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Fortification of Traditional Fermented Milk "Lben" with Date Powder: Physicochemical and Sensory Attributes †

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Abstract: The main objective of this study was to evaluate the effect of date powder supplementation on the main quality attributes of "Lben", a traditional fermented milk. Physicochemical and sensory analyses of fortified Lben showed that the supplementation with date powder (6%; *w*/*v*) allowed the decrease of acidity, the increase of pH with a slight decrease of the final lactic bacteria count. Lben fortification with date powder improved overall acceptability, induced increase of color and odor intensities and enhanced the balance of sweet/sour taste. Besides fortification allowed the development of desirable fruit and sweet tastes.

Keywords: date powder; Lben; physicochemical properties; sensory attributes

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1. Introduction

Date palm (*Phoenix dactylifera* L.) is the main fruit crop in Tunisia with a total production of 305 thousand tons reached in 2018 [1]. The diverse nutritional and functional components of date fruits mainly carbohydrate content, antioxidants, phenolic nutrients, minreals and dietary fiber content were largely reported in literature. Dates are consumed fresh, dried or processed in different products such as honey, sugar, vinegar, syrup, juice and others [2]. Transformation of date fruit into powder could improve its handling, storage and its use in food fortification. In addition, it offers a natural and a suitable ingredient with several nutritional and functional properties.

Lben is one of the main popular traditional fermented milk in North Africa. It is produced by fermentation of cow milk and later separation of Lben from butter formed under the churning of coagulum. The product is characterized by specific sensory attributes mainly its sour/acidic taste due to fermentation at ambient temperature [3].

The consumption of Lben is generally accompanied with date fruit as traditional and refreshing meal entry. This study aimed to investigate some techno-functional and antioxidant properties of date powder and the effect of its supplementation on the physicochemical and sensory properties of Lben.

2. Material and Methods

2.1. Date Powder

Samples of date powder of Deglet Nour variety (moisture content = 7.4 ± 2.01% and water activity = 0.20 ± 0.08 at 25 °C) were provided by a date factory Boudjebel S.A. VACPA (in North of Tunisia). Samples were sieved through a 500 μm sieve before analyses and use for Lben fortification.

2.1.1. Techno-Functional Properties

Hydration properties of date powder were investigated through measurements of water holding capacity (WHC), oil holding capacity (OHC) and milk holding capacity (MHC) following the method described by Dhankhar et al. (2019) [4]. Holding capacities were evaluated as mL of water, milk or corn oil bounded per gram of date powder and expressed in percentage. Bulk density of powder was evaluated as reported by Manickavasagan et al. (2015) [5] and was calculated as weight per unit of volume occupied.

2.1.2. Phenolic, Flavonoids Contents and Antioxidant Activity

Phenolic extract of date powder was prepared by dissolving 2 g of powder in 20 mL of acetone (70:30, *v*/*v*) with shaking for 30 min at 40 °C at a rotational speed of 200 rpm. Then, the mixture was centrifuged at 6000 rpm for 15 min at room temperature. The residue was re-extracted with the same solvent under identical conditions and supernatants of three extractions were combined and filtered. Total phenol contents (TPC), flavonoid and antioxidant activity were determined as reported by M'hiri, Ioannou, Boudhrioua, & Ghoul (2015) [6].

2.1.3. Color Evaluation

For date powder color parameters C.I.E. L*a*b* values were measured using a colorimeter (CPCE, TCR200, Spain): lightness (L*), red/greenness (a*), and yellow/blueness (b*). Calibration was performed prior to the sample analysis and measurements are triplicate.

2.2. Preparation of Lben Fortified with Date Powder

Lben was prepared from pasteurized cow milk. Conditions of fermentation were temperature: 18.5 °C, fermentation time: 20.6 h and starter-level: 1.1×10^1 g/L. Starter culture mixture is formed by *Lactococcus lactis* subsp. *cremoris*, *Lactococcus lactis* subsp. *lactis* and *Lactococcus lactis* subsp. *lactis biovar diacetylactis* (Food.com Granata®, Italy). Optimal fermentation conditions were determined in a previous work dealing with optimization of Lben processing [3]. Date powder (6%, *w*/*v*) was added after milk fermentation and separation of raw butter and Lben to prevent powder loss during milk processing. Detailed methodology adopted is summarized in Figure 1.

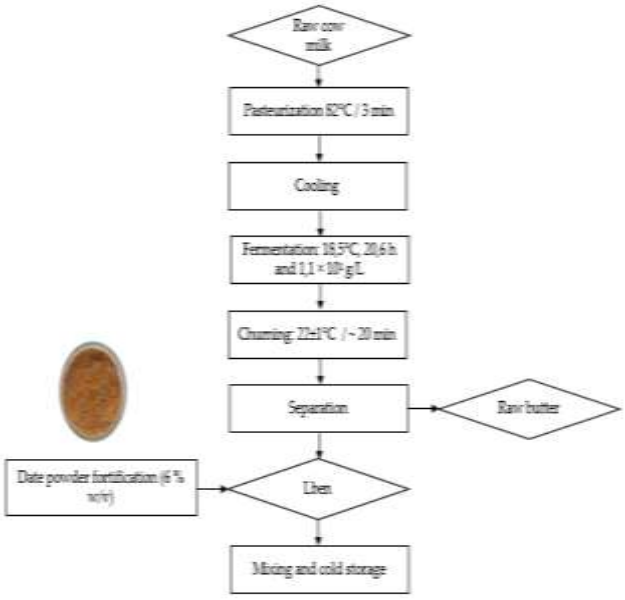

Figure 1. Experimental methodology for Lben processing and fortification.

2.3. Physicochemical, Lactic Bacteria and Sensory Analysis of Lben Fortified with Date Powder

pH values were determined using digital pH meter (OHAUS starter 2100, Pine, Brook, NJ, USA). Dornic acidity was evaluated by titration with 0.1 M sodium hydroxide solution. Color parameters were measured as reported by Mkadem et al. (2022) [3] and the color difference ΔE was calculated as follows:

$$\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{1/2}. \quad (1)$$

where ΔL*, Δa*, Δb* were color difference values among industrial Lben and laboratory processed ones.

Lactic bacteria count was determined by standard plate count method on MRS agar [3]. All analyses were triplicate for raw milk, fortified and unfortified Lben.

Ten trained panelists were selected to evaluate sensory attributes of Lben (fortified and unfortified ones), industrial Lben was also evaluated by using 5-point scale. Lben samples were served at room temperature in 50 mL portions in polystyrene cups and randomly coded with three-digit numbers.

2.4. Statistical Analysis

One-way analysis of variance (ANOVA) using Tuckey test and principal components analysis (PCA) were performed by XLStat software version 2019 (Addinsoft, Paris, France).

3. Results and Discussion

3.1. Technofunctional Proporties of Date Powder

Mean values of technofunctional properties measurements' of date powder are shown in Table 1. No significant difference between holding capacities of date powder have been found in the three tested liquids (water, milk and corn oil) with numerically higher value obtained for milk (MHC = 1.7 ± 0.2 mL/g). López-Marcos et al. (2015) [7] reported that dietary fiber extracted from date showed a higher WHC depending on the extraction method of fiber, the insoluble and soluble dietary fiber ratio and the parts of date (pulp or peel) chosen for fiber extraction. In addition, drying procedure affected rehydration properties of obtained powder and this effect was reported in previous studies dealing with date fruit and other basic plants [5]. The effect of drying conditions mainly temperature have been shown previously on the bulk density of date powder. Higher temperature produced significantly higher bulk density. Similar to our results the bulk density of the date powder ranged from 0.39 to 0.50 g/cm^3 [5]. Due to it hydration properties, date powder justified the potential uses in different matrices to provide optimal product properties mainly sensory ones and lower bulk density is one of desirable properties suitable for dried powder in food formulation.

The total phenol content (TPC) total flavonoids content (TFC) and antioxidant activity of the date powder extract were given in Table 1. The obtained TPC and TFC values were higher than those reported by Benmeddour et al. (2013) for date fruit. Also, date powder has DPPH scavenging capacity (55.3%) and this obtained value was in line with those reported by Benmeddour et al. (2013) [8] and López-Marcos et al. (2015) [7]. L*a*b* color values of date powder were 63.4, 19.1 and 29.9 respectively. The color of powder was affected by drying of date fruit, which cause enzymatic and non-enzymatic browning reaction. Date powder color may affect the product after incorporation for that drying temperature is crucial parameter depending on food application.

Table 1. Techno-functional properties, total phenol, total flavonoid, antioxidant activity and color parameters of date powder.

Evaluated Parameters	Value *
WHC (mL/g)	2.0 ±0.2
OHC (mL/g)	1.7 ±0.5
MHC (mL/g)	1.7 ± 0.2
Bulk density (g/cm^3)	0.45 ± 0.05
Total phenolic content (mg GAE/100 g $_{db}$)	751.75 ± 0.03
Total flavonoids content (mg QE/100 g $_{db}$)	385.39 ± 0.04
DPPH scavenging capacity (%)	55.3 ± 0.9
Color parameters	
L*	63.4 ± 1.7
a*	19.1 ± 0.5
b*	29.9 ± 0.08

* Data are means ± standard deviation of three measurements.

3.2. Effect of Date Powder Supplementation

Results of pH, acidity, lactic bacteria count and color characteristics of Lben with and without date powder are presented in Table 2. The fortification of Lben with date powder significantly increased pH with decrease of acidity values as compared to Lben without date powder and industrial Lben used as control unfortified products. The increase of pH and the decrease of acidity of Lben could be attributed to low metabolic activity of lactic bacteria under date powder incorporation. Similar observations have been reported for yoghurt fortified by date palm spikelet extracts and also for yogurt supplemented with jujube pulp [9,10]. The incorporation of date powder slightly affected lactic bacteria count (9.28 to 8.18 log CFU/mL respectively for unfortified and fortified Lben) with higher value noted for unfortified Lben than industrial one. The effect of date powder on the viability of lactic bacteria could be attributed to phenolic content of date, which may inhibit the growth of lactic bacteria.

Due to the brown color of date powder, the fortification affected greatly color parameters mainly a* and b* values (Table 2). An increase of a* from -1.8 ± 0.8 to 4.5 ± 0.2 and b* values from 3.1± 0.1 to 12.1 ± 0.1 with a decrease of lightness parameter L*. Costa et al. (2015) [11] attributed this effect on color characteristics to the acidity which may induces, a change in the distribution of natural pigments of date powder in dairy matrices.

Table 2. Physicochemical properties, lactic bacteria count and color parameters of unfortified and fortified Lben with date powder.

Evaluated Parameters	pH	Acidity	Lactic Bacteria (log CFU/mL)	Color Parameters			
				L*	a*	b*	ΔE
Unfortified Lben	4.5 ± 0.01 ^{b}	84.1 ± 1.6 ^{a}	9.28	79.1± 0.4 ^{a}	−1.8 ± 0.8 ^{c}	3.1± 0.1 ^{b}	0.76
Lben fortified with date powder (6% *w*/*v*)	4.6 ± 0.01 ^{a}	76.4 ± 2.3 ^{b}	8.18	63.4 ± 0.9 ^{b}	4.5 ± 0.2 ^{a}	12.1 ± 0.1 ^{a}	19.00
Industrial Lben	4.4 ± 0.01 ^{c}	87.7 ± 3.8 ^{a}	5.71	79.1 ± 1.7 ^{a}	−1.1 ± 0.4 ^{b}	2.95 ± 0.2 ^{c}	-

The results of sensory analysis are presented in Figure 2a,b. The addition of 6% (*w*/*v*) date powder induced a change of the sensory intensity of some attributes such as color and odor with the appearance of new sensory attributes due to date powder addition mainly sweet taste, fruit taste and flavored milk odor (Figure 2a). Fortification of Lben by date powder improved sensory acceptance of the product for the majority of descriptors. The effect of date powder supplementation was shown also by principal components analysis PCA (Figure 2b). The bi-plot of variables and observations scores was constructed

by F1 and F2 with approximately 100% of total variability. As observed in radar chart, the sensory profile of Lben fortified with date powder was positively correlated in the two retained principal components with sweet taste, color intensity, odor, fruit taste, balance sweet/sour taste, flavored milk odor and appearance. In the contrast part (positive for F2 and negative for F1), unfortified Lben was correlated with acid taste and fresh milk odor. However, industrial Lben was positioned in the negative quadrant for the two components with fermented milk odor and viscosity. The overall appreciation was positioned in distinctive quadrant due to the different scores attributed by panelists depending on supplementation and by comparing to industrial Lben.

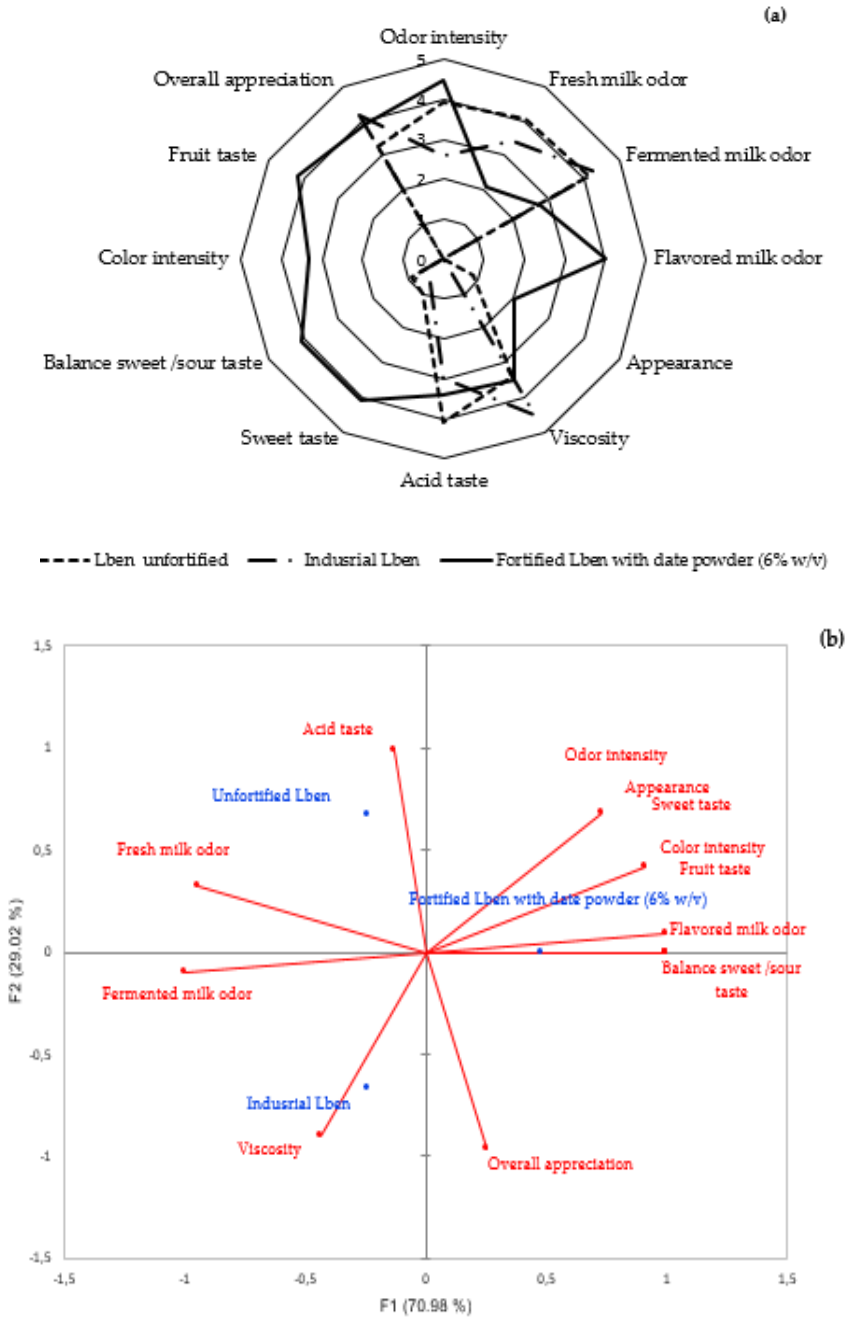

Figure 2. Sensory analysis of Lben with, without date powder and industrial one. (**a**) Sensory profile of different attributes; (**b**) bi-plot of evaluated Lben samples depending on sensory descriptors.

4. Conclusions

Date powder is a multifunctional natural ingredient. Its incorporation to Lben significantly affects principal physicochemical parameters: increase of pH with a decrease of acidity and a slight decrease of lactic bacteria count. Sensory attributes were also affected by date powder supplementation mainly the odor and the color. The addition of date powder allowed the enhancement of overall appreciation with a significant contribution to the development of sweet taste and the decrease of acid taste with an improved balance of sweet/sour taste.

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References

1. Food and Agriculture Organization Statistics Division (FAOSTAT). Available online: www.fao.org/faostat (accessed on 3 May 2021)
2. Ibrahim, S.A.; Fidan, H.; Aljaloud, S.O.; Stankov, S.; Ivanov, G. Application of Date (*Phoenix dactylifera* L.) Fruit in the Composition of a Novel Snack Bar. *Foods* **2021**, *10*, 918. https://doi.org/10.3390/foods10050918
3. Mkadem, W.; Belguith, K.; Semmar, N.; Benzid, M.; Boudhrioua, N. Effect of process parameters on quality attributes of Lben: Correlation between physicochemical and sensory properties. *LWT* **2022**, *155*, 112987.
4. Dhankhar, J.; Vashistha, N.; & Sharma, A. Development of biscuits by partial substitution of refined wheat flour with chickpea flour and date powder. *J. Microbiol. Biotech. Food Sci.* **2019**, *8*, 1093-1097. https://doi.org/10.15414/jmbfs.2019.8.4.1093-1097
5. Manickavasagan, A.; Thangavel, K.; Dev, S.R.S.; Delfiya, D.S.A.; Nambi, E.; Orsat, V.; Raghavan, G.S.V. Physicochemical Characteristics of Date Powder Produced in a Pilot-Scale Spray Dryer. *Dry. Technol.* **2015**, *33*, 1114–1123.
6. M'hiri, N.; Ioannou, I.; Boudhrioua, N.M.; Ghoul, M. Effect of different operating conditions on the extraction of phenolic compounds in orange peel. *Food Bioprod. Process*. **2015**, *96*, 161–170.
7. López-Marcos, M.C.; Bailina, C.; Viuda-Martos, M.; Pérez-Alvarez, J.A.; Fernández-López, J. Properties of Dietary Fibers from Agroindustrial Co-products as Source for Fiber-Enriched Foods. *Food Bioprocess Technol.* **2015**, *8*, 2400–2408.
8. Benmeddour, Z.; Mehinagic, D.; Meurlay, Le.; Louaileche, H. Phenolic composition and antioxidantcapacities of ten Algerian date (Phoenix dactyliferaL.) cultivars: a comparative study. *J. Funct. Foods*. **2013**, *5*, 346–354
9. Almusallam, I.A.; Ahmed, I.A.M.; Babiker, E.E.; Al-Juhaimi, F.Y.; Saleh, A.; Qasem, A.A.; Al Maiman, S.; Osman, M.A.; Ghafoor, K.; Hajji, H.A.; et al. Effect of date palm (*Phoenix dactylifera* L.) spikelets extract on the physicochemical and microbial properties of set-type yogurt during cold storage. *LWT* **2021**, *148*, 111762. https://doi.org/10.1016/j.lwt.2021.111762.
10. Feng, C.; Wang, B.; Zhao, A.; Wei, L.; Shao, Y.; Wang, Y.; Cao, B.; Zhang, F. Quality characteristics and antioxidant activities of goat milk yogurt with added jujube pulp. *Food Chem.* **2019**, *277*, 238–245. https://doi.org/10.1016/j.foodchem.2018.10.104
11. Costa, M.P.; Frasao, B.S.; Silva, A.C.O.; Freitas, M.Q.; Franco, R.M.; ConteJunior, C.A. Cupuassu (*Theobroma grandiflorum*) pulp, probiotic, and prebiotic: Influence on color, apparent viscosity, and texture of goat milk yogurts. *J. Dairy Sci.* **2015**, *98*, 5995–6003. https://doi.org/10.3168/jds.2015-9738