

Physicochemical, Nutritional, and Sensory Evaluation of Two Neo-formulated Tunisian Pastry Products Based on Dates and Enriched with *Moringa oleifera*

Naima Bennour^{1,2,*}, Hedi Mighri¹, Nesrine Harboub¹, Hajer Eljeni¹, Naima Chouikhi¹, Marwa Harabi¹, Ahmed Akrou¹

¹Laboratory of Rangeland Ecosystems and Valorization of Spontaneous Plants and Associated Microorganisms (LR16IRA03), Arid Regions Institute, Medenine 4119, Tunisia.

²Department of Chemistry, Faculty of Sciences, University of Gabes, Gabes 6029, Tunisia.

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***Corresponding author:** Naima Bennour, Laboratory of Rangeland Ecosystems and Valorization of Spontaneous Plants and Associated Microorganisms (LR16IRA03), Arid Regions Institute, Medenine 4119, Tunisia; Department of Chemistry, Faculty of Sciences, University of Gabes, Gabes 6029, Tunisia.

Abstract

Two types of traditional Tunisian biscuits, named Jouza (JDM) and Kaaber (KDM), were developed using dates as a natural sweetener, without white sugar, and enriched with *Moringa oleifera* leaf powder. The commercial versions of these biscuits without enrichment were used as references (Jouza Reference (JR) and Kaaber Reference (KR)). Physicochemical, nutritional, and sensory analyses were performed on these four types of biscuits. The addition of date powder and *Moringa* significantly increased the mineral content (14.92% for JDM and 17.90% for KDM), fiber content (59% for JDM and 40% for KDM), and protein content (11.69% for JDM and 13.57% for KDM). The two enriched biscuits are also richer in potassium (38.9 and 57.6 g/kg DM, respectively), magnesium (4.3 and 6.45 g/kg DM, respectively), total polyphenols (40.23 and 31.21 mg GAE/g DE, respectively), and total flavonoids (3.42 and 2.40 mg QE/g DE, respectively). In terms of sugars, the enriched biscuits have higher concentrations of glucose and fructose, while the references are dominated by sucrose. Sensory evaluation showed that the enriched biscuits were generally appreciated by consumers, with scores similar to those of the reference biscuits. This study demonstrates that the incorporation of date powder and *Moringa* adds value to traditional products.

Keywords

Date; *Moringa oleifera*; Traditional Tunisian biscuits; Nutritional composition; Sensory evaluation

1. Introduction

Date powder is recognized for its aromatic and nutritional qualities and is widely used in food products. Dates are a notable energy source due to their richness in sugars and minerals (notably K, Ca, and Mg) while being low in lipids and proteins [1]. *Moringa oleifera*, a plant native to India, is widely used globally for its exceptional nutritional properties [2]. Its leaves, in particular, are rich in minerals such as calcium, iron, and zinc, making them an ideal supplement to combat malnutrition [3]. This plant is integrated into food security programs in malnutrition-affected regions, such as Chad and Senegal [4, 5].

In Tunisia, *Moringa oleifera* was recently introduced as a versatile plant. However, its potential for enriching traditional foods remains underexplored. This study focuses on integrating date powder and *Moringa oleifera* leaf powder into two traditional Tunisian biscuits (*Jouza* and *Kaaber*), with reduced use of white sugar. The objective is to evaluate the impact of this enrichment on the physicochemical, nutritional, and sensory characteristics of the products.

2. Materials and Methods

2.1 Preparation of Plant-based Powders

Dates of the *Majbouda* variety, considered a by-product in Tunisia, were obtained from a farm in Kébili. The dates were sorted, cleaned, pitted, chopped, dried, ground, and sieved (1 mm). *Moringa oleifera* leaves were sourced from a plot at the Arid Regions Institute of Médenine, where they were dried, ground, and sieved (1 mm).

2.2 Production of Biscuits

The biscuits (*Jouza* and *Kaaber*) were produced following traditional recipes, adapted by an experienced pastry chef to include date powder and *Moringa oleifera*. Four samples were prepared:

- **JR (Jouza Reference)**: traditional biscuit without enrichment.
- **KR (Kaaber Reference)**: traditional biscuit without enrichment.
- **JDM**: biscuit enriched with date powder and *Moringa*.
- **KDM**: biscuit enriched with date powder and *Moringa*.

Production parameters (temperature, baking time, ingredient proportions) were optimized to ensure acceptable texture and flavor.



Figure 1. A visual representation of four types of Tunisian biscuits. (A) JDM: *Jouza* biscuit enriched with date powder and *Moringa oleifera*, (B) JR: Reference *Jouza* biscuit without enrichment, (C) KDM: *Kaaber* biscuit enriched with date powder and *Moringa oleifera*, and (D) KR: Reference *Kaaber* biscuit without enrichment. The image highlights differences in texture and color between the enriched and reference biscuits.

2.3 Preparation of Ethanolic Extracts

Five grams of dry powder from each sample were macerated with 100 mL of an ethanol-water mixture (70:30, v/v) for 72 hours at room temperature, with occasional stirring. The resulting solution was filtered using filter paper, and

the filtrate was concentrated by evaporation under reduced pressure at 40 °C using a rotary evaporator. All extracts were prepared in triplicate to ensure result reproducibility.

2.4 Physicochemical Analyses

Physicochemical parameters such as pH, moisture content, and total ash content were measured using standard analytical methods [6].

2.5 Near-Infrared Spectroscopy (NIRS) Analysis

Near-infrared spectroscopy (NIRS) was used to analyze organic matter (OM), mineral matter (MM), total nitrogen (TN, proteins), and fibers (ADF). The dried and ground samples were placed in quartz cells and illuminated at various wavelengths. The resulting absorption spectra were processed using dedicated software, enabling rapid and non-destructive analysis (under one minute).

2.6 Mineral Content Analysis by Atomic Absorption Spectroscopy (AAS)

Flame air-acetylene atomic absorption spectroscopy (Thermo-Scientific iCE3000 AA) was employed. One gram of dry powder was incinerated in a furnace at 550 °C for four hours. The resulting ash was dissolved in concentrated hydrochloric acid and ultrapure water. The solutions were filtered, diluted to 100 mL, and analyzed to determine sodium, potassium, calcium, magnesium, copper, zinc, manganese, and iron concentrations. The concentrations were calculated using calibration curves derived from standard solutions.

2.7 Quantification of Total Polyphenols (TPC) and Flavonoids (TFC)

Total polyphenol content (TPC) was measured using the Folin-Ciocalteu method, and total flavonoid content (TFC) was determined using the aluminum chloride spectrophotometric method. Absorbances were measured in triplicate with a spectrophotometer (Shimadzu UV Mini 1240). Results are expressed in mg of gallic acid equivalent per gram of dry matter (mg GAE/g DM) for TPC and mg of quercetin equivalent per gram of dry matter (mg QE/g DM) for TFC.

2.8 Sugar Analysis by High-Performance Liquid Chromatography (HPLC)

Qualitative and quantitative sugar analysis was performed using an ultra-fast liquid chromatography (Shimadzu UFLC XR) equipped with an NH2 column (3 µm, 250 mm × 3.0 mm) and a refractive index detector (RID 10A). The mobile phase (water/acetonitrile, 17:83) was used in isocratic mode at a flow rate of 0.75 mL/min. Sugar identification (fructose, glucose, sucrose, palatinose, maltose) was conducted by comparing retention times with standards.

2.9 Sensory Analysis

A sensory analysis was conducted with 60 naïve panelists to evaluate the quality of the biscuits enriched with date and *Moringa oleifera* powders. The samples, randomly coded, were served on cardboard plates with mineral water for palate cleansing between tastings. Evaluated parameters included appearance, smell, taste, aftertaste, and overall preference. A 5-point hedonic scale (Table 1) was used to guide the panelists.

Table 1. Sensory Evaluation Scale

Score	Appreciation
1	Passable
2	Fairly Good
3	Good
4	Very Good
5	Excellent

This rigorous methodology allowed for the characterization of the physicochemical, nutritional, and sensory properties of the enriched biscuits. These results open up interesting prospects for integrating local products into innovative food formulations.

3. Results and Discussion

3.1 Physicochemical Analyses

The physicochemical characteristics of date powder, *Moringa oleifera* leaves, and the four types of biscuits are presented in Table 2.

Table 2. Physicochemical Characteristics of Date Powder, *Moringa oleifera* Leaves, and the Four Biscuit Samples

Parameter	PD	PMO	PJDM	PJR	PKDM	PKR
pH	5.70 ± 0.01	6.30 ± 0.02	6.21 ± 0.03	6.52 ± 0.11	6.25 ± 0.33	6.15 ± 0.12
Moisture (%)	9.95 ± 0.03	9.21 ± 0.04	8.15 ± 0.09	5.46 ± 0.05	10.51 ± 0.02	7.39 ± 0.05
Mineral Content (%)	17.06 ± 0.02	20.73 ± 0.03	14.92 ± 0.02	12.90 ± 0.05	17.90 ± 0.03	4.67 ± 0.03
Fiber (%)	44.95 ± 0.01	28.65 ± 0.02	59.63 ± 0.02	40.31 ± 0.02	40.34 ± 0.01	33.92 ± 0.01
Proteins (%)	11.43 ± 0.02	18.17 ± 0.08	11.69 ± 0.02	10.87 ± 0.05	13.57 ± 0.01	10.05 ± 0.03

All determinations were carried out in triplicate manner and values are expressed as the mean ± SD.

PD: Date Powder; PMO: *Moringa oleifera* Leaf Powder; PJDM: Jouza Biscuit Enriched with Dates and *Moringa*; PJR: Reference Jouza Biscuit; PKDM: Kaaber Biscuit Enriched with Dates and *Moringa*; PKR: Reference Kaaber Biscuit.

The date powder exhibits an acidic pH of 5.70, similar to the value of 5.63 reported by Borchani *et al* [7]. The pH of both enriched and reference biscuits ranges between 6.15 and 6.52, showing relatively consistent values. The moisture content of the powders is 9.95% for date powder and 9.21% for *Moringa oleifera* leaves, which is slightly lower than the 9.86% reported by Fokwen *et al* [8]. This small difference may be attributed to variations in drying methods, environmental conditions during processing, or leaf maturity at harvest. Maintaining a low moisture content is essential for preserving the quality and shelf life of the powder, as higher moisture can promote microbial growth and reduce stability. Both values, however, fall within the acceptable range for dried herbal products. For biscuits enriched with date and *Moringa*, the moisture content is 8.15% for Jouza and 10.51% for Kaaber, which are higher than the reference biscuits (5.46% for Jouza and 7.39% for Kaaber). This increase is likely due to the incorporation of dates. These values fall below the Codex Stan 176 recommended limit of 11.7%, ensuring a longer shelf life by minimizing microbial growth [9].

In terms of mineral content, date powder contains 17.06%, while *Moringa oleifera* powder has a higher content of 20.73%, exceeding the 12% reported by Broin [10]. Enriched biscuits exhibit mineral contents of 14.92% (Jouza) and 17.90% (Kaaber), significantly higher than the reference samples (12.90% for Jouza and 4.67% for Kaaber). This enrichment demonstrates the nutritional enhancement achieved by adding *Moringa oleifera* and dates, both known for their mineral richness.

Regarding fiber content, date powder and *Moringa* leaves contain 44.95% and 28.65%, respectively. Enriched biscuits have higher fiber levels (59.63% for Jouza and 40.34% for Kaaber) compared to their references (40.31% and 33.92%, respectively). This makes the enriched products particularly appealing for dietary fiber intake.

Protein levels in date powder (11.43%) are higher than level (2.64%) reported by Jrad *et al* [11]. *Moringa oleifera* powder has 18.17% of protein slightly higher than level (16%) reported by Fokwen *et al* [8]. Enriched biscuits show increased protein content (11.69% for Jouza and 13.57% for Kaaber) compared to their reference counterparts (10.87% and 10.05%, respectively). These results confirm the nutritional benefits of incorporating *Moringa* and dates into biscuit formulations.

3.2 Mineral Composition

The results of the analyses of the mineral composition of date powder, *Moringa oleifera* leaves and the four biscuit samples, carried out by atomic absorption spectrometry, are presented in Table 3.

Table 3. Mineral Content in Date Powder, *Moringa oleifera* Leaves, and the Four Biscuit Samples

Element (g/kg MS)	PD	PFMO	PJDM	PJR	PKDM	PKR
K	67.3 ± 3.80	11.83 ± 0.06	38.9 ± 0.20	16.55 ± 0.15	57.6 ± 2.00	9.05 ± 0.25
Ca	18.03 ± 0.10	15.53 ± 0.11	10.00 ± 0.40	10.10 ± 0.30	20.20 ± 0.10	13.50 ± 0.30
Mg	5.75 ± 0.15	3.36 ± 0.03	4.30 ± 0.20	2.50 ± 0.30	6.45 ± 0.25	4.10 ± 0.30
Na	3.45 ± 0.05	1.03 ± 0.01	2.30 ± 0.10	4.20 ± 0.30	2.65 ± 0.05	7.75 ± 0.35

All determinations were carried out in triplicate manner and values are expressed as the mean ± SD.

PD: Date Powder; PFMO: *Moringa oleifera* Leaf Powder; PJDM: Jouza Biscuit Enriched with Dates and *Moringa*; PJR: Reference Jouza Biscuit; PKDM: Kaaber Biscuit Enriched with Dates and *Moringa*; PKR: Reference Kaaber Biscuit

The atomic absorption spectrometry analyses confirm the mineral richness of dates and *Moringa oleifera* leaves. The potassium content in *Moringa* leaves is 11.83 g/kg dry matter (DM), as reported by Saint Sauveur et al, which is three times higher than in bananas [12]. The potassium content in date powder is 67.3 g/kg DM. Potassium, in association with sodium, plays a major role in the contraction of all muscles in the body, especially the heart, by facilitating nerve transmission. It also plays a crucial role in carbohydrate and protein metabolism [13, 14]. The calcium content in *Moringa* leaves reaches 15.53 g/kg DM, four times more than in milk [10]. Calcium is essential for the strength of bones and teeth, with more than 99% concentrated in bones and dental enamel. It also plays a fundamental role in cellular physiology and is responsible for the proper functioning of all body cells [15, 16]. The magnesium content in *Moringa oleifera* leaves is 3.36 g/kg DM, while date powder contains 5.57 g/kg DM. Magnesium is involved in numerous cellular functions and more than 300 intracellular enzymatic reactions. It is also involved in neuromuscular transmission and is considered a natural anti-stress agent in recent studies [13, 16]. Sodium content in date powder and *Moringa* leaves is 3.45 g/kg DM and 1.03 g/kg DM, respectively. Sodium plays a crucial role in maintaining fluid balance, muscle contraction, and nerve function [17, 18]. The reformulated Jouza biscuit made from date and enriched with *Moringa* is richer in potassium and magnesium (38.9 and 4.3 g/kg DM, respectively) than the reference biscuit (16.55 and 2.5 g/kg DM, respectively). The reformulated Kaaber biscuit made from date and enriched with *Moringa* is also richer in potassium, calcium, and magnesium (57.6, 20.2, and 6.45 g/kg DM, respectively) than the reference Kaaber biscuit (9.05, 13.5, and 4.10 g/kg DM, respectively). The mineral richness of date powder and *Moringa* leaves could represent significant added value for our reformulated biscuits.

3.3 Total Polyphenols (PT) and Total Flavonoids (FT) Analysis

The total polyphenols (PT) and total flavonoids (FT) content in different extracts obtained from date powder, *Moringa oleifera* leaves, and reformulated biscuits (and their references) are presented in Table 4.

Table 4. Total Polyphenols (PT) and Total Flavonoids (FT) in date powder, *Moringa oleifera* leaves, and four biscuit samples

Element	PD	PFMO	PJDM	PJR	PKDM	PKR
PT (mg GAE/g DE)	8.62±0.77	80.90±1.15	40.23±1.56	26.44±0.33	31.21±1.44	7.47±0.20
FT (mg QE/g DE)	1.80±0.12	44.20±0.08	3.42±0.18	2.45±0.05	2.40±0.15	1.49±0.03

All determinations were carried out in triplicate manner and values are expressed as the mean ± SD.

PD: Date Powder; PFMO: *Moringa oleifera* Leaf Powder; PJDM: Jouza Biscuit Enriched with Dates and *Moringa*; PJR: Reference Jouza Biscuit; PKDM: Kaaber Biscuit Enriched with Dates and *Moringa*; PKR: Reference Kaaber Biscuit.

The results show that the reformulated Jouza biscuit made from dates and enriched with *Moringa* has a higher value of total polyphenols (PT) and total flavonoids (FT) (40.23 mg GAE/g DE and 3.42 mg QE/g DE, respectively) than the reference biscuit (26.44 mg GAE/g DE and 2.45 mg QE/g DE, respectively). The reformulated Kaaber biscuit made from dates and enriched with *Moringa* also presents higher values of PT and FT (31.21 mg GAE/g DE and 2.40 mg QE/g DE, respectively) than the reference biscuit (7.47 mg GAE/g DE and 1.49 mg QE/g DE, respectively). The richness of phenolic compounds in the reformulated biscuits is mainly explained by the addition of *Moringa*, which is particularly rich in phenolic compounds [19].

3.4 Sugar Content by HPLC-MS

The sugar content (fructose, glucose, sucrose, palatinose, and maltose) of the extracts obtained using 70% methanol from date powder, *Moringa oleifera* leaves, and reformulated biscuits are presented in Table 5. The linearity of the method used was verified: solutions at different concentrations (0.05–20 µg/L) containing the five standards were injected under the same operating conditions, in triplicate. The calibration curve of each standard was established, and the calibration equation for quantifying each standard in the analyzed extracts was determined, along with the correlation coefficient.

Table 5. Sugar content by HPLC-MS in extracts of dates, *Moringa oleifera* leaves, and four reformulated biscuits

Sugar (g/kg DM)	Fructose	Glucose	Sucrose	Palatinose	Maltose	Total Sugars
PD	57.25	53.03	167.38	-	-	277.66
PFMO	10.54	14.99	3.33	-	-	28.86
PJDM	60.42	57.04	-	-	-	117.46
PJR	-	-	170.80	-	-	170.80
PKDM	84.2	68.28	10.59	-	-	163.07
PKR	11.57	11.7	179	-	-	202.27

The total sugar content reaches 277.66 g/kg DM in date powder and 28.86 g/kg DM in *Moringa oleifera* leaves. The Jouza biscuit made from dates and enriched with *Moringa* (117.46 g/kg DM) has lower total sugar content than the reference biscuit (170.80 g/kg DM). The Kaaber biscuit made from dates and enriched with *Moringa* (163.07 g/kg DM) also has a lower total sugar content than its reference (202.27 g/kg DM). Both date-based biscuits are rich in reducing sugars such as fructose and glucose, while the reference biscuits are richer in sucrose. Analyses showed the absence of palatinose and maltose in all tested extracts. The integration of date and *Moringa* powder is a new approach for creating biscuit formulations that comply with current standards while meeting consumer expectations. Date powder, due to its richness in natural sugars, can replace refined white sugar, and its valorization could have significant socio-economic impact while improving consumer health.

3.5 Sensory Analysis

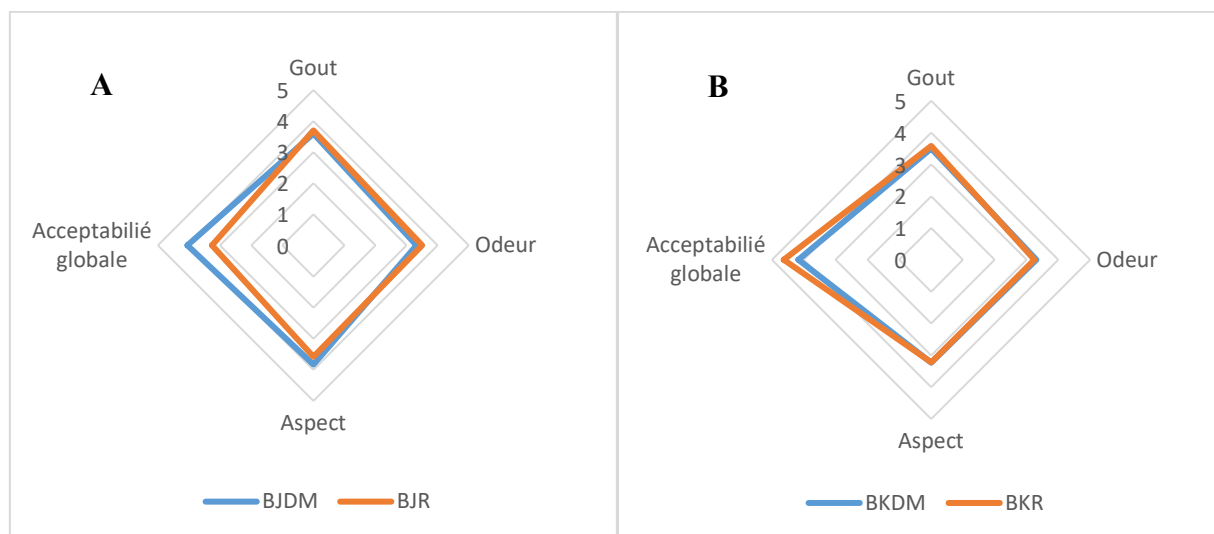


Figure 2. Radar chart representation of sensory evaluation; A: Date and *Moringa* Jouza Biscuit and its reference, B: Date and *Moringa* Kaaber Biscuit and its reference.

This study aimed to conduct a hedonic test to evaluate consumer preference. The various parameters evaluated include appearance, smell, taste, and overall acceptability. The results are presented in Figure 2A for the Jouza biscuit made from dates and enriched with *Moringa* and its reference, as well as in Figure 2B for the Kaaber biscuit made from dates and enriched with *Moringa* and its reference.

The results show that tasters appreciate the taste of both types of biscuits based on date powder and enriched with *Moringa* (scores > 3). The Jouza biscuit made from dates and enriched with *Moringa* is generally better accepted by tasters than its reference. Odor is also an important factor, as it can influence product purchase [20]. The results show that tasters appreciate the smell of the reformulated biscuits. It is noted that the addition of *Moringa* does not negatively influence the smell rating. The taste scores for the biscuits based on dates and enriched with *Moringa* all exceed a score of 3 and are close to the scores for the reference biscuits. The Jouza biscuit made from dates and enriched with *Moringa* is preferred compared to the reference Jouza biscuit. The addition of date powder and *Moringa* influences the overall appearance of the Jouza biscuit, especially due to its green color. The Jouza biscuit made from date powder and enriched with *Moringa* received the highest appearance score (> 4).

4. Conclusion

This study focused on the physico-chemical and nutritional composition of two traditional Tunisian biscuits, Jouza and Kaaber, made from dates and enriched with *Moringa oleifera*. A sensory analysis was also conducted to evaluate their acceptability. Two recipes from traditional cuisine were adapted to create new products by optimizing the proportions of dates and *Moringa*. The addition of date powder and *Moringa* led to a significant increase in the mineral, fiber, and protein content of the Jouza and Kaaber biscuits compared to the reference biscuits. These reformulated biscuits were found to be particularly rich in potassium, calcium, and magnesium, thus enhancing the nutritional value of dates and *Moringa* leaves, which provide real added value. The enriched biscuits also had high concentrations of total polyphenols and flavonoids, much higher than those found in commercial reference biscuits. This richness in phenolic compounds is attributed to the enrichment with *Moringa*, which is known for its high content of these bioactive compounds. In terms of sugars, the date-based Jouza and Kaaber biscuits were mainly rich in fructose and glucose (reducing sugars), while the reference biscuits contained more sucrose. The incorporation of date powder, due to its richness in natural sugars, offers an interesting alternative to refined white sugar, providing an innovative approach to develop formulations that meet current standards and consumer expectations. This valorization of dates also presents strong socio-economic potential while improving consumer health. Sensory evaluation confirmed that the two types of enriched biscuits were accepted by consumers, with scores close to those of the reference biscuits. To further this work, we propose determining the biological activities of the reformulated biscuits, monitoring the evolution of their nutritional composition and biological activities during storage, and exploring the use of other natural flavors to enhance the taste and preservation of other types of Tunisian traditional pastries. Future research should explore the long-term nutritional impact of these enriched biscuits and their potential role in dietary interventions targeting mineral deficiency.

Declaration of Competing Interest

The authors declare that they have no conflict of interest.

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