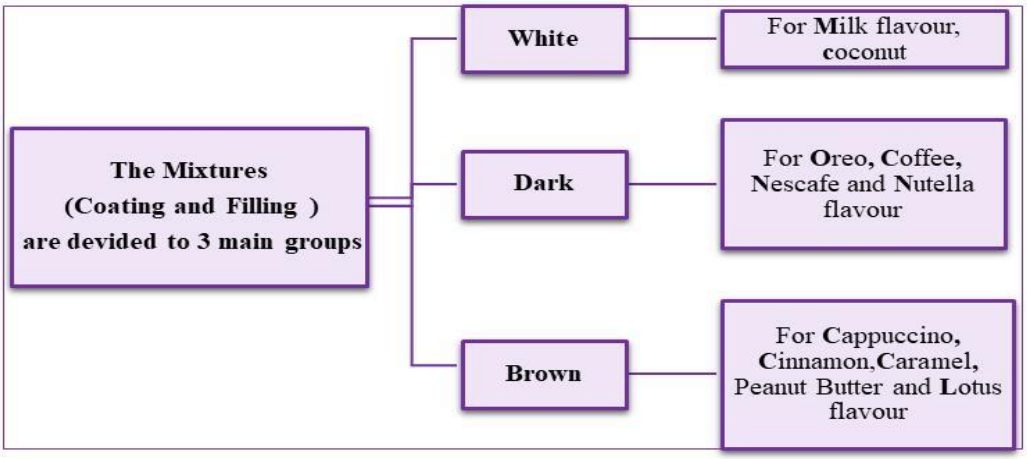


Figure 3: The coating and filling mixtures of date products.

Preparation of coating mixture

Table 1 presents the ingredients of coating white, dark, and brown mix types.

Table 1: The ingredients of coating mix types used for prepared date snacks

Ingredients		White	Dark	Brown
Cocoa butter	gm	60	60	60
Cocoa powder	g	--	35	--
Plain biscuit	g	--	--	35
Hazelnut / Peanut	g	150	150	150
Milk powder	g	35	--	--
Salt	g	0.25	0.25	0.25
Vanilla Extract	g	5	5	--
Cinnamon Extract	g	--	--	5
Maple Syrup	g	20	20	20
The total volume for each mix	g	270	270	270

A- White coating mixture

The white coating mix was prepared to ensure consistency and quality. Briefly, boiled water was placed in a saucepan, creating a gentle heat source. A heat-resistant bowl was positioned over the saucepan, ensuring it did not directly touch the boiling water to create a double boiler setup. Cocoa butter was introduced into the bowl and gently mixed until melting (not to overheat), and icing sugar was added gradually while continuously stirring to avoid lumps. Milk powder and a pinch of salt were incrementally introduced into the mixture, and the ingredients were mixed thoroughly to achieve a smooth and lump-free consistency. Once the white coating mix reached the desired consistency, it was poured into containers, which were then set aside to cool, allowing the mixture to solidify and set properly (**Figure 4**) [16].

Figure 4: The preparation of white coating mixture
1–2) Mixing cocoa butter; 3–4) Icing sugar, milk powder, and salt; 5) Pouring and cooling

B- Dark coating mixture

The dark coating mix was prepared with roasted hazelnuts or peanuts to achieve a rich and flavourful mixture. Hazelnuts or peanuts were evenly spread on a baking sheet and roasted in the oven at 400 °F for approximately 6–8 min, allowing them to brown and develop a deeper flavour. Once roasted, the hazelnuts or peanuts were taken out of the oven, and the skins were removed by rubbing them together using a paper towel, ensuring a smooth and uniform texture. Subsequently, they were processed in a food processor until transformed into a creamy butter consistency with blending for a sufficient duration to achieve a smooth and velvety texture. Then, all other ingredients

required for the dark coating mix were added to the food processor and underwent an extended blending process with intermittent on-and-off cycles for 2 min until the mixture reached a smooth and cohesive consistency. Once the desired texture was achieved, the dark coating mix was considered ready for application. The smooth and flavourful dark coating mix was then prepared for the coating and covering of date products (**Figure 5**) [17,18].

Figure 5: Preparation of dark coating mixture
1) Hazelnuts; 2) Cocoa butter blending; 3) Cocoa powder; 4) Vanilla extract and maple syrup blending

C- Brown coating mixture

The brown coating mix was thoughtfully processed using food processors to blend hazelnuts, plain biscuits, and other ingredients, resulting in a smooth or rustic and crunchy texture spread. Food processors were employed to break up hazelnuts and plain biscuits into less uniform pieces to lay the foundation for the texture and consistency of the brown coating mix. Once hazelnuts and plain biscuits were appropriately processed, all remaining ingredients were introduced to the food processor. The mixture was processed for 2-3 min, aiming for a super smooth spread and a cohesive and velvety texture. An additional 30 s of processing was dedicated to achieving a more rustic and crunchy texture (optional) to customize the texture based on preferences. Extra evaporated milk was added to the mixture to achieve the desired thickness and consistency, making the spread thinner and more suitable for the intended application. Flavors, namely cinnamon, cappuccino, caramel, peanut butter, and Lotus were added to enhance the overall taste profile of the brown coating mix. The processing continued until the mixture reached the desired smoothness, incorporating the flavours seamlessly. Adding extra evaporated milk and the optional rustic and crunchy texture step allowed for tailoring the brown coating mix to specific preferences (**Figure 6**) [19].

Figure 6. Preparation of brown coating mixture
1) Hazelnut and biscuit; 2) Grinding; 3) Cocoa butter and evaporated milk; 4) Vanilla extract and maple syrup blending

Preparation of the filling mixture

Table 2 presents the ingredients of filling white, dark, and brown mix types.

Table 2: The ingredients of filling mix types

Ingredients		White	Dark	Brown
Cocoa butter	G	40	50	50
Cocoa powder	G	--	50	
Plain biscuit	G	--	--	50
Coconut oil	G	80	80	50
Peanut / Hazelnut	G	30	--	30
Honey	G	--	80	--
Milk powder	G	30	--	--
Salt	G	0.25	0.25	0.25
Icing Sugar	G	10	--	--
Vanilla Extract	G	5	5	--
Plain biscuits	G	--	--	50
Maple Syrup	G	80	--	50
The total volume for each mix	G	275	265	280

A- White filling mixture

The white filling mix was prepared by a careful combination of ingredients, incorporating cocoa butter, hazelnuts, salt, maple syrup, and vanilla to achieve silky, runny, and pourable nut butter with a smooth texture. Cocoa butter was placed in a double boiler over medium-low heat and heated until fully melted, ensuring a smooth and liquid consistency. Hazelnuts and a pinch of salt were added to the bowl of a food processor fitted with an S-blade. The ingredients were processed until they reached a coarse texture resembling a creamy consistency. The melted cocoa butter was then introduced into the food processor with the hazelnuts to combine the nutty texture with the smoothness of the melted cocoa butter. Maple syrup and vanilla were incorporated into the mixture to contribute to the overall flavour profile, adding sweetness and aromatic notes. The entire mixture underwent processing at low speed until a silky nut butter with a very runny and pourable consistency was achieved to attain the desired texture for the filling mix. The prepared white filling mix was poured into a jar and set aside for approximately 6-8 h, with regular stirring every 30 min. The stirring intervals were implemented to prevent the cocoa butter from floating to the top of the mixture. This meticulous approach ensured uniform distribution and consistency throughout the filling. After the designated setting period, the white filling mix was ready for the date products. The careful execution of each step contributed to developing a smooth, pourable filling with a delightful blend of hazelnut and cocoa butter flavours (**Figure 7**) [20,21].

Figure 7: Preparation of white filling mixture 1) Hazelnut, salt, and milk powder; 2) Grinding; 3) Cocoa butter, coconut oil, and maple syrup

B- Dark filling mixture

The dark filling mix was prepared straightforwardly using a double boiler, combining coconut oil, cocoa butter, cocoa powder, honey, vanilla, and salt. Coconut oil and cocoa butter were melted in a double boiler set over low heat. The gentle heat ensured a smooth and even melting of the fats. The mixture was removed from the heat source once the coconut oil and cocoa butter were fully melted. Cocoa powder was added to the melted mixture and mixed into the chocolate mixture until it completely dissolved, ensuring a homogenous blend. Honey, vanilla, and salt were stirred into the mixture to add sweetness, aromatic notes, and a hint of saltiness to enhance the overall flavor profile. The mixture was stirred until a smooth, lump-free chocolate sauce was obtained. This step was crucial in ensuring the consistency and texture of the dark filling mix. Once the ingredients were thoroughly combined and a smooth chocolate sauce was achieved, the dark filling mix was considered ready for use (**Figure 8**) [22,23].

Figure 8: Preparation of dark filling mixture 1) Melted cocoa butter and coconut oil; 2) Cocoa powder and salt; 3) Vanilla honey

C- Brown filling mixture

The brown filling mix was prepared utilizing a double boiler and a food processor. The key ingredients included cocoa butter, peanut, plain biscuits, and additional components to enhance the flavour and texture. Cocoa was melted in a double boiler over low heat. The gentle heat facilitated the smooth melting of the fats, ensuring a consistent mixture. The melted cocoa butter was transferred to a food processor. The mixture was combined with finely ground plain biscuits in the food processor. Other ingredients were added to the food processor. These ingredients could include various components to enhance the flavour and texture of the filling mix. The entire mixture underwent processing in the food processor until a smooth and homogenous texture was achieved. This step ensured the plain biscuits and additional ingredients were well integrated with the melted cocoa. The brown filling mix was scraped into a separate bowl once the processing was complete and the desired consistency was attained. This final step marked the completion of the preparation process. The outcome of this process is a brown filling mix characterized by the combined richness of cocoa butter and peanut butter, complemented by the texture and flavour contributions from the ground plain biscuits and other added ingredients. This versatile filling mix can enhance the sensory experience of the date products (**Figure 9**) [24].

Figure 9: Preparation of brown filling mixture 1) Cocoa butter, peanut and plain biscuits ; 2) Cocoa powder and salt; 3) Vanilla honey

Preparation of flavoured coating stuffed whole dates

Preparing flavoured coating stuffed whole dates involved several steps to ensure the cohesion of the dates and the application of a flavourful coating. Dates were cleaned, and a slit was cut on each date to remove the pit. The dates were individually stuffed with a flavoured mixture of various ingredients, such as nut butter, biscuits, or other complementary flavours. After stuffing, the dates were set aside in a tray and placed in the refrigerator for approximately one hour to allow the stuffed dates to firm up and enhance cohesion. The stuffed dates were taken one at a time and dipped into a mix of melted chocolate. Each date was gently rolled in the melted chocolate to ensure an even coating. This step ensured that each date was thoroughly enveloped in the desired coating. The chocolate-covered dates were carefully removed from the coating mixture using a spoon. The coated dates were then placed on a tray lined with parchment paper and in the refrigerator for about 1 h to allow the chocolate to harden, setting the coating on the dates. After the chocolate hardened, the flavoured coating stuffed with whole dates was ready for presentation and consumption. This comprehensive process resulted in delicious and visually appealing date products, where each date was stuffed with a flavourful mixture and coated with a layer of chocolate for added richness and texture (**Figure 10**) [24].

Figure 10: Preparation of flavored coating stuffed whole dates.
1) Removing the pit; 2) Stuffing with flavors; 3) Cooling; 4) Cohesion well; 5) Dropping into the melted mix; 6) Rolling gently; 7) Refrigeration; 8) Cross-section of the flavored coating stuffed whole dates

Chemical analysis

A- Proximate composition

Moisture, ash, fat, and protein contents of different date types were determined according to the Association of Official Agricultural Chemists (AOAC) procedures [25]. The moisture content was calculated based on weight loss after the sample was dried in the oven at 105 °C overnight. Fat content was determined by extraction with petroleum ether in a Soxhlet apparatus. The Kjeldahl method was employed to determine the total protein content (Kjeldahl Analyzer K9840, Jinan Hanon Instruments Co., Ltd., China) using 6.25 as a conversion factor. Dietary fibre was determined using an ANKOM 220 fibre analysis according to AOAC [26]. Herein, we also analysed total sugars and total carbohydrates [27,28]. The energy was determined by the mathematical equation (Fat × 9 + Protein × 4 + Carbohydrate × 4) [29].

B- Vitamin and mineral contents

Analyses were conducted in the Ministry of Agriculture (Agricultural Research Centre/ Central laboratory of residue analysis of pesticides and heavy metals in food QCAP)

High-Pressure Liquid Chromatography (HPLC) was used to determine vitamins, the limit of quantification (LOQ) was 5 mg/kg, and the estimated relative standard deviation was < 20% [30]. Minerals were determined utilizing an AA spectrometer (Thermo Fisher Scientific, MESLO Company, Cairo, Egypt), Iron was determined by inductively coupled plasma Mass Spectrometry (ICP-MS) after high-pressure microwave digestion [31]. The measurement of uncertainty was expressed as expanded uncertainty (at 95% confidence level) within the range of ±26%.

C- Quality attributes of dates and its products

The pH was determined at room temperature using a digital pH meter (Basic20 PH-Meter; Crison Instruments, Barcelona, EU). The pH meter was calibrated with three buffer standards of pH 4, pH 7 and pH 9 prior to use. Briefly, 10 ml of each sample was placed in a beaker, the probe of the pH meter was inserted and pH value was recorded.

Texture was analysed using Brookfield CT3 Texture analyser [32].

D- Safety attributes of dates and its products

Microbiological and aflatoxin analysis

The microbiological analysis of different dates was analysed according to the International Dairy Federation IDF standard method at 122 °C [33]. The total viable bacterial counts were enumerated on plate count agar medium at 32 °C for 48 h [34]. Dates samples were ten-fold serially diluted in 0.15% sterile peptone water. Using the drop plate method, 20 µL of each dilution was plated in triplicate on selective media [35]. *S. thermophilus* was enumerated on *S. thermophilus* agar medium (ST agar) and incubated aerobically at 37 °C for 24 h, while *Lb. bulgaricus* was counted on MRS adjusted to pH 5.2 and incubated anaerobically at 45 °C for 72 h [36]. *B. lactis* was enumerated on MRS agar and incubated anaerobically at 37 °C for 72 h [37]. *Coliform* bacteria were determined using violet-red bile agar medium after incubation at 37 °C for 24 h [38]. Counts of aerobic spore-forming bacteria were determined on a nutrient agar medium at 37 °C [39]. Molds and yeasts were enumerated on potato dextrose agar medium, and plates were incubated at 25 ± 2 °C for 5 days [40].

Aflatoxin was analysed by Liquid chromatography-tandem mass chromatography (LC-MS/MS) for quantitative determination of Aflatoxins. The limit of quantification (LOQ) of Aflatoxins detected was B1, B2; G1; G2 = 1 ug/kg. [41]

Sensory evaluation

The prepared date products were subjected to sensory evaluation by 20 panellists for each of the different flavours. Panellists were randomly selected from the staff and students of HIPH and the food science department faculty of agriculture. The panellist used the score sheet of 5 points [42] where (5= very good, 4= good, 3= acceptable, 2= bad, and 1= very bad) samples were evaluated for colour, degree of chewiness, taste, odour, and overall acceptability. Each result of characteristic was calculated as a mean value, analysed statistically, and tabulated.

Statistical Analysis

The statistical analysis of the data was conducted using IBM SPSS software package version 20.0 (IBM Corp, 2011). The approach included describing quantitative data as means and standard deviations (SD). The normality of the data was assessed using the Kolmogorov-Smirnov test. The significance level for judging the obtained results was set at 5%. Differences among groups were tested for significance using the Duncan test. One-way analysis of variance (ANOVA) was utilized for analysing the data. The statistical model used was: $Yij = \mu + Ti + eij$, where: Yij = the observed trait for the ij - th sample, μ = overall mean, Ti = the effect of treatment, eij = random error.

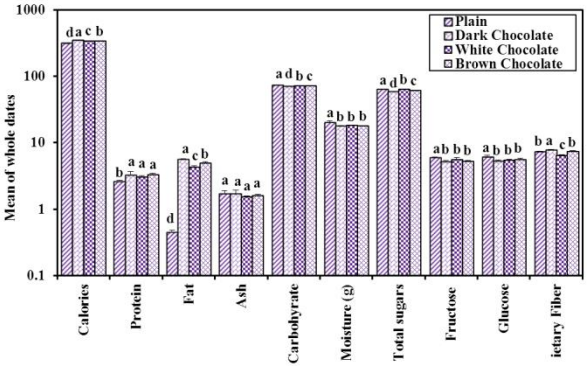
Ethical considerations

The researcher obtained approval from the High Institute of Public Health Research Ethics Committee to conduct the research. Adherence to International Guidelines for Research Ethics was ensured. Verbal consent was obtained from panellists after providing a clear explanation of the purpose of the study.

RESULTS

Proximate composition

Figure 11 shows that calories, protein, fat, ash, carbohydrates, moisture, total sugars, fructose, glucose, and dietary fibre varied across different types of date snacks. Notably, the dark mix whole dates had the highest calorie, protein, fat, and dietary fibre content, while the plain whole dates had the lowest. Carbohydrate content, moisture, total sugars, fructose, and glucose were highest in plain whole dates.

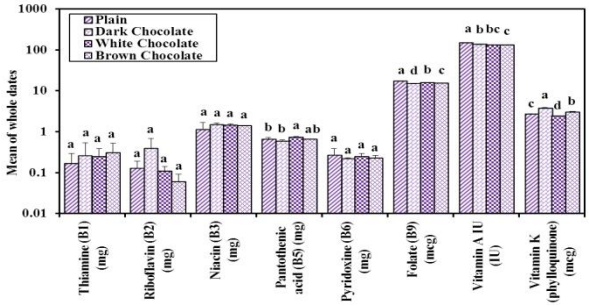


Different small letters above columns means statistically significant difference

Figure 11: Proximate analysis of the whole date snacks prepared from Siwi semi-dry dates.

Vitamin and mineral contents

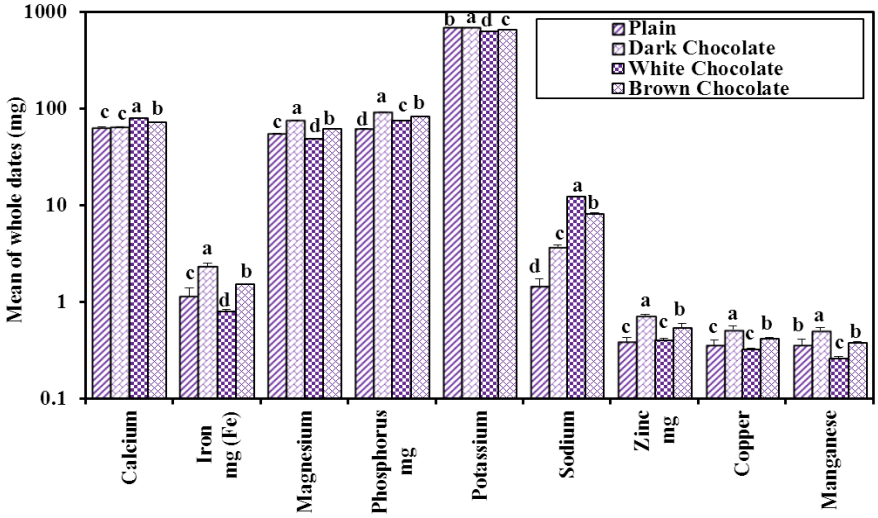
Vitamin content, including thiamine (B1), riboflavin (B2), niacin (B3), pantothenic acid (B5), pyridoxin (B6), folate (B9), and vitamins A and K, varied among the date snacks. Dark mix whole dates generally showed higher values, while plain whole dates usually had lower values (**Figure 12**).



Different small letters above columns means statistically significant difference

Figure 12: Vitamin content of the whole date snacks prepared from Siwi semi-dry dates.

Mineral content, such as calcium, iron, magnesium, phosphorus, potassium, sodium, zinc, copper, and manganese, varied among date snacks. Dark mix whole dates generally had the highest values except for sodium, while white mix whole dates had the lowest in most minerals except for sodium (**Figure 13**).



Different small letters above columns means statistically significant difference

Figure 13: Minerals content of the whole date snacks prepared from Siwi semi-dry dates.

Quality attributes of dates and its products

Measurement of texture and viscosity

Texture parameters varied among date snacks, including hardness, adhesiveness, springiness, gumminess, and chewiness. Plain whole dates showed the highest values, **(Table 3)**.

Table 3: Texture for plain snacks prepared from Siwi semi-dry dates

Samples	Texture				
	Hardness (g)	Adhesiveness (mj)	Springiness (mm)	Gumminess (g)	Chewiness (mj)
Whole Dates	121	5.3	6.11	189	8.03

Safety attributes of dates and its products

Microbiological and Aflatoxin Analysis

Microbiological analysis indicated that total plate count as well as yeast and mold were within acceptable limits (<10^5 cfu/g for total plate count, <10^4 cfu/g for yeast and mold) during preparation and storage. Aflatoxins, including Aflatoxin G2, G1, B2, and B1, were not detected in any samples during the entire process.

Sensory evaluation

The findings revealed that milk whole dates exhibited the highest values for various parameters in terms of color, taste, odor, texture, and general acceptance, followed by coconut, coffee, and peanut butter whole dates (Table 5)

Table 4: Microbiological and aflatoxin analysis for whole dates

Microbiological analysis	Whole Dates
Total plate count	10^3 cfu/g
Yeast and mold count	10^3 cfu/g
Mycotoxins	
Aflatoxin G2	ND
Aflatoxin G1	ND
Aflatoxin B 2	ND
Aflatoxin B 1	ND

*[1]ND: not detected in 1.0 mL. The LOQ of aflatoxins B1, B2; G1, G2 = 1 ug/kg. The measurements uncertainty expositions expanded uncertainty (95% CI) is within the range ± 30%

Table 5: Sensory evaluation of different whole date snacks prepared from Siwi semi-dry dates (n = 220)

Whole Dates	Colour	Taste	Odour	Texture	General Acceptance
Milk	$4.78^{a} \pm 0.38$	$4.63^{a} \pm .46$	$4.55^{a} \pm 0.48$	$4.65^{a} \pm 0.46$	$4.63^{a} \pm 0.46$
Oreo	$3.75^{d} \pm 1.06$	$3.90^{b} \pm 1.14$	$3.90^{bc} \pm 1.15$	$3.80^{bcd} \pm 1.15$	$4.13^{ab} \pm 0.97$
Cinnamon	$4.10^{bcd} \pm 1.06$	$3.83^{b} \pm 1.12$	$3.83^{bc} \pm 0.89$	$3.80^{bcd} \pm 1.04$	$3.83^{bc} \pm 0.96$
Coffee	$4.33^{abc} \pm 0.63$	$4.50^{a} \pm 0.67$	$4.20a^{bc} \pm 0.75$	$4.35^{ab} \pm 0.69$	$4.25^{ab} \pm 0.75$
Nescafé	$2.85^{e} \pm 0.86$	$2.45^{c} \pm 1.10$	$2.95^{d} \pm 0.90$	$2.88^{e} \pm 1.13$	$3.13^{d} \pm 0.89$
Cappuccino	$2.80^{e} \pm 0.82$	$2.40^{c} \pm 1.14$	$3.05^{d} \pm 0.78$	$2.93^{e} \pm 1.24$	$3.13^{d} \pm 0.87$
Caramel	$3.80^{bcd} \pm 1.15$	$3.83^{b} \pm 1.10$	$3.95^{bc} \pm 1.04$	$3.83^{bcd} \pm 1.10$	$4.13^{ab} \pm 0.84$
Peanut Butter	$4.23^{abcd} \pm 0.99$	$4.50^{a} \pm 0.78$	$4.20^{abc} \pm 0.85$	$4.28^{abc} \pm 0.98$	$4.25^{ab} \pm 1.02$
Lotus	$3.78^{cd} \pm 0.94$	$3.73^{b} \pm 0.88$	$3.73^{c} \pm 1.20$	$3.30^{de} \pm 1.04$	$3.38^{cd} \pm 0.97$
Nutella	$3.70^{d} \pm 1.01$	$3.88^{b} \pm 1.0$	$3.70^{c} \pm 1.03$	$3.73^{cd} \pm 1.02$	$3.35^{cd} \pm 1.04$
Coconut	$4.35^{ab} \pm 0.69$	$4.25^{ab} \pm 0.75$	$4.33^{ab} \pm 0.63$	$4.50^{a} \pm 0.67$	$4.20^{ab} \pm 0.75$
F	**9.115***	**12.622***	**5.993***	**7.445***	**7.022***
P	**< 0.001***	**< 0.001***	**< 0.001***	**< 0.001***	**< 0.001***
LSD 5%	**0.5599**	**0.5908**	**0.5651**	**0.6142**	**0.5489**

Data are expressed as Mean ± SD
F: F is for the one-way ANOVA test, pairwise comparison bet. each two groups was performed using a Post Hoc test (LSD)
Means with Common letters are not significant (i.e., means with different letters are significant) *Statistically significant at $p \leq 0.05$

DISCUSSION

The proximate analysis highlighted significant variations in the nutritional composition of date snacks, particularly in terms of calories, protein, fat, and carbohydrates. The dark mix whole dates consistently exhibited higher values, suggesting that the specific mix and preparation method influence the nutritional content. The higher fat content in dark mix whole dates might be attributed to the type of chocolate used or additional ingredients. These findings underscore the importance of considering the composition of ingredients in date-based snacks for those seeking specific nutritional profiles. The observed differences in protein content between dark and white chocolate align with Shinde et al., 2020 [43], who has suggested content variations in different chocolate types. However, our study revealed a non-significant difference between the dark mix and white mix, indicating that factors beyond chocolate type may contribute to protein variations. The complexity of date snacks, combining chocolate and date components, emphasizes the need for a nuanced understanding of the interplay between ingredients.

The variations in vitamin and mineral content across different date snacks reflect the influence of the specific date mix. Dark mix whole dates consistently demonstrated higher values for several vitamins and minerals, aligning with previous studies suggesting that the cocoa content in chocolate may contribute to these differences. Comparisons with established nutritional values for whole dates, such as those provided by Al-Farsi et al. (2008) [13], revealed that the nutritional content in our study generally fell within the expected ranges. However, the differences between various date snacks emphasize the impact of processing and additional ingredients on the final nutritional profile. Whole dates are essential for haemoglobin, the immune system, cognitive function, and energy production. They also contain magnesium, phosphorus, potassium, sodium, zinc, copper, manganese, and other minerals [11]. Incorporating whole dates into your diet can help increase your intake of essential nutrients. These variations could be attributed to factors like the ripeness of the dates, the chocolate formulation, or the processing methods employed [13].

The texture analysis provided insights into the textural attributes of different date snacks. Plain whole dates exhibited the highest values for hardness, adhesiveness, springiness, gumminess, and chewiness, indicating a firm and chewy texture. Bar dates showed the second-highest values, suggesting that the specific format or additional ingredients influenced the texture. The variation in textural attributes emphasizes the role of processing and formulation in shaping the sensory characteristics of date snacks. Campos et al. [44] demonstrated the positive effects of chia mucilage on ice cream quality, supporting the idea that additives can influence the texture of date-based products. Understanding and optimizing these textural qualities can contribute to consumer acceptance and satisfaction.

Microbiological analysis revealed that the plain snacks met acceptable standards for total plate count and yeast and mold count during preparation and storage. The absence of aflatoxins, including aflatoxin G2, G1, B2, and B1, throughout the entire process indicates the safety and quality of the date snacks. These findings align with previous research by

Mahmoud et al. [45] who have emphasized the importance of quality control measures in producing date-based products.

The assessment of sensory attributes in whole-date snacks might yield significant insights into their overall quality and level of popularity among consumers. Sensory evaluation enables a full assessment of sensory qualities involving numerous senses, including taste, texture, scent, and appearance [46]. This information has the potential to assist producers in optimizing their product compositions and packaging to align with consumer preferences and improve their market competitiveness. In addition, sensory evaluation can be a valuable tool in detecting probable defects or undesirable taste profiles in snacks, enabling manufacturers to implement requisite enhancements [47]. Manufacturers can make informed decisions regarding ingredient selection, processing procedures, and product presentation by comprehending consumers' sensory perception of the product. Incorporating sensory evaluation into the planning and production process has the potential to yield a more gratifying and prosperous whole-date snack for consumers [48]. The results of our study indicate that whole dates soaked in milk demonstrated the top scores in terms of colour, taste, odour, texture, and overall acceptance across multiple categories. This was followed by whole dates soaked in coconut, coffee, and peanut butter. This may be due to the high nutritional value of milk and its components, including organic substances, which are present in about equal quantity and are divided into elements builders, proteins, energy components, carbohydrates, and lipids. It also comprises functional elements, such as traces of vitamins, enzymes, dissolved gases, and dissolved salts, especially in the form of phosphates, nitrates, and chlorides of calcium, magnesium, potassium, and sodium. Altogether, incorporating additives enhances the nutritional value of dates and adds variety to the flavours and textures of snacks made from Siwi semi-dry dates. By evaluating the chemical composition, safety features, and sensory properties of these snacks, we provide valuable insights into their overall quality and potential market appeal.

CONCLUSION AND RECOMMENDATIONS

Our results underscore the intricate interplay of ingredients, processing methods, and formulations in determining the nutritional, microbiological, and textural attributes of date snacks. The variations observed highlight the need for a nuanced approach in research and production, considering the specific mix of dates, chocolate, and other ingredients. Future studies could delve deeper into the impact of individual components on the overall quality of date snacks, providing valuable insights for both the food industry and consumers. The combined findings contribute to our understanding of the potential health benefits and quality attributes of date-based products, opening avenues for further exploration and innovation in functional food.

CONFLICT OF INTEREST

The authors have no conflict of interest to declare.

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