engineering proceedings

MDPI

Proceeding Paper

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

Wafa Mkadem *, Khaoula Belguith, Malek Ben Zid and Nourhene Boudhrioua *

Laboratory of Physiopathology, Foods and Biomolecules (LR17ES03), Higher Institute of Biotechnology Sidi Thabet, University of Manouba, BP-66, Ariana 2020, Tunisia; khaoula.belguith@isbst.uma.tn (K.B.); malek_benzid@outlook.fr (M.B.Z.)

* Correspondence: mkademwafa@gmail.com (W.M.); nourhene.boudhrioua@isbst.uma.tn (N.B.)

† Presented at the 1st International Electronic Conference on Processes: Processes System Innovation, 17–31 May 2022; Available online: https://ecp2022.sciforum.net.

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 supplementation with date powder (6%; *w*/*v*) conducted to a decrease in acidity and an increase in pH, with a slight decrease in the final lactic bacteria count. Lben fortification with date powder improved its overall acceptability, induced an increase in color and odor intensities, and enhanced the balance of the sweet/sour tastes. Additionally, fortification resulted in the development of fruity and sweet tastes in Lben.

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

check for updates

Citation: Mkadem, W.; Belguith, K.; Ben Zid, M.; Boudhrioua, N. Fortification of Traditional Fermented Milk "Lben" with Date Powder: Physicochemical and Sensory Attributes. *Eng. Proc.* **2022**, *19*, 43. https://doi.org/10.3390/ECP2022-12618

Academic Editor: Dariusz Dziki

Published: 17 May 2022

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 carbohydrates, antioxidants, phenolic nutrients, minerals, and dietary fiber content, are largely reported in the literature. Dates are consumed fresh, dried, or processed into different products such as honey, sugar, vinegar, syrup, juice, and others [2]. The transformation of date fruit into powder could improve its handling and storage, and its use in food fortification. In addition, it offers a natural and suitable ingredient with several nutritional and functional properties.

Lben is one of the most popular traditional fermented milk products in North Africa. It is produced via spontaneous fermentation of cow's milk. After fermentation, the formed coagulum is churned to separate Lben from raw butter. The product is characterized by specific sensory attributes, mainly its sour/acidic taste due to fermentation at an ambient temperature [3].

This study aimed to investigate the 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 the Deglet Nour variety (moisture content = 7.4 ± 2.01% and water activity = 0.20 ± 0.08 at 25 °C) were provided by the date factory Boudjebel SA VACPA (Beni Khalled, Nabeul, North of Tunisia). The samples were sieved through a 500 µm sieve before analyses and use for Lben fortification.

2.1.1. Techno-Functional Properties

The 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]. The holding capacities were evaluated as mL of water, milk or corn oil bounded per gram of date powder and expressed as a percentage. The bulk density of powder was evaluated as reported by Manickavasagan et al. (2015) [5] and was calculated as weight per unit of the volume occupied.

2.1.2. Phenolic and Flavonoid Contents and Antioxidant Activity

The 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 the supernatants of the three extractions were combined and filtered. The total phenol content (TPC), flavonoid (TFC) and antioxidant activity were determined as reported by M'hiri, Ioannou, Boudhrioua, and Ghoul (2015) [6].

2.1.3. Color Evaluation

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

2.2. Preparation of Lben Fortified with Date Powder

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

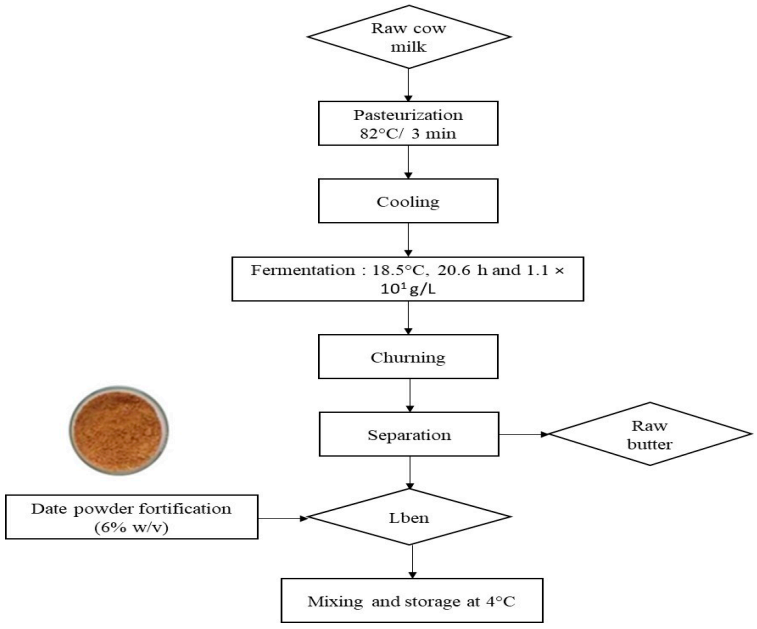

Figure 1. Experimental methodology for Lben processing and fortification.

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

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

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

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

The lactic bacteria count was determined using the standard plate count method on MRS agar [3]. All analyses were performed in triplicate for raw milk, and for fortified and unfortified Lben.

Ten trained panelists were selected to evaluate the sensory attributes of experimental (fortified and unfortified ones) and industrial Lben using a 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 Tukey's test and principal components analysis (PCA) were performed using XLStat software version 2019 (Addinsoft, Paris, France).

3. Results and Discussion

3.1. Techno-Functional Properties of Date Powder

The mean values of the techno-functional property measurements of date powder are shown in Table 1. No significant differences between the holding capacities of date powder were found in the three tested liquids (water, milk, and corn oil), with a 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 dates showed a higher WHC depending on the extraction method of fiber, the insoluble and soluble dietary fiber ratio, and the parts of the date (pulp or peel) chosen for fiber extraction. In addition, the drying procedure affected the rehydration properties of the 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, has been shown on the bulk density of date powder. Higher drying temperatures obtained powder with 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 its hydration properties, date powder justified the potential uses in different matrices to provide optimal product properties, mainly sensory ones.

The total phenol content (TPC), total flavonoid content (TFC) and antioxidant activity of the date powder extract are given in Table 1. The obtained TPC and TFC values were higher than those reported by Benmeddour et al. (2013) for date fruit. Additionally, date powder has a DPPH scavenging capacity represented by 55.3%. The obtained results are in line with those reported by Benmeddour et al. (2013) [8] and López-Marcos et al. (2015) [7]. The L*a*b* color parameters were 63.4, 19.1 and 29.9, respectively. The color of date powder was affected by the drying of fruit, which caused enzymatic and non-enzymatic browning reactions. The fortification by date powder significantly affected the color of the final product.

Table 1. Techno-functional property, 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 $_{DW}$)	751.75 ± 0.03
Total flavonoid content (mg QE/100 g $_{DW}$)	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; DW: dry weight.

3.2. Effect of Date Powder Supplementation

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

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
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}	-

Values followed by different letters in the same column indicate significant statistical difference ($p < 0.05$).

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

The results of the sensory analysis are presented in Figure 2. The addition of 6% (*w*/*v*) date powder induced changes in the sensory intensity of some attributes such as color and odor, with the appearance of new sensory attributes due to the addition of date powder mainly sweet and fruit tastes and flavored milk odor (Figure 2a). Fortification of Lben with date powder improved the sensory acceptance of the product for the majority of descriptors. The effect of date powder supplementation was also shown via principal component analysis PCA (Figure 2b). The bi-plot of variables and observation scores was constructed using F1 and F2 with approximately 100% of the total variability. As observed in the PCA plot, Lben fortified with date powder was positively correlated in the two retained principal components with sweet taste, color intensity, odor, fruit taste, balance of sweet/sour taste, flavored milk odor and appearance. In the quadrant positive for F2 and negative for F1, unfortified Lben was correlated with acidic taste and fresh milk odor. However, industrial Lben was positioned in the negative quadrant for the two components with fermented milk odor and viscosity. Overall appreciation was positioned in a distinctive quadrant due to the different scores attributed to it by the panelists depending on supplementation and by comparing it to industrial Lben.

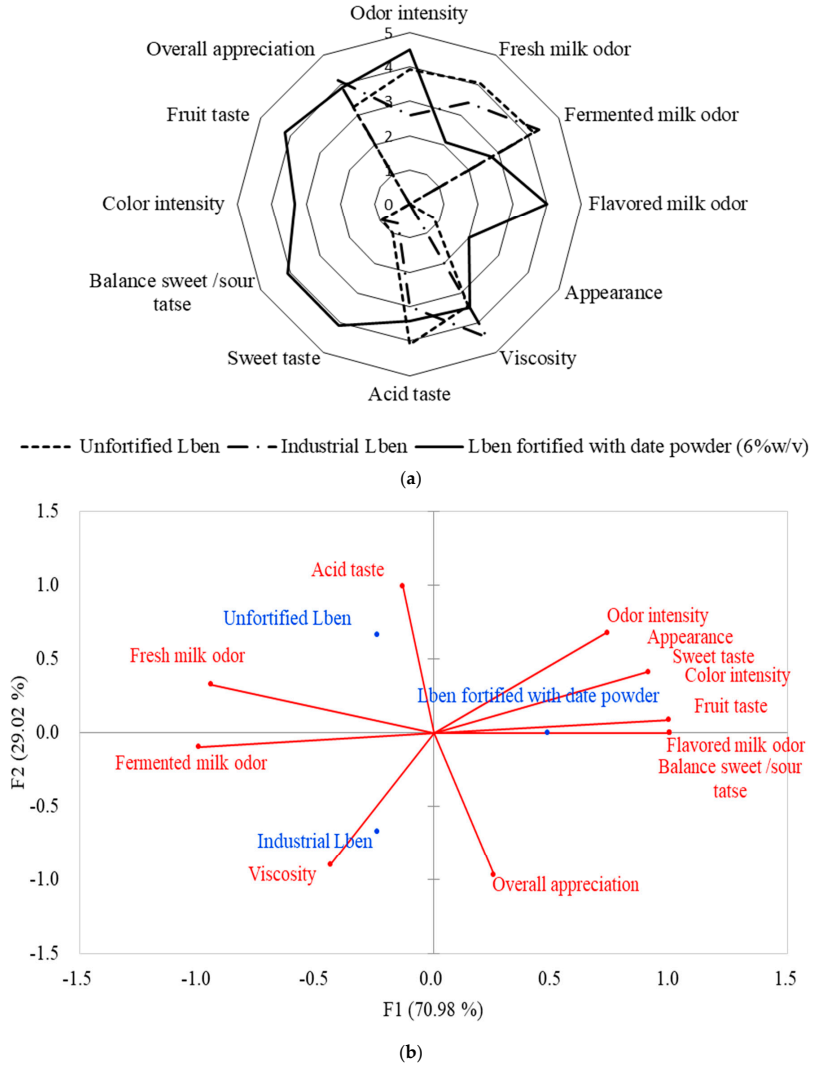

Figure 2. Sensory analysis of Lben fortified and unfortified by date powder, and the industrial one: (**a**) Sensory profile of different attributes; (**b**) bi-plot of evaluated Lben samples depending on sensory descriptors. (Sensory descriptors are presented in red color and analyzed products are in blue).

4. Conclusions

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

Author Contributions: Conceptualization, software, writing—original draft preparation: W.M.; review and editing, visualization: K.B.; methodology: M.B.Z.; funding acquisition, writing—review and editing, project administration: N.B. All authors have read and agreed to the published version of the manuscript.

Funding: This work was financially supported by the PRIMA project ArtiSaneFood (PRIMA-S2-2018-PCI2019-103453: Innovative Bio-interventions and Risk Modelling Approaches for Ensuring Microbial Safety and Quality of Mediterranean Artisanal Fermented Foods) and by PROMESSE project (PAQ PAES: T1-PAS 25), funded by the Tunisian Ministry of Higher Education and Scientific Research.

Acknowledgments: The authors wish to thank Boudjebel SA VACPA-global date's supplier for providing us the date powder.

Conflicts of Interest: The authors declare no conflict of interest.

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. [CrossRef] [PubMed]
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. [CrossRef]
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. [CrossRef]
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. [CrossRef]
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. [CrossRef]
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. [CrossRef]
8. Benmeddour, Z.; Mehinagic, D.; Le Meurlay, D.; Louaileche, H. Phenolic composition and antioxidantcapacities of ten Algerian date (*Phoenix dactylifera* L.) 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. [CrossRef]
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. [CrossRef] [PubMed]
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. [CrossRef] [PubMed]