Original Article
Food Science and Technology
ISSN 0101-2061 (Print)
ISSN 1678-457X (Online)
DOI: https://doi.org/10.5327/fst.00273

Crafting Algerian "Jben": a traditional soft cheese enhanced by locally derived starters

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Abstract

The global dairy industry faces challenges in sourcing cost-effective and suitable lactic starters for traditional cheese production. This study investigates the use of locally selected lactic starters in crafting Algerian Jben cheese, aiming to provide a sustainable alternative to imported starters. Local lactic starters comprising *Lactococcus lactis*, *Leuconostoc mesenteroides*, and *Enterococcus durans* were characterized by their technological properties when applied to cow's milk. The resulting cheese was compared with another cheese produced under similar conditions but using an industrial mesophilic starter, including strains of *Lactococcus* and *Leuconostoc*. Physicochemical and microbiological analyses were conducted on both cheeses, followed by sensory evaluations using the triangular and classification tests. Microbiological analyses revealed the absence of pathogenic germs or spores in both types of cheese. However, the cheese made with the industrial starter exceeded the standards for fecal coliforms and total coliforms. Titratable acidity measurements indicated comparable levels in both cheeses. Interestingly, there were no discernible differences in taste or aroma between the two types, with both being well received by tasters. In conclusion, our findings suggest that local lactic starters have the potential to replace the commercial starters currently employed in the Algerian dairy industry.

Keywords: Algeria; dairy industry; cheese production; lactic starters; food microbiology.

Practical application: Utilizing locally sourced lactic acid bacteria, this study explores the feasibility of replacing imported starters in Algerian Jben cheese production. Findings suggest that local starters offer a sustainable alternative, ensuring product safety and preserving cultural authenticity.

1 INTRODUCTION

Jben, a cheese rooted in Algerian Sahara nomadic culture, was traditionally crafted during their desert journeys. Nomads, consuming abundant milk, processed it into dairy products like Leben, butter, and Jben, cottage cheese. Originally rural, Jben production has urbanized and is now easily made within hours without aging. Despite its prevalence in Algerian dairies, many use costly imported starter cultures, diverging from traditional methods (Tadjine et al., 2021). While industrial cheese production in many countries often prioritizes the mass production of fresh, soft, and processed cheeses due to their ease of manufacture, the global culinary landscape is enriched by the diversity of traditional dairy products. These products, rooted in local cultures and traditions, offer unique flavors and textures that reflect centuries-old culinary practices. Algeria is no exception, boasting a rich tapestry of traditional dairy delicacies, including the fresh cheese "Jben" (Dahou et al., 2015), mature cheese "Bouhezza" (Aissaoui-Zitou et al., 2011), and very hard cheese "Klila" (Benamara et al., 2022; Khaldi et al., 2006; Medouni et al., 2006; Koussou et al., 2007).

Crafted with care and expertise, these cheeses have been a cornerstone of Algerian gastronomy for generations. Traditionally made by women in their homes (Lahsaoui, 2009) using raw cow, goat, or sheep milk (Bencharif, 2001), these cheeses are not only cherished for their taste but also hold deep cultural significance (Giuseppe, 2010). They are often enjoyed during festive occasions, family gatherings, and everyday meals, embodying the essence of Algerian culinary heritage. However, despite their cultural importance, traditional Algerian dairy products are facing challenges. The phenomenon of rural exodus, coupled with the growing dominance of industrial dairy industries, poses a threat to the survival of these time-honored culinary traditions. As modernization and globalization reshape food preferences and consumption patterns, there is a risk of these traditional cheeses fading into obscurity. Instead of preserving and promoting local products, the prevalence of industrial products risks erasing the opportunity for consumers to appreciate the unique taste, cultural context, and biodiversity of traditional Algerian dairy items (El Marrakchi & Hamama, 1995). In Algeria, only "Lben," a fermented milk, and "Jben," a

Received 31 Jan., 2023.
Accepted 10 Mar., 2024.
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This document has an erratum: https://doi.org/10.5327/fst.00273ERRATUM

fresh cheese, have transitioned from traditional to industrial production scales. While these products have undergone this transition, there remains a notable gap in research regarding the broader landscape of traditional dairy products and their evolution in Algeria. Understanding this transition and its implications requires contextualizing it within the broader Mediterranean region, where similar dairy items are widely consumed. For instance, neighboring countries such as Morocco (Hamama, 1988, 1997; Benkerroum & Tamime, 2004; De Angelis et al., 2004), Tunisia (Khaldi et al., 2006), and Egypt (Abou-Donia, 1984, 2008) have their own variations of fermented milk and fresh cheese, suggesting a shared cultural and culinary heritage. Moreover, comparable dairy products can be found beyond the Mediterranean region, extending to countries like Iraq (Belal et al., 2022), various sub-Saharan nations (Koussou et al., 2007), and even as far as Turkmenistan (Turantas et al., 1989). Despite geographical and cultural differences, these regions exhibit similarities in their dairy traditions, highlighting the universality of certain dairy products and production methods. However, the transition of traditional Algerian dairy products to industrial scales raises important questions and challenges that remain unsolved. Issues such as the impact on small-scale producers, changes in product quality and authenticity, and the preservation of cultural heritage amid modernization are areas that require further exploration and research. By examining these unresolved problems and citing similar works from other regions, we can gain valuable insights into the complexities of dairy production transitions and their broader implications.

This study introduces a pioneering approach to cheese production, departing from conventional methods reliant on imported industrial starters. By experimenting with locally sourced starters to create a traditional fresh cheese akin to "Jben," this research explores uncharted territory in the realm of dairy product innovation. Unlike previous studies, which have primarily focused on industrial-scale production, our work delves into the feasibility and implications of utilizing indigenous starters that align with Algerian tastes and customs. By highlighting the use of locally sourced ingredients in dairy production, this study not only enriches the understanding of Algerian culinary heritage but also sets a precedent for leveraging indigenous resources to enhance food sustainability and cultural authenticity. The methodology and findings presented herein contribute to a burgeoning field of research aimed at preserving and promoting local culinary traditions worldwide, offering valuable insights for researchers and practitioners navigating the complexities of modern food systems.

2 MATERIALS AND METHODS

2.1 Preparation of starters

The local Algerian lactic acid bacteria (LAB) utilized in this study were isolated from local cow's milk and previously identified through phenotypic and molecular tests. The LAB cultures, namely *Lactococcus lactis* subsp. *lactis biovar diacetylactis* (Lc95), *Leuconostoc mesenteroides* subsp. *mesenteroides* (Leu109), and *Enterococcus durans* 1 (Ed16), were characterized for their technological capacities (Bendimerad, 2013; Bendimerad et al., 2012). Additionally, an industrial starter in freeze-dried form, with the business code SMADL77 (Choozit, Danisco, Dupont group), was employed. This mesophilic starter comprises isolates of homo-fermentative strains, including *L. lactis* subsp. *cremoris*, *L. lactis* subsp. *lactis*, and *L. lactis* subsp. *lactis biovardiacetylactis*.

The first starter was prepared by reconstituting 120 g of whole milk powder (Régilait brand) with 880 mL of potable water heated to 40–45°C. After complete dissolution, the reconstituted milk was pasteurized at 85°C for 5 min and then cooled to 25–26°C. Inoculation of 100 mL of reconstituted milk with a 3 mL mixture of Lc95, Ed16, and Leu109 cultures followed. After incubation for 16–18 h at 25–26°C to achieve an acidity of 80–85°D (corresponding to a pH of 4.5–5.0), the obtained starter was cooled to 4°C to stop further acidity increase.

The second starter, SMADL77, was also prepared following the same protocol as the first, with the freeze-dried culture used in fresh cheeses at a dose of 2–5 L of starter per 100 L of milk, according to the supplier's recommendations.

2.2 Production Flow Sheet of "Jben"

Two different "Jben" cheeses were simultaneously made under identical conditions, differing only in the choice of starter (either from our laboratory collection or an industrial starter). Each starter (45 mL) was used to inoculate 5 L of cow's milk (purchased from a shop). The milk was heated for 5 min at 85°C and then cooled to 24–23°C. Freeze-dried rennet (1/5,000) was diluted in distilled water (2.5 g in 50 mL) and added after 30 min. The milk started coagulating after 30 min, and after 45 min, the curd firmness was observed, followed by serum release. The serum was drained for 24 h using a fine-pore cloth, resulting in the production of "Jben."

2.3 Analysis of elaborated cheeses

2.3.1 Microbial Analysis

Microbiological analyses were conducted to assess the quality and safety of the cheeses. Total mesophilic microflora was enumerated on Plate Count Agar in accordance with ISO 4833-1 and ISO 4833-2 standards. Enumeration of total coliforms was performed on Brilliant Green Bile Lactose Broth using the most probable number (MPN) method. Fecal coliforms were examined and enumerated through the MacKenzie test, adhering to Algerian regulations.

Additionally, fecal enterococci were enumerated using Rothe broth for presumptive and Eva Litsky for confirmatory tests. *Salmonella* testing was carried out on solid SS medium after enrichment in SFB selenite broth, following ISO 6579-1 standard procedures. Enumeration of *Staphylococcus aureus* was conducted on Baird-Parker egg yolk medium and potassium tellurite after enrichment in Giolitti and Cantoni broth, in accordance with Algerian regulation ISO 6888-1. *Clostridia* spores were enumerated on meat-liver agar supplemented with ammonium

ferric citrate and sodium sulfite after heating at 80°C for 10 min, with incubation for 24 h at 37°C.

2.3.2 Physical and chemical analysis

Post draining, each "Jben" underwent a comprehensive analysis involving four key parameters:

- Weight determination

Conducted using an electronic precision balance to ascertain the precise weight of the cheese.

- Temperature measurement

Performed by inserting a thermometer at various points within the cheese to gauge temperature variations.

- Titratable acidity measurement

Employed the technique outlined by Meribai et al. (2017) with results expressed in Dornic degrees (°D).

- Total dry extract determination

Followed ISO 5534/IDF 4 standards, with the moisture content (Hm) calculated as Hm = 100 - ED.

- Fat content determination

Utilized the Gerber acid butyrometric method, with F/D calculated by Equation 1:

$$F/D = FAT/EXTRACT\ DRY \times 100 \quad (1)$$

These analyses provided a comprehensive overview of the physical and chemical attributes, contributing to a thorough understanding of the characteristics of the "Jben" cheeses.

2.3.3 Acidity test

Each lactic acid bacterium and starter used in "Jben" production underwent acidity testing, measuring the acidity produced every 2 h up to 24 h after inoculation of the lactic acid starter in 100 mL of partially skimmed and sterilized milk. The titratable acidity of the starter and the curd was also measured every 2 h according to the 24 h acidification kinetics.

2.3.4 Sensorial evaluation

A total of 16 randomly selected individuals aged between 18 and 60 years participated in the sensory tests, including the triangular and ranking tests. The triangular test aimed to assess sensory differences between "Jben" produced with local LAB and the industrial starter. The ranking test focused on four characteristics: consistency, aroma, acidity, and general appreciation, analyzed using Friedman's chi-square test.

3 RESULTS AND DISCUSSION

3.1 Cheese characteristics

The cheese produced with the laboratory starter exhibited a whitish color, crumbly texture, a pleasant odor, and a moderately acidic taste. Similarly, the cheese made with the industrial starter was white and crumbly, sharing similar characteristics with the first cheese (Figure 1).

3.2 Microbiological analysis

Regardless of whether the cheese was made with a laboratory or industrial starter, the total aerobic mesophilic flora load adhered to standards: 1.6×10^4 cfu/g for cheeses with a laboratory starter and 3.5×10^4 cfu/g for cheeses with an industrial starter. In contrast to traditional Moroccan Jben (El Marnissi et al., 2013), both cheeses lacked pathogenic flora such as *S. aureus* and *Salmonella*, as well as *Clostridium* spores, yeasts, and molds. Fecal contaminants, including fecal enterococci, were absent in both kinds of cheese, while fecal coliforms were present only in the cheese made with the industrial starter (140 cfu/g). Total coliforms were also detected in the "Jben" cheese made with the industrial starter at 350 cfu/g, surpassing the Algerian standard ISO 5534: IDF 4. This contamination was likely attributed to

Figure 1. Appearance of the produced type Jben cheeses. On the left, cheese elaborated with industrial starter and on the right with laboratory strains.

the industrial starter, given that the two different "Jben" were produced under identical conditions. Comparable results were observed for fresh pasta prepared in the laboratory (El Marrakchi & Hamama, 1995) and traditional Moroccan Jben (Hamama, 1988). Other studies revealed the presence of yeasts, molds, fecal contamination germs, *S. aureus*, and *Clostridium* spores, while *Salmonella* was absent in traditional Moroccan Jben (El Marnissi et al., 2013). Additionally, traditional Moroccan Jben made from recombined milk showed similar findings (Hamama et al., 2023). In another study, *Salmonella* was present in 10% of samples, and *S. aureus* was found in 17.4% of samples of fresh cheese produced by traditional dairies in Rabat (Hamama, 1988). Traditional Egyptian fresh cheese, known as "Karich," was reported to have poor hygienic quality (Abou-donia, 1984).

3.3 Physicochemical analysis

The cheese yield obtained with the industrial ferment was higher than that obtained with the laboratory ferment, despite nearly identical dry matter (Table 1). This difference could be attributed to variations in the draining process. The titratable acidity, corresponding to a pH of 4.3, was consistent for both cheeses and aligned with values described for Moroccan Jbens (El Marnissi et al., 2013). Mean values for dry matter, fat, and fat/dry matter slightly differed between the two Jben cheeses. This discrepancy in values may be attributed to the method of preparation, the type of milk used, or the cattle feed (Ouadghiri et al., 2005). Since both cheeses were produced under the same conditions, the hypothesis of the starter type influencing these differences is plausible. The cheese made with the commercial starter had a rather coarse paste. The dry matter content was approximately 30% for both cheeses, as anticipated for a "Jben" cheese. The fat content was lower than that reported by El Marakkchi et al., 1995 and Hamama et al. (2003) for Moroccan "Jben" (15%), potentially owing to variations in the quality of the milk used.

3.3.1 Acidity

The laboratory strains employed for "Jben" production exhibited similar acidification kinetics. However, the acid production rate of the *L. lactis* isolates after 24 h was higher (100 °D) than the acid production rate of *Leuconostoc* and *Enterococcus* (65 °D) (Figure 2). In the dairy sector, lactococci play a direct role in the initial stages of the dairy process (Hemme & Foucaud-Scheunemann, 2004). Lactococci, in association or not with *Leuconostoc* and streptococci, play a crucial role in shaping dairy product characteristics, owing to their diverse metabolic activities, including acid production/consumption and biosynthesis of flavor compounds (Tachon et al., 2010). Over 24 h at 30°C, pH values were not linearly related to the quantities of acids present in the milk (Figure 3). This observation was consistent with the *Lactococcus*, *Leuconostoc*, and *Enterococcus* strains cited by Bendimerad (2013).

The kinetics of acid accumulation by the starter prepared with the laboratory starter comprised two distinct phases, including a slow phase up to 6 h. The acid levels reached after 24 h were close to 100 °D. The amount of acid produced in the curd by the laboratory starter gradually increased over time, reaching 87 °D after 24 h (Figure 4).

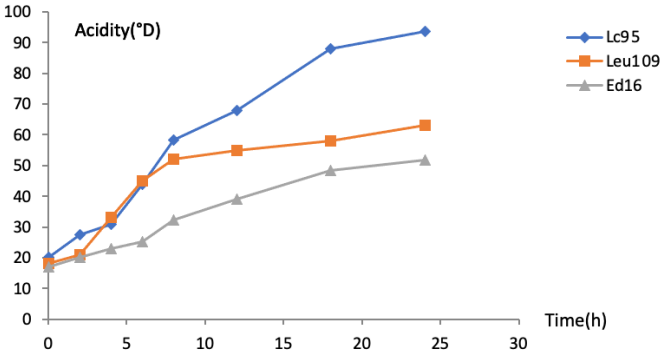

Figure 2. Acidifying activity of three over 24 h at 3°C for the three strains.

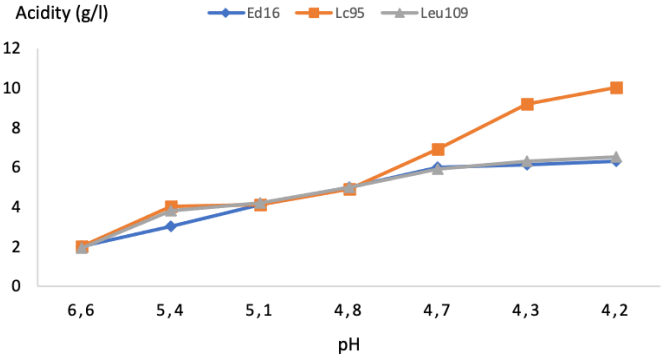

Figure 3. Variation in pH as a function of acid accumulated over 24 h at 3°C for the three strains.

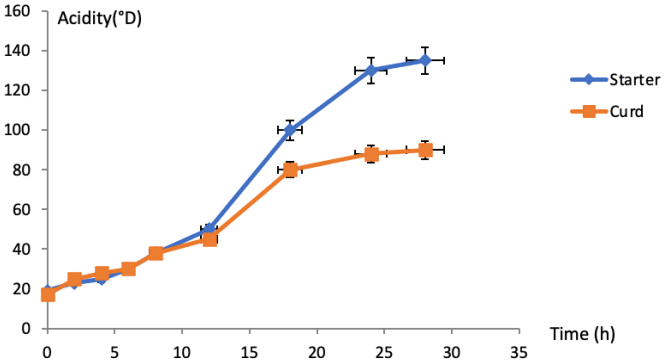

Figure 4. Acidity kinetic for lactic starter and curd at 23°C.

Table 1. Physicochemical analyses of the two different "Jben".

Cheese	Yield	*T* (°C)	pH	Acidity (°)	FAT(%)	DE (%)	F/D (%)
Laboratory strain	26.8	6.25 ± 1.27	4.3	88 ± 1.7	10.2 ± 0.6	28.5 ± 2.5	35 ± 4.1
Industrial strain	35.6	6.00 ± 1.8	4.3	88 ± 2.6	8.9 ± 2.2	20.3 ± 6.7	33.2 ± 17.2

This aligned with its starter, particularly up to 6 h of production, but it remained lower than the starter at 24 h of production, consistent with the work of Hamama et al. (2003). At such a low pH, casein micelles lose cohesion as highly mineralized entities, and the equilibrium between casein micelles and milk micelles breaks down. Proteins lose their ability to bind water, causing the cheese to lose moisture in the initial days and become hard and brittle (Hynes et al., 1999).

3.3.2 Sensory test

3.3.2.1 Triangular test

The two different "Jbens" exhibited significantly different external appearances (Table 2). The industrial starter contained homo-fermentative isolates (*Lactococcus*), while the laboratory fermentations contained both homo-fermentative (Lc95, Ed16) and hetero-fermentative (Leu109) isolates, resulting in distinct external appearances. Nevertheless, tasters perceived the taste of both kinds of cheese as almost identical.

3.3.2.2 Ranking test

The ranking test evaluated three criteria: consistency, aroma, acidity, and general appreciation of the cheese. Tasters appreciated both "Jbens," noting similar consistency and aroma for the two different products tested. Flavor compounds were attributed to *L. lactis* subsp. *lactis biovardiacetylactis* for the cheese produced by industrial fermentation and to the isolate belonging to the species *L. mesenteroides* for the cheese produced by laboratory fermentation. According to Bendimerad (2013), the Leu109 isolate produces diacetyl. Consistency in the cheeses obtained may be attributed to an excessively long maturing time, excessive coagulant, or highly proteolytic coagulants. Increasing the temperature enhances the activity of proteolytic enzymes. As the coagulant has a significant residual proteolytic effect during maturation, a high dosage could produce this proteolytic effect. The use of a high dosage could also result in this defect. Other common defects in soft cheeses are associated with spoilage microorganisms, emphasizing the need for proper hygiene measures. Spoilage organisms can originate from raw milk, surviving pasteurization. However, these microorganisms can proliferate during cheese ripening (De Angelis et al., 2004). Some spoilage microorganisms contribute positively to cheese ripening, enhancing typicality, flavor complexity, and product quality. Others may cause defects such as lack of flavor, parasitic flavors, undesirable openings, or the appearance of calcium lactate crystals (Reinheimer, 2022).

Table 2. Triangular test applied for visual appearance and taste of traditional "Jben" cheeses.

Theoretical μ (*df* = 31)= 1.64 at 5%, 2.33 at 1% and 2.81 at 1‰		
Character	**Observed μ**	**Conclusion**
Visual appearance (*n* = 32)	5.4	Very highly significant
Acidity	1.50	Not significant

After chi-square calculation (Table 3), it was determined that acidity was not significant but slightly noticeable; some judges favored the acidity of the cheese made with the laboratory starter. Hence, it was preferable to use a mixed culture of *L. lactis*, including subspecies *L. lactis* ssp. *cremoris, L. lactis* ssp. *lactis*, and *L. lactis* ssp. *lactis biovar diacetylactis*, akin to the industrial starter. In contrast, the laboratory starter, consisting of a mixed culture of Lactococci/*Leuconostoc*, resulted in a slightly more acidic flavor for the same final titratable acidity, likely due to citrate utilization by the *Leuconostoc* according to Bendimerad et al. (2012). The combination of *Leuconostoc* with Lactococci in starters fulfills the roles of acidification and flavor better than *Lactococcus* lactis alone for fermented butter (Vedamuthu, 1994).

The results of this study shed light on several key aspects of Jben cheese production using locally sourced and industrial starters. First, the microbiological analysis revealed that both cheeses complied with standards regarding aerobic mesophilic flora load and lacked pathogenic flora. However, notable differences were observed in terms of fecal coliform and total coliform counts, with the cheese made with the industrial starter exceeding permissible limits. This discrepancy underscores the importance of starter selection in cheese production and its implications for product safety and quality.

Furthermore, the physicochemical analysis highlighted differences in cheese yield, acidity, and fat content between cheeses produced with laboratory and industrial starters. While both cheeses exhibited consistent titratable acidity, the cheese made with the industrial starter had a higher yield and lower fat content compared to its counterpart. These findings suggest that starter type significantly influences cheese characteristics, potentially impacting consumer preferences and product acceptance.

The acidification kinetics of the starters revealed distinct patterns, with the laboratory starter exhibiting higher acid production rates attributed to specific microbial strains. This observation aligns with previous studies (El Marrakchi & Hamama, 1995; Hamama et al., 2003) and underscores the importance of understanding starter composition and metabolic activities in cheese production. Additionally, sensory evaluation demonstrated similarities in taste and aroma between cheeses, despite differences in external appearance attributed to starter composition.

Comparison with existing literature reveals both similarities and discrepancies in cheese characteristics and microbiological quality. While our findings align with studies on Moroccan Jben (El Marnissi et al., 2003; Hamama et al., 2003), differences in

Table 3. Comparison between two cheeses (JL made with the laboratory strains, and JI with industrial starter.

df = 15, theoretical chi square =25 (at 5%) and 30 (at 1%)				
Criteria	**n**	**k**	**Observed chi square**	**Conclusion**
Consistency	16	2	5.12	Not significant
Acidity	16	2	4.04	Not significant
Aroma	16	2	4.71	Not significant
Visual appearance	16	2	4.82	Not significant

microbial flora and acidity profiles highlight the influence of regional variations and production methods. Moreover, the identification of spoilage microorganisms underscores the importance of strict hygiene practices and quality control measures in cheese production.

4 CONCLUSION

Our study demonstrated the feasibility of using local LAB as starters for "Jben," a traditional Algerian cheese. The local LAB strains showcased their potential in curd formation, contributing to the unique characteristics of "Jben." Comparative analyses with an industrial starter revealed both cheeses met safety standards, and the use of local LAB proved viable for "Jben" production.

Preserving traditional cheeses is crucial for cultural diversity, and our findings highlight the value of leveraging local resources. The sensory evaluations affirmed that "Jben" produced with local LAB is comparable in taste and appreciation to industrially produced counterparts. This underscores the potential of using local starters to maintain the authenticity and cultural significance of traditional Algerian dairy products.

In essence, our study supports the adoption of indigenous LAB strains for sustainable and culturally rooted dairy practices. Integrating such approaches into local industries can contribute to preserving culinary heritage while meeting modern production demands in the Algerian dairy sector.

ACKNOWLEDGMENTS

We thank our professor Boumediene Moussa-Boudjemâa, the leader of the research team, for his close collaboration with the first author in refining the article, validating its subject matter, and enhancing the overall manuscript.

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