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# Experimental Studies on the Siirt Herby Tulum Cheese: II. Evaluation of a New Industrial Process Model

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## Abstract

This study was conducted to test a process that we had previously developed in parallel to the traditional Siirt Herby Cheese production method. Both raw and pasteurized Eve's milk were used parallelly in the study. Pasteurized milk was inoculated with an autochthonous starter culture which we have developed. After clot formation, breaking the clot, straining and acidification of curd by using acid whey, first pressing, adding herb and salt, and applying the second pressing stages were followed. Then, the cheese samples were packaged. No air gap was presented in the cheese containers. The entire production was completed within 24 hours. During the 120-d ripening period of the samples at 4 °C, pH was observed to be 5 and acidity was 0.7% (lactic acid). In raw milk cheese, pH was 6.8 and acidity was 1.12% at the end of the ripening period. It was determined that the method tested in this study was not recommendable for making raw milk cheese. The pasteurized milk cheese samples had at least 0.7 acidity, 5 pH, 20% fat and 20% protein; It was observed that at least 45% dry matter values could be obtained. However, the pasteurized milk cheese samples did not fully meet our expectations. The crumbling property of the cheese samples was not ideal just seen in the tradiditonal Tulum Cheeses of Türkiye. The slightly sticky and melted appearance was considered a negative property of the cheese and should be eliminated with more detailed work. Traditional production takes at least 10 d. This period may be long for industrial production. Raw milk is used in traditional production, and excessive salt is added to the cheese for hygiene purposes. Also, it is not easy to make a standard production. More research is needed to eliminate such negativities, and to recommend a valuable industrial process.
Key words: Siirt Herby Tulum Cheese, process, ripening, hygiene, chemical, composition.

## Introduction

Approximately 770.000 tons of cheese are produced annually in Türkiye (1). Among Türkiye's cheeses, White pickled cheese, Kashar cheese and Tulum Cheese are the most produced cheeses (2). It has been reported that Türkiye has very rich resources in terms of local cheese varieties (3). Many local cheese varieties of Türkiye have been backed with Protected Designation of Origin (PDO) (4-9). Some of these cheeses contain herbs and are called erby (otlu in Turkish) cheeses. Apart from Van herby cheese, there are some other herby cheese varieties of Türkiye such as Urfa, Siirt, Erzincan and Trabzon herby cheeses and Hatay Carra (testi) and Sürk cheeses. The most produced one of the herby cheeses in Türkiye is Van herby cheese (10). In the Turkish Food Codex Communique on Cheese, legislative regulations on the cheese varieties have been documented (11).

Most of the local cheeses produced in Türkiye are derived from fresh cheese obtained through the processes of cloth filtering the milk mostly obtained from sheep and goats in the plateaus. The milk is used as its raw form of the milk-

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ing. Nevertheless, as mentioned in the Cheese Regulation, raw milk is not allowed for making brine-ripened or Tulum-type cheeses11. Raw milk, if it is obtained from disease free farms can only be used for making cheese (11-12). Thus, use of pasteurized milk in the cheese-making process is especially important for the industry.

Environmental factors such as the quality of raw milk used in making cheese, the hygiene of personnel and materials used, the temperature of the production area and light intensity affect the quality of the cheese produced (13). The traditional experiences are used instead of standard methods in the production of traditional cheeses (4-9). In this case, the cheeses produced have been stated to be un-hygienic or different compositional constituents (13-28). Although many studies have been conducted on traditional cheeses, in most of these studies, the use of raw milk was preferred, as in traditional methods. Since other factors affecting the quality of cheese are not standardized in research, the properties of experimental cheeses produced vary (29-36). Therefore, it is very difficult to make comparisons between previously made studies. In some scientific studies, efforts have been made to develop processes using pasteurized and standardized milk to facilitate the industrial production of such cheeses (37-38). Among the herby cheeses, Van Herby cheese is produced from pasteurized milk by the cheese industry in Türkiye (31). Siirt Herby Tulum Cheese is produced only from raw Eve's milk or a combination of Eve's and Goat's milk by using traditional methods in its local geographic area (21-26). Developing an industrial production model of Siirt herb cheese can contribute to the economy.

More than 60 wild plant species from nine different plant families have been stated to used in Van Herby cheese. The most used plant species for the cheese production have been stated to be *Ferula sp*. (Siyabo), *Allium sp*. (Sirmo), *Chaerophyllum sp*. (Mendo), *Heracleaum sp*. (Sov), *Thymus sp*. (Kekik), *Prangos sp*. (Heliz) and *Zizophora* sp. (Catır) (49). Herbs that are required to be used in the Van Herby cheese PDO; *Allium schoenoprasum* L. (Sirmo/Sirik leaf and stem), *Anhriscus nemorosa* (Mendo, Leaf and Stem), *Ferula Orientalis* L. (Heliz, Leaf and Stem), *Mentha Spicata* (Wild mint, leaf), *Thymus Migricus* (Thyme, leaf). Apart from these herbs, the use of 13 herbs is also allowed in the PDO (5). In Siirt Herby cheese, many herbs are stated to be used (50). Nevertheless, Sirmo varieties are mostly used in the cheese production (21-26).

Such as White pickled cheeses and brine ripened cheeses, Tulum Cheeses of Türkiye are also semi-hard cheeses (11). Van Herby cheese is a semi-hard cheese and its' non-fat dry matter content (%) have to be between 57 and 64 (5). Siirt Herby cheese has also been reported to have semi-hard cheese characteristics (21-26). Van Herby Cheese has two different characteristics in its registration certificate that the production methods have been explained. One of them is raw milk cheese. These include breaking the curd, dry salting, keeping it under pressure for 3-4 days and pressing the cheese moulds together with the jaji (cacık in Turkish) tightly into the packaging. The production period takes at least 5 d. The other type is brine ripened Van Herby Cheese. Siirt Herby Cheese don not resemble to brine ripened or jaji added types of Van Herby Cheese (21-26). In the Siirt Herby Tulum Cheese, jaji is not used. The previously prepared herbs are added to the curd before drainage of the whey by application of pressing. After the pressing, the curd is sliced and dry salted. The dry salted slices are maintained 3-5 d for acidification and excess whey release from the cheese. Then, dry salted cheese slices are crumbled and pressed into plastic or ceramic containers in such a way that there is no air gap inside. Cheeses are consumed after a 1-3 month ripening period. Traditional Siirt Herby Tulum Cheese is produced from raw Eve's milk in the spring and summer seasons. The production period of the cheese takes minimum five d. In scientific studies conducted to date, cheese has been made using traditional methods, and it has been reported that no studies have been conducted on process development suitable for any industry (33, 36, 43-49).

It would be beneficial to develop the traditional production of Siirt Herby Tulum Cheese towards an industrial production model. Developing a product with brand value and quality that can be marketed in a widespread sales network is only possible by standardizing the production. To our knowledge, no industrial process development study for herby tulum cheeses has been conducted yet. Only one study has been conducted on the use of pasteurized Eve's milk in the production model in comparison with the use of raw milk (37). In this study, a newly designed production model was evaluated in terms of its suitability for the industrial production process of Siirt Herby Tulum Cheese. Cheese making process was evaluated by physical, chemicall and microbiological differences between the raw and pasteurized milk cheeses during a 12 d of ripening period.

## Material and Methods

### Material

Raw milk: Eve's milk was readily filtered through a clot after milking, and brought to the laboratory from a sheep farm in one village of Siirt within 1 h.

**Coagulant:** A commercial microbial coagulant (Yayla Rennet, Tuzla Istanbul) was purchased from sales points and brought to the laboratory.

**Starter culture:** An autochthonous lactic acid bacteria culture was prepared from the culture of traditional Siirt Herby Cheese samples taken from retail markets in Siirt and used in the study as starter cultures. Briefly, 10 g samples from each of the three cheese samples were mixed. Then, ten-fold serial dilutions in physiological saline solution (PS, 0.8% salt) were made by using the mixed cheese sample. The De Man Rogosa Sharpe Agar (MRS agar, Oxoid, CM1153) and M17 (Oxoid, CM0785) agar plates were inoculated by using the serial dilutions. After incubations at 37 oC for 48 h, all the growing colonies were harvested from the plate surfaces by washing the agar surfaces using PS. The pH of the harvested flora in PS was reduced 4 using lactic acid, for 24 h to ensure that acid-resistant ones remained alive. This culture was inoculated to pasteurized Eve's milk at a rate of 3%, and the milk was fermented by keeping it at 37°C until its pH reached to 4. The process mentioned above was repeated 3 consecutive times. The third soured milk was used as a starter culture in the study by adding it at a rate of 3% to the pasteurized milk at 32°C (51, 52).

**Sour whey:** Whey was obtained from prevailing studies of this study. The fresh whey was pasteurized at 72°C for 1 min and cooled to 37°C. The starter culture defined above was added to the pasteurized whey at a rate of 3% and incubated at 37°C until the pH reached 4 and the acidity reached 1.2% lactic acid. Sour whey was used in curd processing (53).

**Press material:** Water-filled containers with adjusted weights were used as press materials. After the curd in the press clot was placed on a hard surface, weights were placed on it and pressed for 90 min.
Salt: Rock salt, which was harvested in the region and used in cheese making, was used in cheese making. The cheese was salted before adding the herb.

Herb (*Allium sp*., sirmo, sirik): Herbs collected from the plateaus by citizens and sold in the market in the Siirt city center were used. After the herbs were sorted and washed with drinking water, they were chopped to approximately 5 mm in size, and then added to the curd samples.

Cheese curd: Eve's milk was pasteurized at 72°C for 1 min, coagulant strength was calculated, fermented at 32°C for 90 min, and the clot was cut into 1x1x1 cm size. After cutting the clot, it was waited for 45 minutes for syneresis. Then, the clot was transferred to filter cloth for whey's self-drainage in 15 min. The self-drained curd was used as materials for cheese making in the 6 consecutive trials reported below. In each trial, acidity, pH, dry matter, fat, salt (in trials where salt was used) and cheese yield analyses (milk/cheese, %) were made.

## Methods

Cheesemaking: The milk was pasteurized at 72˚C for 1 min, cooled to 37°C and 3% starter culture was added. The milk was waited for 30 min, then coagulated at 32˚C for 90 min. The clot was cut into 1x1x1 cm sizes, then maintained for 30 min and left to drain spontaneously for 15 min in the cotton bag. The first press was applied by using a weight at half the weight of the milk for 90 min. Then, the curd was cut into pieces (approximately 1 cm cubes), and sour whey at 37˚C was added on at an amount equal to the curd. The curd kept in sour whey was waited for 30 min, and then left to drain spontaneously for 15 min. After the first press, the curd was broken into chickpea-size pieces and the herb and salt were kindly mixed in by hand. For more drainage of the whey, the curd in the cotton bag was pressed secondly by using the press with half the weight of the milk for 12 h. The control samples were prepared in the same manner as the pasteurized cheese samples mentioned above. Nevertheless, the milk did not make pasteurized.

**Analyses**

Coagulant activity analysis: Coagulant (Yayla Rennet, Tuzla Istanbul) was diluted 1/10. A 10 ml of raw milk was heated to 35˚C. A 1 ml of coagulant solution was added to the milk and the timer was started at the same time. Milk was controlled by stirring with a glass drumstick. The timer was stopped as soon as grains of curd were seen in the baguette. This process was repeated 3 times and the average was taken. Coagulant strength was calculated according to the following formula54. Coagulant strength calculation = (2400 X S) / Z.

Physical and chemical analyses of raw milk and cheese samples: Some analyses of milk were performed using a milk auto-analyzer (Lactoscan LS, Nova Zagora, Bulgaria). The pH measurement was performed using a handheld pH meter (Milwaukee AZ 8685, Taiwan). Acidity determination was made by titrimetric method and the results are expressed as % lactic acids (55). Fat analysis was performed using a milk butyrometer according to the Van Gulik method (TS ISO 3433) (56). The dry matter was determined gravimetrically according to TS EN ISO 5534/AC (57). Salt was determined by titration according to TS EN ISO 5943;

2007 (58). The ash (%, w/w) was measured gravimetrically from each cheese sample (59).

Microbiological analyses of milk and cheese samples: For microbiological analysis, reference methods were followed (60). Briefly, 10 ml from each milk sample or 10 g from each cheese sample was used for making ten-fold serial dilutions in 90 ml of sterile PS. For count of total mesophilic aerobes, Plate Count Agar (PCA, Oxoid CM 0463) was used and the petri dishes were incubated at 30±2°C for 72 h (61). For coliforms, Violet Red Bile Lactose Agar (VRBLA, Oxoid CM0107) was used and the petri plates were incubated at 37 °C for 24 h. The growing pink-red colonies with a pink precipitation ring around counted (62). For counts of faecal coliforms, E.C Broth (Oxoid CM0853) tubes were used. The tubes were inoculated according to the standard EMS method were first incubated at 35°C for 3 hours and then at 44.5°C for 21 hours. Calculations were made by using Standard EMS Table according to the number of tubes with gas formation (63). For Coagulase positive staphylococci, Baird Parker Agar plates including Baird Parker Agar Base (BPA, Oxoid CM1127) and Egg Yolk Tellurite Emulsion (Oxoid SR0054) were used. The plates were incubated at 37°C for 48 h. Black shiny coagulase positive colonies with a diameter of 1.5- 2.5 mm with a transparent zone around were counted. Then, 5 susceptive colonies selected randomly for each sample were tested for their Coagulase reaction before calculation of cfu/g values (64). For yeasts and moulds, Yeast Extract Glucose Chloramphenicol Agar (YGCA, Merck 1.16000) was used and the petri plates were incubated at 25°C for 5 d. Colonies grown on the agar plates were counted (65). The MRS agar (Oxoid, CM1153) for Lactobacilli and M17 Agar (Oxoid, CM0785) for Lactococci were used for colony counts (60). One-way analysis of variance (ANOVA) followed by a Duncan test was done to verify differences between means using IBM SPSS Statistics 28 (IBM Corporation, Somers, NY, USA Differences were considered significant at the probability level $p < 0.05$.

Table 1. The values obtained as a result of the microbiological analyses of raw milk.

| | pH | Acidity (%, Lactic acid) | Dry matter (%, w/w) | Protein (%, w/w) | Fat (%, w/w) | Laktose (%, w/w) | Minerals (%, w/w) | Density (%, w/w) | Frrezing point (°C) | Conductivity (Ω cm⁻¹) | Cheese yield (milk/cheese, %, w/w) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Raw milk | 6,9 ±0,2 | 0,3 ±0,05 | 16,0 ±0,1 | 4, 1 ±0,1 | 5,9 ±0,2 | 4,5 ±0,1 | 0,7 ±0,1 | 0,28 ±0,01 | -0,6 ±0,03 | 4,8 ±0,04 | ND |

## Results

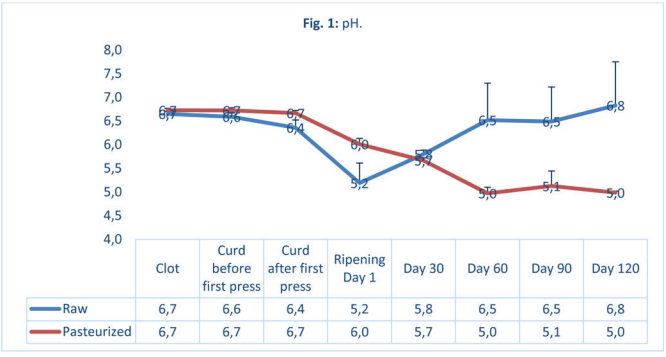
The analysis results of the clot samples obtained from raw Eve's milk are given in Table 1. It was found that the self-drained clot weight was 53.8% of the processed milk volume. It was understood that 46.2% of the milk was separated from clot as whey. While the acidity of raw milk was 0.32%, the acidity of the self-drained clot was 0.08%. While the pH was 6.69 in raw milk, it was measured as 6.67 in the clot.

The values obtained as a result of the microbiological analyses of raw milk are given in Table 2. It was observed that pasteurization made a significant decrease in microorganism loads. The pasteurization process made milk hygienic by causing significant reductions in the number of coliforms, faecal coliforms and coagulase-positive staphylococci. However, along with a decrease in the numbers of lactobacilli and lactic streptococci, it was observed that members of the natural lactic acid bacterial flora remained alive at an average level of 2 log cfu/ml (Table 2).

Table 2. The counts of microorganism in raw milk and milk pasteurized at 72°C for 1 min (log cfu/ml

| | Total mesophilic aerobes | Enterobacteriaceae | Coliforms | Faecal coliforms | Coagulase positive staphylococci | Yeasts and moulds | Lactobacilli | Lactococci |
|---|---|---|---|---|---|---|---|---|
| Raw milk | 5,5±0,2 | 4,5±0,4 | 3,7±0,3 | 1,12±0,2 | 3,6±0,3 | 5,1±0,2 | 5,1±0,5 | 5,2±0,5 |
| Pasteurized milk | 2,9±0,1 | 1,1±0,1 | 0,4±0,1 | <1 | <1 | 1,1±0,1 | 2,1±0,3 | 1,8±0,2 |

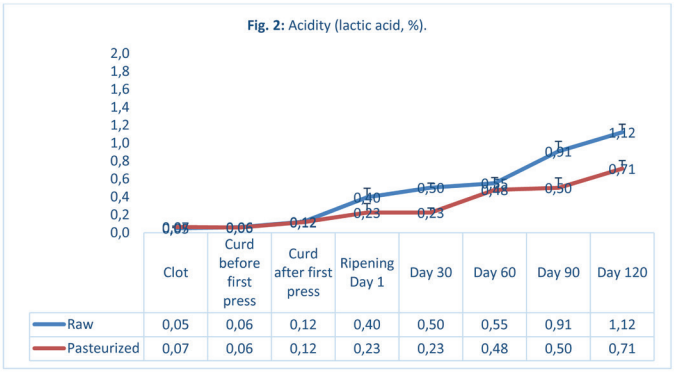
The results of the physical and chemical analyzes performed during the production and ripening stages are given in Fig. 1.




Figures 1. The pH values of samples of Siirt Herby Tulum Cheese made with raw and pasteurized Eve's milk.

The pH values are given in Fig. 1. While the initial pH values are similar in both samples, the difference that occurs in the following d is remarkable. In the PMC samples, on the 1st d of ripening, pH was 5.2 in the RMC samples, while it was 6.0 in the PMC samples. During the ripening period, pH gradually increased in the RMC samples, reaching 6.5 on the 60th d and 6.8 on the 120th d. In the PMC samples,

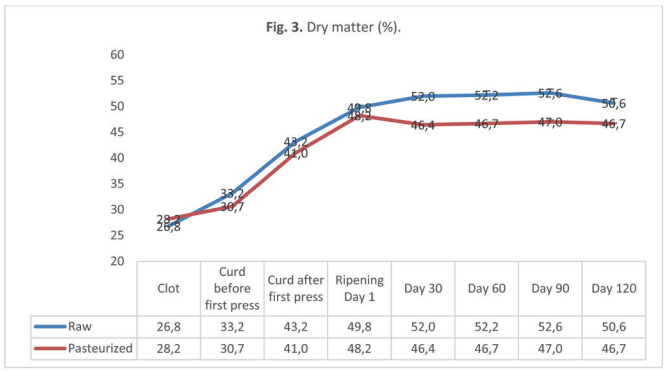
on the contrary, it decreased until the 60th d and reached 5.0, and remained at the same level until the 120th d.



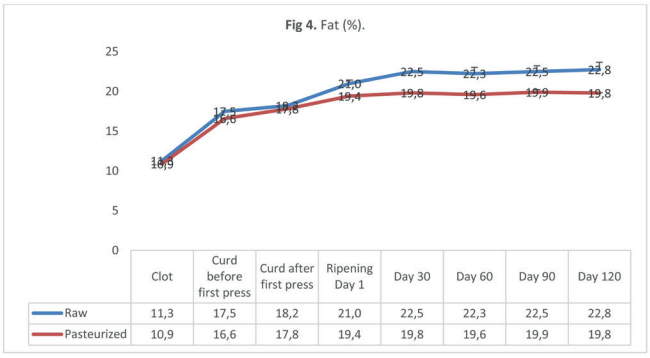

Figures 2. The acidity (lactic acid, %) values of samples of Siirt Herby Tulum Cheese made with raw and pasteurized Eve's milk.

Acidity values are given in Fig. 2. While the initial acidity values were similar in both samples, increases were observed in both samples from the first d of ripening. RMC samples were consistently found to be more acidic. The acidity of RMC and PMC samples were measured to be 0.91 and 0.48 % (as lactic acid) on the 90th d of ripening. Also, the acidity were measured as 1.12 and 0.71, respectively, on the 120th d.

Figures 3. The dry matter (%) values of samples of Siirt Herby Tulum Cheese made with raw and pasteurized Eve's milk.

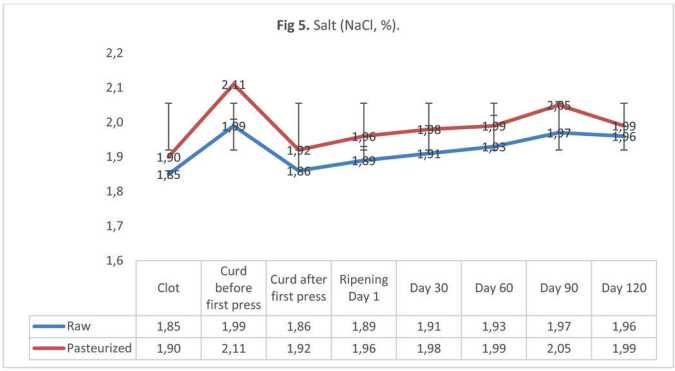



Dry matter values are given in Fig. 3. In terms of dry matter levels, no statistical difference could be detected between the two samples in the production stage until the first d of ripening. However, during the ripening period, the dry matter increase in the RMC samples was higher than PMC samples. On the 120th d of ripening, dry matter was determined as 50.6% in the RMC samples and 46.7% in the PMC samples. The dry matter difference between both samples was 3.9%. This difference was found to be statistically significant ($p<0.05$).



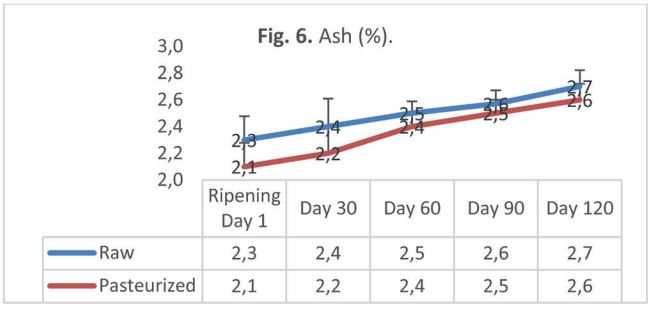

Figures 4. The fat (%) values of samples of Siirt Herby Tulum Cheese made with raw and pasteurized Eve's milk.

Fat level values are given in Fig. 4. In terms of fat levels, no statistically significant difference could be detected between the two samples in the production stage until after the first press. However, during the maturation period, the fat increase in RMC samples was higher than PMC samples. On the 120th d of ripening, fat was found to be 22.8% in Raw samples and 19.8% in PMC samples. The fat difference between both samples was 3%. This difference was found to be statistically significant ($p<0.05$).




Figures 5. The salt (NaCl, %) values of samples of Siirt Herby Tulum Cheese made with raw and pasteurized Eve's milk.

Salt values are given in Fig. 5. Salt levels were always found to be high in Raw samples. In both samples, the salt level was around 2%. The second press process applied after the first press caused a decrease in the salt level. No statistical difference was found in terms of salt levels between the two samples.




Figures 6. The ash (%) values of samples of Siirt Herby Tulum Cheese made with raw and pasteurized Eve's milk.

Ash values are given in Fig. 6. Ash levels were always found to be high in RMC samples. In both samples, the ash level was around 2.6%. The ash level increased in both samples during the maturation period applied after the first pressing. The ash levels in the RMC and PMC samples, respectively, were 2.3% and 2.1% on the first d, and became 2.7% and 2.6% on the 120th d. No statistical difference was found in terms of salt levels between the two samples.

The RMC and PMC were packaged in plastic sample containers with lids and stored in the cold. Microbiological count (log cfu/g) was performed on d 1, 30, 60, 90 and 120 of ripening. The microbiological values are given in Fig. 4.

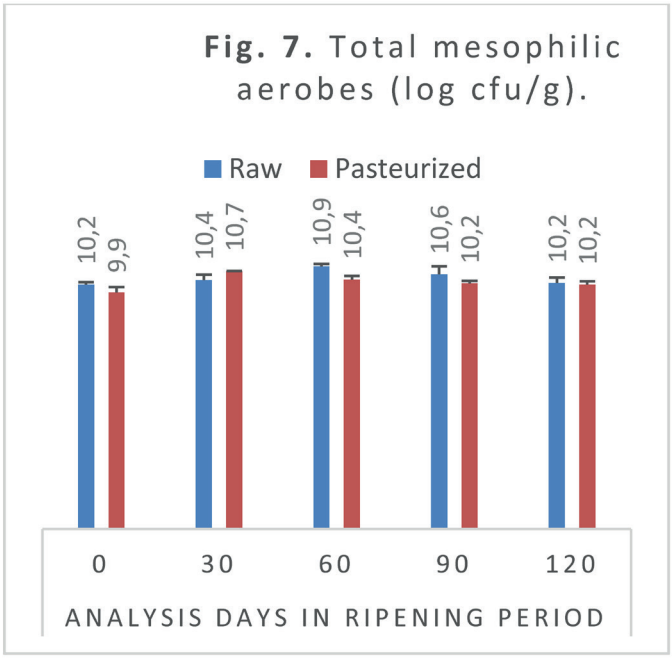



Fig. 7. The counts of total mesophilic aerobes of Siirt Herby Tulum Cheese made with raw and pasteurized Eve's milk (log cfu/g).

Total mesophilic aerobic bacteria (TMAB) numbers were found to be approximately similar in RMC and PMC (Fig. 7). Because, along with the original microflora of raw milk, there is also the flora from the starter culture. There was no statistically significant increase in the number of flora during the ripening period.

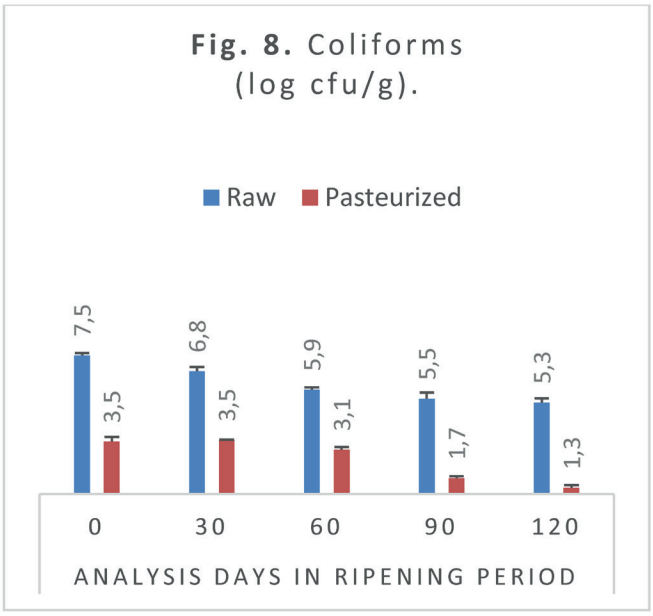



Fig. 8. The counts of coliforms of Siirt Herby Tulum Cheese made with raw and pasteurized Eve's milk (log cfu/g).

Coliform counts decreased from 7.5 log cfu/g in RMC to 5.3 log cfu/g on the 120th d (Fig. 8). This level decreased from 3.5 to 1.3 in PMC in the same period. It was evaluated as a remarkable finding that there is a difference of 4 logarithm units between PMC and RMC on the 120th d of ripening period. There were statistically significant differences between the RMC and PMC samples in all the analysis days ($p<0.05$).

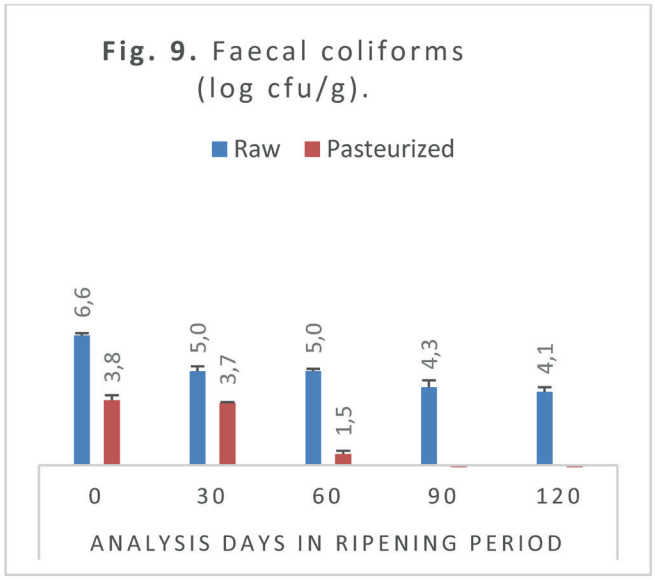



Fig. 9. The counts of faecal coliforms of Siirt Herby Tulum Cheese made with raw and pasteurized Eve's milk (log cfu/g).

The faecal coliforms were determined to be 6.6 log cfu/g on the 1st d; It was observed that it only decreased to 4.1 log cfu/g at the end of the 120 d of ripening period (Fig. 9). However, in the PMC samples, these values were determined to be 3.8 log cfu/g on the 1st d and 1.5 log cfu/g on

the 60th d. In the PMC samples on the 90th and 120th d, it was observed that the counts of faecal coliforms decreased to ≤1 log cfu/g, which is under the countable level.

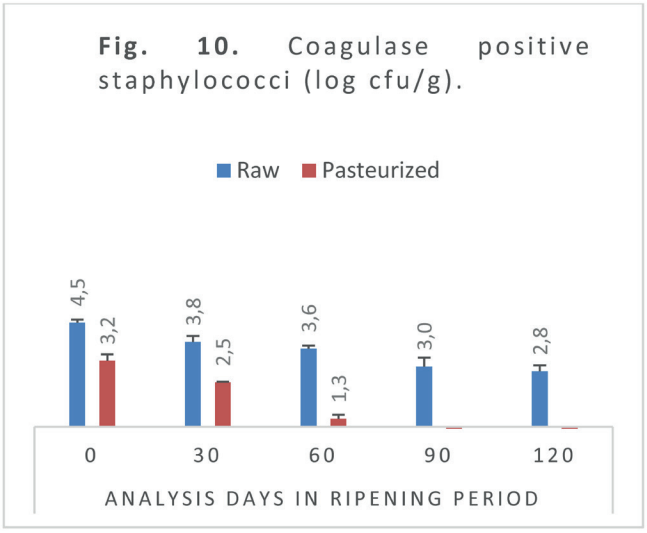



Fig. 10. The counts of Coagulase positive staphylococci of Siirt Herby Tulum Cheese made with raw and pasteurized Eve's milk (log cfu/g).

The number of Coagulase positive staphylococci in the RMC was 4.5 log cfu/g on the first d, and 2.8 log cfu/g on the 120th d (Fig. 10). However, in the PMC group samples produced as PMC, these levels were 3.2 log cfu/g on the first d; It was detected as 1.3 log cfu/g on the 60th d. In the PMC samples on the 90th and 120th d, it was observed that the counts of faecal coliforms decreased to ≤1 log cfu/g, which is under the countable level.

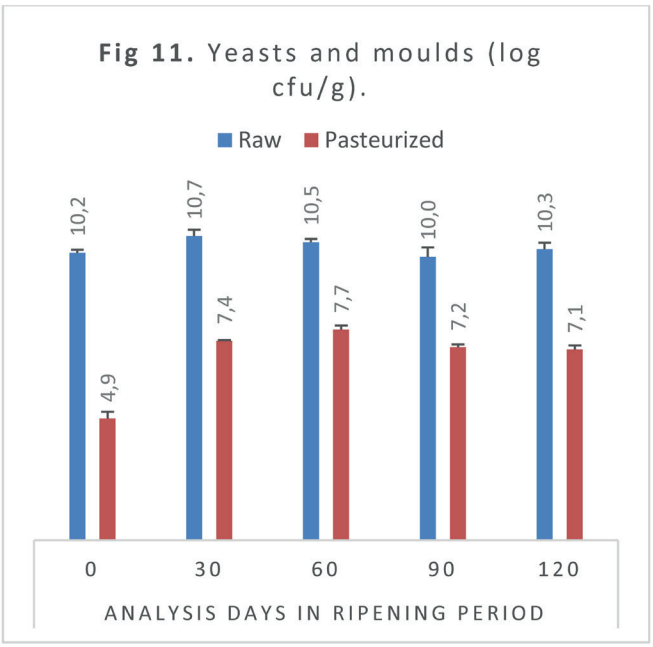



Fig. 11. The counts of yeasts and moulds of Siirt Herby Tulum Cheese made with raw and pasteurized Eve's milk (log cfu/g).

Yeasts and moulds numbers were determined to be over 10 log cfu/g in RMC, and no statistically significant changes were observed during the ripening period ($p>0.05$) (Fig. 11). However, the number (4.9 log cfu/g), which decreased due to pasteurization in the PMC samples, increased to 7.4 log cfu/g on the 30th d and remained approximately at the same level in the following period. The highest yeasts and moulds counts in the PMC samples was 7.7 log cfu/g on the 60th d and the lowest was 7.1 log cfu/g on the 120th d.

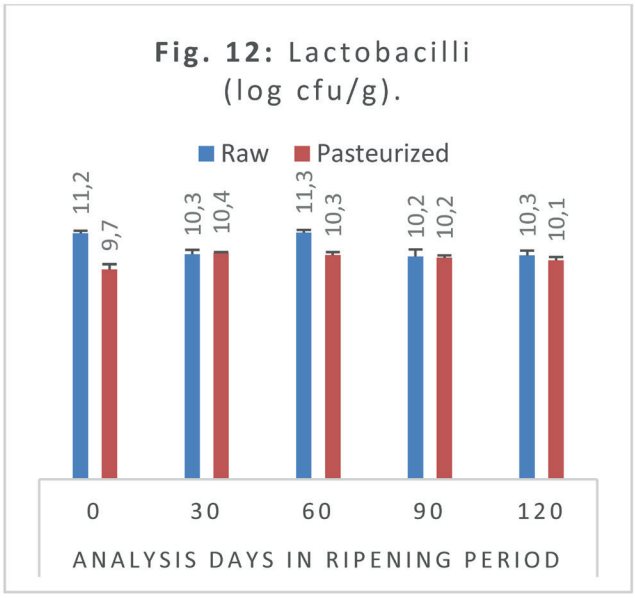



Fig. 12. The counts of lactobacilli of Siirt Herby Tulum Cheese made with raw and pasteurized Eve's milk (log cfu/g).

The lactobacilli levels in PMC samples remained below the level found in RMC on the first d and on the 60th d of the ripening period (Fig. 12). However, on other analysis d of the ripening period, it was observed that the level of PMC exceeded 10 log cfu/g, as in RMC. The levels of Lactobacilli in the RMC and PMC samples were determined to be about 10 log cfu/g in the analysis d of the ripening period except for the 1st d.

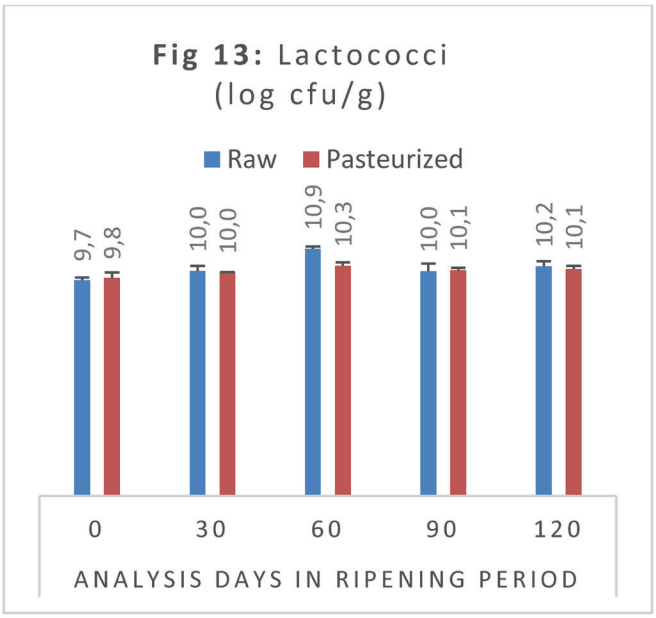



Fig. 13. The counts of lactococci of Siirt Herby Tulum Cheese made with raw and pasteurized Eve's milk (log cfu/g).

The levels of lactic streptococci were found to be at similar levels in the RMC and PMC samples at the analysis d of the ripening period (Fig. 13). On the 60th d of ripening, it was determined that the RMC sample had a statistically higher number of Lactococci than the PMC sample ($p>0.05$). On the other d, no statistical difference was observed between the two samples.

## Discussion

Among Turkish cheeses, White pickled cheese, Kashar cheese and Tulum Cheese are the most produced cheeses, respectively (66). The Tulum Cheese is a semi-hard and aromatic cheese. It is produced traditionally by using raw milk, and its production period is about 10 d at ambient temperatures. The cheese is ripened at 4 °C for about 4 months before consumption. Traditionally made cheeses have determined to be not meet the regulative standards by their compositional and hygienic constituents (43, 45, 47, 67). Many experimental studies have been conducted on the traditional Tulum Cheeses of Türkiye (27-34, 37-42). In most of these studies, raw milk has been used for making the cheese to mimic the traditional methods. To our knowledge, the first experimental study in which pasteurized milk is used for making Siirt Herby Cheesewas conducted in 2022 (37). In this study, pasteurized milk, autochthonous starter culture and a process method that is probably used for the first time were used for cheese making, and the duration of cheese making was at most 24 h.

Changes made in curd processing techniques are effective in making changes in cheese (68). In this study, a slightly melted and slightly sticky feature was observed in all samples. However, the samples of Siirt Herby Cheese should have been more granular and capable of being lumped and dispersed. There are many factors effective in improving this feature of cheese (26, 30, 42). More studies should be conducted to investigate in detail factors such as standardization of milk, pasteurization, fermentation, acceleration of starter development, redesignation of press processes, salting regime and packaging time.

Starter cultures may originate from raw milk and, especially, from high quality ripened cheeses. Cheeses ripened by using such cultures have been reported to be more aromatic than cheeses ripened by using commercial starter cultures. Undefined cultures such as pasteurized milk flora, sour milk and sour milk are used in businesses as natural or artisanal starters (69, 70). However, no record has been found indicating such a practice in Siirt Herby Tulum Cheese. In this study, an autochthonous starter culture including lactobacilli and lactococi was used in the process. In this way, sufficient pH and acidity development could be achieved in the early period of ripening of PMC (Fig. 1, 2). Nevertheless, more detailed studies should be made to develop starter culture for Siirt Herby tulu cheese.

The physical structure of Tulum Cheeses is dispersible and clumpy. So, it is tightly pressed into its container and no air gap is presented in it (7-9, 11). The hygiene and shelf life of cheese depends on its acidic, ripe and salty structure which is needed at least a 10 d of processing period. During this period, the cheese is kept at approximately 20°C, allowing the acidity to increase and ripening to begin (35, 36, 43-48). We believe that this long production process and the excessive amount of manual processing during the process will not be suitable for hygienic and technological production. For this reason, we think that it would be appropriate to finish the production within 24 h and package the product on the same d, as was done in this study. In this study, both chemical and microbiological analysis results demonstrated that it is possible to produce herby tulum cheese from pasteurized milk in a short time such as 24 h (Fig. 1-13).

In the Herby CheeseStandard (71), moisture, dry matter, fat in dry matter and salt in dry matter values are included. Van Herby CheeseGeographical Indication Certificate (5). includes dry matter, fat, ash and salt values. The pH and acidity values are not included in both documents. The ash, pH, acidity and protein values in the Tulum Cheese Standard have not been mentioned72. This indicates that there is no standard to be followed regarding acidity and pH in

process development. In a previously made study, pH of Siirt Herby Tulum Cheese taken from sales points in Siirt province, have been demonstrated to be minimum 4.4, maximum 6.3 and average 5.3 (21). According to the findings of many other studies, the pH level in Herby Cheese samples obtained from the sales point was reported to be 4.2-6.8 (13-15, 16, 18). In another previous made study, it has been reported that the pH of Herby Cheese decreased from 4.89 to 4.52 during 90 d of ripening (33). In PMC, it was observed that the pH was 5 in the 60th d of ripening and this value remained constant until the 120th d (Fig. 1). We believe that it would be appropriate to determine the legal limits for the pH of cheeses that are offered for sale after ripening in their packaging, such as Herby cheeses.
The lowest, median anf highest acidity values of Herby cheeses sold in Siirt city center have been determined to be 0.8, 1.9and 4.1, respectively (21). In other studies, the acidity values of Herby Cheese samples collected at retail stores have been stated to be as low as 0.11%, 0.18% and 0.24 (30, 31, 40). The high acidity values detected in Herby Cheese samples taken from sales points have been stated to be as high as 1.36% - 2.42% (35, 38-40). In a study, it has been reported that acidity (lactic acid, %) increased from 0.62% to 1.05% during the ripening period (37). In another previously made study, it has been reported that the acidity of Siirt Herby cheese, produced using Eve's milk, increased to 0.8% lactic acid level during the 120-d of ripening period. The researchers have demonstrated that the differences between RMC and PMC have become closer to each other on the 120th d ripening (21). In this study, while the initial acidity values were similar in RMC and PMC samples, increases were observed in both samples from the first d of ripening. The acid level in the RMC samples were determined to be higher than in PMC samples during a 120 d of ripening period. While the acidity values (% lactic acid) on the 90th d of ripening in RMC and PMC samples were measured as 0.91 and 0.48; these values were measured as 1.12 and 0.71, respectively, on the 120th d. We believe that the addition of the acidity levels of Tulum Cheeses in the legislative regulations may be more informative.

In the Herby CheeseComminique, the minimum and maximum moisture contents are reported to be 45 and 50%, respectively (72). The maximum moisture content is reported to be higher (maximum 60%) in the Tulum Cheese Comminique (71). This value is similar to the value of White pickled cheese (11). Gülmez et al. (37) have reported that the dry matter level in Siirt Herby Tulum Cheese samples made using Eve's milk varied between 41-46%. Many researchers have reported that there have been large differences in dry matter contents among the cheeses offered for sale. In other previous studies, far different values were detected in terms of dry matter ratio in field samples (18, 20, 23, 26, 28). In a field study, the moisture contents of retailed Siirt Herby Cheesehave been stated to be 34.6% at minimum 57.9% at maximum and 49.6% on average. In this study, the dry matter increase in the RMC sample was higher than in the PMC samples. On the 120th d of ripening, the dry matter was determined to be 50.6% in the RMC samples and 46.7% in the PMC samples (Fig. 3). The dry matter difference between both samples was 3.9%. This difference was found to be statistically significant ($p<0.05$). Based on this finding, it would be recommended that a standard Siirt Herby Tulum Cheese may contain minimally 50% dry matter.

In the Cheese Communiqué, the maximum salt content in dry matter in Tulum Cheese is stated to be 5% (11). In another word, salt in Tulum Cheese is recommended to be at most 2.25%. Salt content is stated to be maximally 7.5% in the Herby Cheese Comminique (72) and maximally 6.9% in the Van Herby Cheese PDO Certificate (7). The minimum, maximum and average salt contents of the samples taken from sales points in Siirt city center have been determined to be 1.1, 4.5 and 2.9%, respectively (21).. Considering the values reported in previous studies, it was reported in two research articles that less than 3% salt content was found in Herby Cheese samples taken at the point of sale (33-38). In other research articles, it has been reported that cheese samples taken at sales points contain salt at different levels between 1-18% (23, 25, 26, 30-32, 34). In this study, salt contents were determined to be around 2% in RMC and PMC samples. The second press process applied after the first press caused a decrease in the salt level. No statistical difference was found in terms of salt levels between the two samples. Our results can These findings may serve as an example for studies on salt reduction in Tulum Cheese.

The average, minimum and maximum ash levels in the Siirt Herby chheses at retail have been stated to be 5.6%, 1.2% and 8.1%, respectively (21). In this study, ash levels in RMC and PMC samples were determined to be 2.3% and 2.1% on the 1st d, and 2.7% and 2.6% on the 120th d, respectively. One of the possible reasons why the ash level is lower than the values reported above may be the low salt content of the cheese.

Total mesophilic aerobes were found to be approximately at the same levels in RMC and PMC samples (Fig. 7). Because, along with the original microflora of raw milk, there is also the flora from the starter culture. There was no statistically significant increase between the counts of to-

tal mesophilic aerobes of RMC samples and PMC samples during the ripening period.

The coliform counts were determined to be 3.7 log cfu/g in raw milk and 0.44 log cfu/g in pasteurized milk; faecal coliforms were detected to be 1.12 log cfu/g in raw milk and <1 cfu/g in pasteurized milk (Table 2). In Turkish Food Codex Microbiological Criteria Communiqué73, coliform bacteria in cheese has not been mentioned as the hygiene criterion. However, in this study, analyzes were made to determine the hygienic level and to comment in detail on the effect of pasteurization on cheese hygien*E. coli*form counts were decreased during ripening (Fig. 8). There has been a difference of 4 log cfu/g between PMC and RMC samples on the 120th ripening d. This was evaluated a remerkable hygienic difference between the two. Faecal coliforms in the RMC samples were 6.6 log cfu/g on the 1st d and 4.1 log cfu/g at the end of the 120th d of ripening period (Fig. 9). However, in the PMC samples, faecal coliform counts were determined to be 3.8 log cfu/g on the 1st d and 1.5 log cfu/g on the 60th d. In the PMC samples, it was observed that the counts of the bacteria decreased below 1 log cfu/g, which is the minimum countable level, on the 90th and 120th d. It is observed that the coliform and faecal coliform counts have decreased in the RMC and PMC samples during ripening (Fig. 8,9). Assuming that there is no possible contamination during cheese processing, it is understood that this group of microorganisms is decreased during ripening to a safe level. Nevertheless, traditional Herby cheeses are produced from raw milk, and the production period is as long as 10 d. During this period, primary contamination of coliforms and faecal coliforms coming from raw cheese, and also manual processing procedures may cause a secondary contamination risk.  possibly due to the high pH and low acidity at that point. In the Herby Cheese samples taken from sales points in the city center of Siirt, the coliforms have been determined to be minimum 1 log cfu/g, maximum 9 log cfu/g, and on average 4.6 log cfu/g. In some other previously made studies, it has been determined that the number of coliforms in samples taken from sales points was above 3 log cfu/g (21-23, 25, 26). This may be due to using raw milk in the production of traditional Herby Cheeseand/or secondary contaminations.

According to the Turkish Food Codex Microbiological Criteria Communiqué (73), Coagulase positive staphylococci are mentioned between hygiene indicator microorganism, and it is allowed to be present at a maximum level of 103 cfu/g in the Tulum Cheese. In this study, Coagulase positive staphylococci were detected to be 3.62 log cfu/g in raw milk used for making cheese samples (Table 2). The counts of Coagulase positive staphylococci in the RMC samples were detected to be 4.5 log cfu/g on the 1st d, and 2.8 log cfu/g on the 120th d (Fig. 10). It was observed that sufficient hygienic assurance could not be obtained in RMC samples in terms of Coagulase positive staphylococci. However, in the PMC samples, these levels were 3.2 log cfu/g on the 1st d; On the 60th d, it was detected as 1.3 log cfu/g. In the PMC samples on the 90th and 120th d, it was seen that the bacteria fell below 1 log cfu/g, which is an uncountable level, and hygienic assurance was provided in terms of the number of Coagulase positive staphylococci in the samples. It has previously been reported that only pasteurization could provide sufficient hygienic assurance (37). In herby cheese samples taken from sales points in the city center of Siirt, Coagulase positive staphylococci have been determined to be minimum 3.2 log cfu/g, maximum 7.3 log cfu/g, and on average 5 log cfu/g (21). In some other previously made studies, high contamination levels have been detected in samples taken from sales points (21-23, 25, 26).

The yeasts and moulds count was detected to be 5.09 log cfu/g in RMC samples, they remained at the same values from the 1st d to the 120th d of the ripening (approximately 10 log cfu/g). Yeasts and moulds numbers were detected as 1.06 log cfu/g in PMC samples and increased from the 1st d to the 30th d of the ripening period (Fig. 11). The number (4.9 log cfu/g), which decreased due to pasteurization of the milk in PMC, increased to 7.4 log cfu/g on the 30th d and remained approximately the same in the following period. The source of the increased yeasts and moulds number in PMC samples, development conditions and their effects on cheese could be investigated in detail in future studies. The yeasts and moulds levels detected in RMC were found to be higher than the yeasts and moulds numbers detected in samples taken from sales points in previous studies (21-23, 25, 26).

Fast ripening methods for cheese include enzymes, acids, salt, antimicrobial substances such as potassium sorbate and cheese slurry applications. Cheese slurry is effective by diluting old cheese and then mixing it with new cheese. By that way, the transfer of acids, enzymes and microorganisms from ripened cheese to fresh one. Increasing the ripening temperature also accelerates ripening (67). It has been reported that fast ripening was possible with Divle Tulum Cheese slurry, but the sensory properties of model cheeses decrease with the addition of slurry (69). Duman Aydın and Gülmez (48), in the fast ripening experiment of Erzincan Tulum Cheese by using the appropriate starter culture and keeping the curd for 3 h without straining, have

reported that Tulum Cheese produced by applying pressure at 20°C for 12 h, keeping it in a synthetic salami casing at 25°C for 48 h and then at 4-7°C for 13 d would have been recommended for technological production. Fast ripening of cheese provides economic advantages. However, care must be taken in matters such as slurry and keeping it at high temperatures, and there may be a possibility that the cheese may have a short shelf life during cold storage and/or sales periods. For this reason, cheese ripening time and production time should be considered as separate issues. We believe that shortening the production time is a more technical issue. Uğurdoğan (67) described the technological production model of Erzincan Tulum Cheese in his study. However, it seems that this model is not technological and imitates the traditional model. Production again appears to take more than 10 d. Using technological methods, producing cheese and packaging it within 24 h is important in terms of labor, environmental contamination, space and energy savings.

## Conclusion

As a result, using pasteurized milk and starter culture have been suggested as the minimum requirement for the production of a hygienic and standard Siirt Herby Tulum Cheese. It has been shown that production can be completed within 24 h at most by applying two-stage pressure to the curd and treating the curd with sour whey before the second pressing. It has been deemed necessary to research many issues, with priority given to standardizing the milk in cheeses produced with this technique, developing an appropriate starter culture, investigating the relationship between pre-ripening and pressing, and clarifying the defining characteristics of the product. These studies will provide the opportunity to more easily test and revise the method according to the dynamics of each business. The method used in this study was determinded to be applicable for pasteurized milk cheese. Nevertheless, it was not found to be appropriate for making raw milk cheeses.

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