# Innovation aspects of Serdaleh, a traditional Lebanese cheese produced from raw extensive goat's milk

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# Innovation aspects of Serdaleh, a traditional Lebanese cheese produced from raw extensive goat's milk

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**Abstract.** Serdaleh is a traditional lactic goat cheese originated in mountainous areas of Lebanon. It is highly recommended for its unique taste and manufacturing technique using jars. Unfortunately, little information is available about this traditional product and its distinctive ripening method, which represents an obstacle for the protection of such authentic and original products. Our study aims to investigate the changes in microbial flora and chemical composition of Serdaleh cheese throughout ripening, and to optimize its manufacturing product by using innovative ripening materials. Serdaleh cheeses were manufactured from raw goat's milk and ripened in terracotta jars or plastic barrels to understand the effect of ripening material on the physico-chemical and microbiological properties of Serdaleh cheeses during 35 days of ripening.

Results showed that the chemical composition of Serdaleh cheese was significantly affected by the ripening period rather than the material used (jars or plastic barrels). Moisture and fat content decreased gradually due to regular whey drainage and fat removal throughout the production period. However, cheeses ripened in jars exhibited a higher moisture loss due to the porous structure of terracotta jars. Microbiological results showed that samples fall within the standards for *Salmonella* spp. and *Staphylococcus aureus*, whereas a high contamination with fecal coliforms was recorded in the samples produced in jars, which can pose a potential hazard to consumers. Our findings represent an opportunity for the Lebanese dairy sector, to adapt artisanal goat cheese production to the new demands of consumers, and ensure its sustainability, specificity and authenticity.

**Keywords.** Serdaleh – Goat cheese – Ripening material – Terracotta jars – Plastic barrels.

***Les aspects innovants dans la production du Serdaleh, un fromage de chèvre libanais***

***Résumé.*** *Serdaleh est un fromage lactique de chèvre, originaire des régions montagneuses au Liban. Il est fortement recommandé pour son goût unique et sa technique de fabrication dans des jarres en terre cuite. Malheureusement, il existe peu d'informations sur ce produit traditionnel et sa méthode d'affinage, ce qui représente un obstacle à la protection de ces produits authentiques de terroir. Notre étude vise à étudier les changements dans la flore microbienne et la composition chimique du fromage Serdaleh tout au long de l'affinage, et à optimiser sa production en utilisant des matériaux innovants pour son affinage. Le fromage Serdaleh a été fabriqué à partir du lait de chèvre et affiné dans des jarres en terre cuite ou des barils en plastique, afin de comprendre l'effet du matériau d'affinage sur les propriétés physico-chimiques et microbiologiques du fromage Serdaleh pendant 35 jours d'affinage.*

*Les résultats ont montré que la composition chimique du fromage Serdaleh était significativement influencée par la période d'affinage plutôt que par le matériau utilisé (jarres ou barils en plastique). La teneur en humidité et en matières grasses a diminué progressivement en raison du drainage régulier du lactosérum et de l'élimination de la couche superficielle de matières grasses tout au long de la période de production. Cependant, les fromages affinés dans les jarres en terre cuite ont montré une perte en eau plus accentuée en raison de la structure poreuse de ces dernières. Les résultats microbiologiques ont montré que les échantillons sont conformes aux normes concernant la présence de Salmonella spp. et Staphylococcus aureus, alors qu'une contamination élevée par des coliformes fécaux a été décelée dans les échantillons produits dans les jarres, ce qui cause un risque potentiel pour les consommateurs. Nos résultats représentent une opportunité pour le secteur laitier libanais, pour adapter la production artisanale du fromage de chèvre aux nouvelles demandes des consommateurs et en assurer la durabilité, la spécificité et l'authenticité.*

***Mots-clés.*** *Serdaleh – Fromage de chèvre – Matériau d'affinage – Jarres en terre cuite – Barils en plastique.*

# I – Introduction

Traditional dairy products have always been an important component of Lebanese diet; their production is fundamentally rooted in culinary heritage. Nevertheless, the future of these artisanal products is uncertain and needs considerable scientific efforts to save them from extinction, due to changes in lifestyle, consumer preferences and market challenges. Serdaleh is a traditional lactic goat cheese originated in mountainous areas of Lebanon, more specifically in Chouf region, where extensive farming is still practiced. It is also known as Ambarise or Labnet el-jarra in the Bekaa valley (Hajj Semaan *et al*., 2011). It is traditionally produced to preserve goat milk through the non-milking season for winter consumption. However, studies on Serdaleh cheese are very limited and little information is available about this traditional product, which represents an obstacle for the protection of such authentic products. Serhan and Mattar (2013) studied the physico-chemical and microbiological characteristics of Serdaleh produced in different regions. Serdaleh cheese is highly recommended for its distinctive taste and unique manufacturing technique using terracotta jars. The jars are filled with raw goat milk, and with time, whey will drain through the small hole in the bottom of each jar. Goat milk and salt is added every 7 to 15 days, depending on weather conditions until the jar is completely full and entirely dry. (Hajj Semaan *et al*., 2011; Massaad, 2010).

Recently, some Serdaleh producers are substituting terracotta jars with plastic barrels for economic and practical reasons. However, the effect of using different ripening materials (jars or plastic barrels) on the properties of Serdaleh cheese has not been studied. Consequently, the aim of this research is to study the evolution of physicochemical and microbiological properties of Serdaleh cheese during ripening period, and to investigate the effect of ripening material on these characteristics.

# II – Material and methods

## 1. Serdaleh production

In this study, Serdaleh cheese samples were produced according to a traditional method (Figure 1), using terracotta jars (cheeses J1 and J2) and plastic barrels (cheeses P1 and P2). Terracotta jars were obtained from local producers. The first step is to put raw and salted goat milk in jars and barrels. Coagulation is obtained within 15 days. Two weeks later, the whey is drained through the hole present at the base of the jar (or the barrel). The moldy surface layer is removed, followed by addition of raw goat milk and salt to assist the coagulation of fermented milk. Removal of whey and addition of raw goat milk and salt is done every two weeks. The coagulum is then collected, put in canvas bags to dry for 24 hours. Cheese making was performed in duplicate, and the cheese samples were analyzed during ripening period (Day 6, 20 and 35).

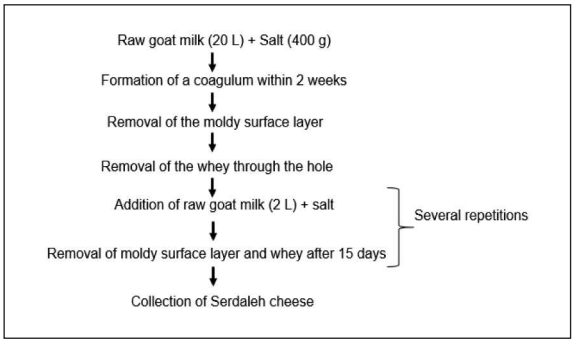


**Fig. 1. Flow diagram of Serdaleh production.**

## 2. Chemical analysis

Cheese composition was determined according to AOAC standard methods . Moisture content was calculated by heating 3 g of each sample to a constant weight in an oven maintained at 105 °C. The pH values of cheeses were measured, by homogenizing 10 g of cheese and 10 ml of distilled water, with a pH meter (SI Analytics GmbH, Mainz, Germany). Protein was determined by the Kjeldahl method with a conversion factor of 6.38. For determination of ash, 3 g of each sample were ashed at 550°C in a furnace until constant weight. Fat was obtained by extracting 5 g of each sample in a Soxhlet apparatus using petroleum ether as the extractant.

## 3. Microbiological analyses

Cheese samples (10 g) were diluted in 90 mL peptone water solution and homogenized in a sterile polyethylene bag using a stomacher 400 circulator lab blender (Thomas Scientific, Swedesboro, USA). Further tenfold serial dilutions ranging from $10^{-2}$ to $10^{-6}$ were prepared, and 0.1 mL from the different dilutions were plated onto selective media for enumeration of isolates. All samples were evaluated for total aerobic bacteria (Nutrient Agar at 37 °C for 48 h), fecal coliforms (MacConkey Sorbitol Agar at 37 °C for 48 h), *Staphylococcus aureus* (Mannitol Salt Agar at 37 °C for 36 h), Salmonella spp. (Salmonella Shigella Agar at 37C for 24h), thermophilic cocci (M17 agar at 42 °C for 48 h) and thermophilic *Lactobacillus* (MRS agar at 42 °C for 48 h), respecting the suitable medium and incubation temperatures. All media were purchased from Scharlab S.L. (Barcelona, Spain). Counts were carried out in triplicate.

## 4. Statistical analysis

Data is tested using the SPSS software (version 16.0). Statistical analysis of the results is based on one-way analysis of variance and t-test. Statistically significant differences are considered at the level of $p<0.05$.

# II – Results and discussion

## 1. Chemical analysis

The changes in chemical composition and pH values of Serdaleh cheeses during ripening are given in Table 1. The initial pH ranged between 4.33 and 4.65, then it decreased significantly during the first 20 d of ripening, in both types of cheese, owing to the production of organic acids by lactic acid bacteria. Moisture contents of all cheeses decreased gradually during ripening period due to regular drainage through the hole, and evaporation of water from the surface of cheese (Arslaner and Bakırcı, 2016). However, moisture loss was observed at higher level in jars because of their porous structure. Similar results were reported by Hayaloglu et al. (2007) where ripening in tulums (goatskin bag) caused more moisture loss than plastic barrels. The ripening material didn't significantly affect protein and fat contents. Nevertheless, protein levels increased significantly throughout the ripening period in all cheese samples, due to the regular addition of milk and to the moisture loss during 35 days. Initial fat levels varied between 13.24 and 14.85; but these values decreased significantly during ripening, due to the repeated elimination of the moldy surface of the coagulum. In fact, the fat tends to float on the upper layer in the barrel or jar. Thus, the removal of the moldy surface layer will induce indirect skimming (Hajj Semaan *et al.,* 2011; Serhan and Mattar, 2013).

**Table 1. Chemical composition and pH of Serdaleh cheeses ripened in terracotta jars (J) or plastic barrels (P) during 35 days of ripening**

| Variable | Days | Cheese | | | |
|---|---|---|---|---|---|
| | | J1 | J2 | P1 | P2 |
| pH | J6 | 4.33 ± 0.15$^{a,B}$ | 4.44 ± 0.31$^{a,B}$ | 4.77 ± 0.2$^{a,B}$ | 4.65 ± 0.13$^{a,B}$ |
| | J20 | 3.84 ± 0.26$^{a,A}$ | 3.96 ± 0.19$^{a,A}$ | 3.65 ± 0.13$^{a,A}$ | 3.72 ± 0.12$^{a,A}$ |
| | J3 | 53.78 ± 0.09$^{a,A}$ | 3.82 ± 0.12$^{a,A}$ | 3.63 ± 0.35$^{a,A}$ | 3.64 ± 0.27$^{a,A}$ |
| Moisture (%) | J6 | 65.07 ± 0.22$^{a,B}$ | 64.94 ± 0.26$^{a,B}$ | 66.64 ± 0.21$^{a,B}$ | 66.82 ± 0.26$^{a,B}$ |
| | J20 | 61.58 ± 0.19$^{a,A}$ | 61.15 ± 0.22$^{a,A}$ | 64.55 ± 0.15$^{b,B}$ | 64.76 ± 0.19$^{b,B}$ |
| | J3 | 557.64 ± 0.25$^{a,A}$ | 57.97 ± 0.2$^{a,A}$ | 60.49 ± 0.17$^{a,A}$ | 60.48 ± 0.25$^{a,A}$ |
| Ash (%) | J6 | 3.27 ± 0.35$^{a,A}$ | 3.34 ± 0.39$^{a,A}$ | 3.93 ± 0.08$^{a,A}$ | 4.05 ± 0.11$^{a,A}$ |
| | J2 | 04.78 ± 0.28$^{a,B}$ | 4.74 ± 0.25$^{a,B}$ | 5.51 ± 0.19$^{a,B}$ | 5.65 ± 0.21$^{a,B}$ |
| | J3 | 54.24 ± 0.31$^{a,B}$ | 4.28 ± 0.24$^{a,B}$ | 5.28 ± 0.08$^{a,B}$ | 5.35 ± 0.09$^{a,B}$ |
| Protein (%) | J6 | 7.55 ± 0.25$^{a,A}$ | 7.66 ± 0.36$^{a,A}$ | 6.75 ± 0.35$^{a,A}$ | 7.2 ± 0.38$^{a,A}$ |
| | J2 | 09.73 ± 0.19$^{a,B}$ | 10.04 ± 0.42$^{a,B}$ | 12.13 ± 0.29$^{a,B}$ | 12.25 ± 0.25$^{a,B}$ |
| | J35 | 13.24 ± 0.1$^{a,C}$ | 13.38 ± 0.34$^{a,C}$ | 14.72 ± 0.19$^{a,C}$ | 14.85 ± 0.18$^{a,C}$ |
| Fat (%) | J6 | 5.64 ± 0.26$^{a,C}$ | 5.5 ± 0.17$^{a,C}$ | 5.92 ± 0.28$^{a,C}$ | 5.84 ± 0.31$^{a,C}$ |
| | J2 | 04.8 ± 0.34$^{a,B}$ | 4.92 ± 0.22$^{a,B}$ | 4.6 ± 0.39$^{a,B}$ | 4.54 ± 0.37$^{a,B}$ |
| | J35 | 4.2 ± 0.17$^{a,A}$ | 4.35 ± 0.19$^{a,A}$ | 4.02 ± 0.15$^{a,A}$ | 3.9 ± 0.18$^{a,A}$ |

Different letters (A, B) within the column across the table show significant differences at $p<0.05$.

Different letters (a, b) within the row across the table show significant differences at $p<0.05$.

P: Serdaleh ripened in plastic; J: Serdaleh ripened in terracotta jars.

## 2. Microbiological analyses

The counts of different microbial groups investigated during ripening of Serdaleh cheese, in terracotta jars (J1 and J2) or plastic barrels (P1 and P2), are presented in Table 2. At the beginning of the ripening, initial counts of total aerobic bacteria ranged between 6.63 and 7.08 $\log_{10}$ CFU/g, then they decreased significantly in the following 35 days. A similar trend was reported by Hayaloglu *et al.* (2007) on Tulum cheese, and by Jahromi and Jalali (2012) on Iranian jar cheese. This reduction of microbial counts can be attributed to the increase in salt and acid content, and decrease in moisture content during ripening period. None of the cheese samples contained Salmonella spp. or Staphylococcus aureus. As for the presence of fecal coliforms, Serdaleh samples produced in jars showed an unacceptable amount (approximatively 4.5 $\log_{10}$ CFU/g) indicating that contamination occurred throughout the ripening. This might be related to an initial contamination of terracotta jars or workplace prior to Serdaleh production. High coliform numbers are common in raw goat's milk cheeses (El Galiou *et al.*, 2015), and represent a great concern for the dairy industry because of their technological and public health significance.

The highest counts of thermophilic lactic acid bacteria (LAB) were observed at the beginning of ripening, then they decreased significantly during 35 days. The growth of LAB exhibited a similar trend after 1 month of ripening for many Mediterranean cheeses such as Feta (Manolopoulou *et al*., 2003), Tulum (Hayaloglu *et al*., 2007), and Halloumi (Milci *et al*., 2005). Nevertheless, cheese samples ripened in jars exhibited higher numbers of thermophilic LAB than those ripened in goatskin bags after 20 days of ripening. These differences may be related to the porous structure of jars that preserves higher microbial counts.

**Table 2. Changes in microbial counts (Log CFU/g) during ripening of Serdaleh cheeses ripened in plastic barrels or terracotta jars**

| Variable | Days | Cheese | | | |
|---|---|---|---|---|---|
| | | J1 | J2 | P1 | P2 |
| Total aerobic bacteria | D6 | $6.63 \pm 0.38^{a,B}$ | $6.87 \pm 0.31^{a,B}$ | $7.08 \pm 0.22^{a,B}$ | $6.92 \pm 0.15^{a,B}$ |
| | D20 | $6.24 \pm 0.28^{a,B}$ | $6.34 \pm 0.23^{a,B}$ | $6.66 \pm 0.34^{a,B}$ | $6.78 \pm 0.27^{a,B}$ |
| | D35 | $5.64 \pm 0.42^{a,A}$ | $5.73 \pm 0.45^{a,A}$ | $4.65 \pm 0.12^{a,A}$ | $4.79 \pm 0.08^{a,A}$ |
| Fecal coliforms | D6 | $4.5 \pm 0.22^{A}$ | $4.7 \pm 0.15^{A}$ | – | – |
| | D20 | $4.49 \pm 0.31^{A}$ | $4.55 \pm 0.26^{A}$ | – | – |
| | D35 | $4.38 \pm 0.41^{A}$ | $4.58 \pm 0.32^{A}$ | – | – |
| *Staphylococcus aureus* | D6 | – | – | – | – |
| | D20 | – | – | – | – |
| | D35 | – | – | – | – |
| *Salmonella* spp. | D6 | – | – | – | – |
| | D20 | – | – | – | – |
| | D35 | – | – | – | – |
| Thermophilic cocci | D6 | $7.07 \pm 0.18^{a,B}$ | $6.99 \pm 0.29^{a,B}$ | $6.9 \pm 0.26^{a,B}$ | $7 \pm 0.33^{a,B}$ |
| | D20 | $6.71 \pm 0.25^{b,B}$ | $6.75 \pm 0.35^{b,B}$ | $4.67 \pm 0.09^{a,A}$ | $4.74 \pm 0.13^{a,A}$ |
| | D35 | $5.47 \pm 0.32^{b,A}$ | $5.66 \pm 0.45^{b,A}$ | $4.4 \pm 0.36^{a,A}$ | $4.34 \pm 0.3^{a,A}$ |
| Thermophilic *Lactobacillus* | D6 | $6.81 \pm 0.34^{a,B}$ | $6.79 \pm 0.29^{a,B}$ | $7.18 \pm 0.28^{a,B}$ | $7.25 \pm 0.21^{a,B}$ |
| | D20 | $6.41 \pm 0.19^{b,B}$ | $6.65 \pm 0.26^{b,B}$ | $4.29 \pm 0.42^{a,A}$ | $4.43 \pm 0.4a^{,A}$ |
| | D35 | $5.48 \pm 0.26^{b,A}$ | $5.59 \pm 0.28^{b,A}$ | $4.19 \pm 0.08^{a,A}$ | $4.22 \pm 0.12^{a,A}$ |

Different letters (A, B) within the column across the table show significant differences at $p<0.05$.

Different letters (a, b) within the row across the table show significant differences at $p<0.05$.

P: Serdaleh ripened in plastic; J: Serdaleh ripened in terracotta jars.

## IV – Conclusion

In order to preserve an endangered traditional Lebanese goat cheese and increase its competitiveness, our research aims to assess the effect of ripening material (plastic barrels and terracotta jars) on the physico-chemical and microbiological properties of Serdaleh cheeses during 35 days of ripening. This study is the first approach in Lebanon to investigate the influence of ripening container on Serdaleh cheese.

No significant differences were recorded among Serdaleh samples produced in jars or plastic barrels, except for moisture content. However, the results revealed high contamination with fecal coliforms in Serdaleh produced in jars, which can pose a potential hazard to consumers. Therefore, it is crucial to optimize the manufacturing process using an alternative ripening material, in order to obtain a uniform and safe product. However, the distinctive flavor and local characteristics of Serdaleh cheese must be considered, to avoid losing the product's specificity and authenticity. Thus, further studies are essential to assess the effect of using plastic barrels on the sensory properties and volatile compounds of Serdaleh cheese, in order to maintain Serdaleh peculiarities, while improving its sanitary quality.

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