Dicle Üniversitesi Veteriner Fakültesi Dergisi
https://dergipark.org.tr/tr/pub/duvetfd
Araştırma Makalesi/Research Article
ISSN:1307-9972 Dicle Üniv Vet Fak Derg 2024;17(1):65-77 e-ISSN:1308-0679
DOI: 10.47027/duvetfd.1420950

Experimental Studies on the Siirt Herby Tulum Cheese: I. Development of an Industrial Process Model

Murat GÜLMEZ[1,a,✉], Sefa ÜNER[1,b], Kübranur YILDIZ BAYHAN[1,c]

[1]Department of Food Hygiene and Technology, Faculty of Veterinary Medicine, Siirt University, Siirt, TÜRKİYE

[a]ORCID0000-0003-3888-6815; [b]ORCID: 0000-0003-0416-7476; [c]ORCID: 0000-0002-9740-9843

Geliş Tarihi/Received	Kabul Tarihi/Accepted	Yayın Tarihi/Published
16.01.2024	05.06.2024	30.06.2024

Abstract

In this study, a method was developed that uses pasteurized Eve's milk to produce Siirt Herby Tulum Cheese in less than 24 hours. Pasteurization was done for one minute at 72˚C, followed by fifteen minutes of straining, curd formation for 90 minutes at 32˚C, first pressing for 90 minutes at half the weight of milk, curd souring for 45 min, and second press for twelve h at half the weight of milk. Before the second pressing, 2% sirmo (*Allium sp.*) and 1% salt were added to the curd. The ripening culture was obtained from the lactic flora found in traditional Siirt herby cheese. The Herby Cheese Standard, Tulum Cheese Standard, and Van Herby Cheese Geographical Indication Certificate are the three primary statutory regulations, all of which are based on traditional manufacturing techniques. We referred to them as references. This cheese that has been processed to a minimum pH of 5.5, 0.7% lactic acidity, 20% fat, 45% dry matter, and 2.5% salt content before packing could be made by using pasteurized Eve's milk. The fat and dry matter levels were in the middle of the reference ranges. As a result, the regulations' minimum four-day production period was decreased to a maximum of 24 h. The method was apparently employed for the first time in this study. Before being implemented in a business, the suggested technique must be tested with regard to environmental parameters, milk quality, and other variables. More research on the proposed approach is required to establish a starter culture, detect ripening process variations, and determine whether different Tulum Cheeses may be manufactured utilizing such a short-term production procedure.

Key Words: Ewe's milk, pasteurization, process development, Siirt herby tulum cheese

Siirt Otlu Tulum Peyniri Üzerine Deneysel Çalışmalar: 1. Endüstriyel Üretim Modeli Geliştirmek

Öz

Bu çalışmada pastörize koyun sütü kullanılarak Siirt otlu tulum peynirinin 24 saatten daha kısa sürede üretilmesini sağlayan bir yöntem geliştirilmiştir. Pastörizasyon 72°C'de bir dakika süreyle yapıldı, ardından on beş dakika süzme, 32°C'de 90 dakika süreyle pıhtı oluşumu, ilk olarak sütün ağırlığının yarısı kadar ağırlık altında 90 dakika süreyle presleme, 45 dakika süreyle pıhtı ekşitme ve ikinci kez sütün ağırlığının yarısı kadar ağırlık altında 12 saat süreyle presleme yapıldı. İkinci preslemeden önce süt ağırlığına %2 sirmo (*Allium sp.*) ve %1 peynir tuzu ilave edildi. Olgunlaştırma kültürü, geleneksel Siirt otlu peynirinde bulunan laktik floradan elde edilmiştir. Otlu Peynir Standardı, Tulum Peyniri Standardı ve Van Otlu Peynir Coğrafi İşaret Belgesi, tamamı geleneksel üretim tekniklerine dayanan üç temel yasal düzenlemedir. Bunlar referans alındı. Bu peynirin ambalajlamadan önce minimum pH 5,5, %0.7 laktik asit, %20 yağ, %45 kuru madde ve %2.5 tuz içeriğine sahip olacak şekilde pastörize koyun sütünden yapılabildiği ortaya kondu. Yağ ve kuru madde düzeyleri referans değerlere uygun bulundu. Bunun sonucunda yönetmeliğin asgari dört günlük üretim süresi azami 24 saate indirildi. Yöntemin ilk kez bu çalışmada kullanıldığı düşünülmektedir. Önerilen tekniğin bir işletmede uygulanmadan önce çevresel parametreler, süt kalitesi ve diğer değişkenler açısından test edilmesi gerekir. Bir starter kültür oluşturmak, olgunlaşma sürecindeki değişiklikleri tespit etmek ve bu kadar kısa süreli bir üretim prosedürü kullanılarak farklı tulum peynirlerinin üretilip üretilemeyeceğini belirlemek için önerilen yaklaşımla ilgili daha fazla araştırma yapılması gerekmektedir.

Anahtar Kelimeler: Koyun sütü, pastörizasyon, proses geliştirme, Siirt otlu tulum peyniri

INTRODUCTION

Türkiye produces over seven hundred thousand tons of cheese a year. The most widely made cheeses in Türkiye are tulum, kashar, and white cheese (1). According to reports, Türkiye boasts an abundance of native cheese kinds (2–5). Known as "herby cheeses," some of these cheeses include herbs in them. Van Herby cheese is the most manufactured and consumed of these. Herbs have been shown to provide extra health advantages to cheese in addition to its flavor and aroma (6). The Eastern and Southeast parts of Türkiye are where most herbal cheeses are made and consumed. Van Herby Cheese comes to mind when discussing herby cheese in Türkiye (7). Under the terms of Industrial Property Law No. 6769 (Registration No. 405) (8), Van Herby Cheese was registered by the Van Chamber of Commerce and Industry on December 31, 2018, with the geographical boundaries of Van and Hakkâri. The cheese was protected as of

July 27, 2017. In addition to Van herby cheese, other varieties include Hatay Testi Cheese, Sürk Cheeses and Urfa, Siirt, Erzincan, and Trabzon herby cheeses (9). There is insufficient research on cheeses other Van Herby Cheese. It has been reported that once industrial manufacturing is accomplished, herby cheeses can be exported to EU nations (7).

The following herbs must be used in the Van Herby Cheese Registration document: *Mentha Spicata* (Wild mint, leaf), *Anhriscus nemorosa* (Mendo, leaf and stem), *Ferula Orientalis* L. (Heliz, leaf and stem), and *Allium schoenoprasum* L. (Sirmo/Sirik, leaf and stem). In addition to these herbs, 13 other herbs (8) can be used with registration. Only Sirmo herb is used in Siirt herby cheese. Van Herby Cheese's non-fat dry matter percentage, which ranges from 57% to 64%, qualifies it as semi-hard cheese (8). It has also been noted that semi-hard cheese qualities are present in siirt herby cheese (9). The registration certificate for Van Herby Cheese lists two distinct features, both of which are an explanation of the production techniques. Unbrined cheese made from raw milk is one of them. These methods include splitting the curd, salting it dry, pressing it tightly into the packaging for three to four days, and packing the cheese molds with the jaji (known as cacık in Turkish). These processes are said to require at least five d. Herby cheese that has been brine-ripened is the other variety. There is no specific sort of brine used in Siirt Herby Cheese. The tulum variety does not use cacık. After crumbling, the cheese is packed into airtight receptacles. The cheese cuts are salted dry and allowed to stand for approximately five days in order to allow the water to evaporate (8).

While raw Eve's milk is typically used to make Siirt herby cheese, goat and cow milk may also be used in specific amounts, depending on the financial situation of the family that makes the cheese (7). Raw milk is used to make traditional Herby Tulum Cheese from Siirt. After producing curd, sirmo is added and the mixture is placed in a clot bag. The bag is allowed to drain for three to four hours while it is weighed down. Next, the curd is sliced into thin pieces, about 2-3 cm in thickness. After dusting the slices with coarse kitchen salt, set them aside for three to four d at room temperature. After that, the slices are crushed and firmly packed into plastic containers or clay jars. Grape leaves can be filled, then the mouths of the containers can be covered with mud plaster. The container is covered with loose soil or sand and placed in the cellar, which is typically underground, with its mouth facing downward. The cheese container is positioned in the soil with the intention of hastening the cheese's moisture loss. After ripening for a minimum of four months and a maximum of seven months, it is made available for eating (9). Siirt herby cheese is quite distinct from Van herby cheese, despite their similarities in terms of production process. This cheese's manufacturing process is more akin to that of Tulum Cheese (7). Some customers purchase curd cheese from the area and handle the rolling, salting, sprinkling, pressing, and ripening at home. The manufacturing of herby cheese is concentrated in the summer months in Siirt province and its areas. Traditional methods have been used in scientific studies to date to make cheese, and it has been noted that no studies have been done on process development appropriate for any industry (9). İzmen and Kaptan (2) found that the herby cheeses made in the provinces of Van, Kars, Diyarbakır, and Siirt had 46.20% moisture, 55.39% dry matter, 24.2% fat, 5.1% salt, 21.92% protein, and 1.69% acidity. It has been discovered that the histamine levels in the herby cheeses sold in the provinces of Van, Siirt, Batman, and Diyarbakır may rise to levels that are harmful to human health (10). In another investigation, it was shown that histamine levels in herby cheeses bought from Van Provincial sales locations were above the harmful thresholds (11). In a different investigation, Urfa and Van herby cheeses had lower than permitted quantities of biogenic amines (12). Another experimental investigation found that when the amount of sirmo (wild garlic) herby added increased (to 2% and 3%), the nitrite levels rose but the nitrate level remained the same (13). According to a study, mice that ate Van Herby Cheese had higher serum triglyceride levels (14). According to a different study, the preparation of Van Herby Cheese with starter culture using pasteurized milk and pasteurized herbs produced reduced amounts of free fatty acids when compared to raw milk cheeses (15).

Studies on other herby cheeses have also been done, but not to the same extent as those on Van herby cheese (2,6,7). Businesses that meet specific minimal technical and hygienic criteria are granted production permits, which allow them to produce cheese in compliance with the law. Official documents specify the minimum technical and hygienic standards for cheeses, and official inspections are conducted in accordance with these standards (16–18). After looking into the chemical and microbiological quality characteristics of herby cheeses, it was found that there are no product requirements for local cheeses. Studies have revealed that these items don't offer enough guarantees for public health and have poor sanitary quality (19–27). According to Gülmez et al. (28) local cheeses did not meet the necessary criteria of hygienic and technical excellence. They stated that the products could be harmful to the general public's health and that the cheese they inspected did not adhere to regulatory standards. Van Herby Cheese has now developed a certain production technology as a consequence of scientific research (29–35). Nonetheless, there is a dearth of research on the experimental manufacturing of tulum, or herby cheeses, where the curd is crumbled and packed without the use of cacık. The effects of utilizing pasteurized and raw milk on the quality of Siirt Herby Tulum Cheese were examined by Gülmez et al. (36) in their investigation. They came to the conclusion that pasteurization of milk was required for a standard production using Eve's milk. Moving Siirt herby cheese production from a traditional to an industrial approach might be advantageous. with the notion that standardizing production is the only way to create a product with quality and brand value that can be sold in a large sales network. As far as we are aware, no industrial process development study has been carried out for Herby Tulum Cheeses. Defining a model process appropriate for industrial production was the aim of this study. Process steps were created to ensure that the final cheese composition met all applicable legal requirements.

MATERIAL AND METHODS

Material

Raw milk: Freshly milked Eve's milk from a sheep farm in Siirt's city center was filtered through a clot strainer and transported to the laboratory within an hour.

Coagulant: A commercial microbial coagulant (Yayla Rennet, Tuzla Istanbul) was obtained at a sales point and transported to the laboratory. Before adding the coagulant to the milk to be made into cheese, the coagulant strength was checked and employed based on the results.

Sta*rter culture:* 10 g samples of three herby tulum cheeses purchased from sales locations in Siirt province were mixed, serially diluted in physiological saline solution (PS, 0.8% salt), and added to MRS (Oxoid, CM1153) and M17 (Oxoid, CM0785). It was obtained by collecting the developing colonies, washing the agar surface with PS, and increasing the lactic acid bacteria obtained from milk and whey. The collected culture was first maintained in PS for 24 h, with the pH decreased to 4 using lactic acid, to guarantee that acid-resistant cells were picked. This culture was added to pasteurized Eve's milk at a rate of 3%, and the milk was fermented at 37°C until the pH reached 4. Soured milk was employed as a starter culture, with 3% added to pasteurized milk at 32°C.

Sour whey: Whey was taken from previous research in this investigation. The fresh whey was pasteurized at 72°C for 1 minute and then cooled to 37°C. The above-mentioned starter culture was added to pasteurized whey at a rate of 3% and incubated at 37°C until the pH reached 4 and the acidity reached 1.2% lactate. Sour whey was employed in curd production.

Press materials: Water-filled containers with varying weights were used as press materials. The curd in the press clot was placed on a firm surface, weights were added, and it was pressed for 90 min.

Salt: Cheese was made using rock salt gathered in the region. The cheese was salted prior to adding the herb.

Herb (*Allium sp*., known locally as sirmo or sirik): Citizens harvested herbs from the plateaus and sold them at the Siirt city center market. After sorting and washing with drinking water, the herbs were cut to around 5 mm and mixed into the curd samples.

Cheese curd: Eve's milk was pasteurized at 72°C for 1 min, coagulant strength was determined, fermented at 32°C for 90 min, and the clot was sliced into 1 x 1 x 1 cm pieces. After severing the clot, 45 min were allowed for sineresis. The clot was then placed in a cotton bag to allow the whey to drain itself over a 15 min period. In the six successive trials described below, self-drained curd was employed as the raw cheese material. Acidity, pH, dry matter, fat, salt (in trials where salt was used), and cheese production (milk/ cheese, %) were all measured.

Trial one (first press). Four distinct groupings were formed from the curd. There was no pressure exerted on the Control group (1K). The experimental groups were put under pressure of ¼ (1A), ½ (1B), and 1/1 (1C) of the weight of raw milk. The press time was set to 90 min.

Trial 2 (addition of hot water). The Control group (2K) did not receive any applications before pressing. After draining the curd samples, 90˚C hot water (2A) or 90˚C salty hot water (2B) were added to raise the temperature to 45˚C. The curds were then allowed to drain naturally for 30 min. The strained curds were pressed for 90 min with a pressing weight equivalent to half the amount of milk.

Trial 3 (sour whey addition). The control group (3K) received no therapy after curd cutting. To the other groups, 90˚C hot water (3A), 90˚C sour whey (3B), and 37˚C sour whey (3C) were added, with the curd temperature raised to 45˚C. After waiting 15 min, the curd was allowed to drip naturally for 30 min. The strained curds were pressed for 90 min with a pressing weight equivalent to half the amount of milk.

Trial 4 (herb addition). The self-drained clot was formed in a normal manner. Sour whey was introduced to the self-drained curd at the same rate as the curd's weight. After 30 min of waiting, the curd was allowed to drain on its own for 30 min. The drained curd was utilized to prepare experimental samples. In the Control group, no herb was added (4K). In other groups, herbs were applied after clot cutting (4A), before first pressing (4B), or after first pressing (4C). The chunks of crumbled curd were the size of chickpeas. The herb added to each curd accounted for up to 20% of the dry matter in the milk utilized. The press was applied to each sample at half its milk weight for 90 min.

Trial 5 (starter culture and/or sour whey addition). The groups were 5k (Negative Control, no starter or sour whey was applied), 5A (Positive Control, the starter culture was added to milk at 37˚C at a rate of 3%, waited for 45 min and the milk was coagulated), 5B (sour whey at 37˚C was added to milk as for the starter culture), and 5C (the starter culture was added to the milk as made as for Group 5A, then milk was clotted and cut). The clot slices were self-drained for 15 min before adding sour whey at 37˚C at an equal weight. The clot was left in the sour whey for 45 min before being self-drained for an additional 15 min. The press was applied to each sample at half its milk weight for 90 min.

Trial 6 (second press). Milk was pasteurized at 72˚C for 1 min, then chilled to 37˚C with 3% starter culture added. After a 30-min interval, the milk was coagulated for 90 min at 32˚C. The clot was sliced into 1 x 1 x 1 cm pieces, waited 30 min, and then allowed to drain naturally for 15 min in the cotton bag. The initial press was performed with a weight half the weight of the milk for 90 min. The curd was sliced into pieces (about 1 cm cubes), and sour whey at 37˚C was added in an equal amount to the curd. The curd was immersed in sour whey for 30 min and then allowed to drain naturally for 15 min. For better whey drainage, the curd in the cotton bag was pressed a second time with a press weighing half the milk for 12 h.

Trial 7 (salt addition). The samples were prepared as described in Trial 6. The curd was broken into pea-sized bits after the first and second presses. The herb was put to the curd before the first and second presses. Following the herb addition, salt was added to each sample at varying rates. The groups were 7A (1% salt) and 7B (1.5% salt). 7C (2% salt), 7D (2.5%), and 7E (3% salt). Each sample containing the herb

and salt was left under a press weighing half the weight of the milk for 12 h.

Analyzes

Coagulant activity: The coagulant (Yayla Rennet, Tuzla Istanbul) was diluted by one-tenth. A 10 ml of raw milk was cooked at 35˚C. A 1 cc coagulant solution was added to the milk, and the timer was started simultaneously. Milk was stirred with a glass drumstick. As soon as grains of curd appeared in the baguette, the timer was stopped. The method was repeated three times, and the average was calculated. The coagulant strength was estimated using the following formula (37). Coagulant strength is calculated as (2400 X S)/Z.

Physical and chemical analyses of raw milk and cheese samples were carried out with a milk auto analyzer (Lactoscan LS, Nova Zagora, Bulgaria). The pH was measured with a handheld pH meter (Milwaukee AZ 8685, Taiwan). The acidity was determined using the titrimetric method, and the results are represented as lactic acid percentages (38). Fat analysis was carried out using a milk butyrometer in accordance with the Van Gulik method (TS ISO 3433). The dry matter was measured gravimetrically in accordance with TS EN ISO 5534/AC (40). Salt was determined by titration in accordance with TS EN ISO 5943; 2007 (41).

Microbiological analysis of raw and pasteurized milk. For microbiological analysis, reference procedures were used (42). Briefly, 10 g of each sample was used to make tenfold serial dilutions in 90 ml of sterile physiological saline (PS). Plate Count Agar (PCA, Oxoid CM 0463) was used to count the total aerobic mesophilic bacteria (TAMB). To count Enterobacteriaceae, petri dishes were incubated at 30±2°C for 72 h. Then, Violet Red Bile Glucose Agar (VRBGA, Oxoid-CM0485) was utilized and incubated at 37±2°C for 48 h. For coliforms, Violet Red Bile Lactose Agar (VRBLA, Oxoid CM0107) was employed, and the Petri dishes were incubated at 37 °C for 24 h. The expanding pink-red colonies with a pink precipitation ring were counted. For coagulase-positive staphylococci, Baird Parker Agar (BPA, Oxoid CM1127) plates with Egg Yolk Tellurite Emulsion (Oxoid SR0054) were utilized. The plates were incubated at 37°C for 48 h. Black, shinny coagulase-positive colonies with a diameter of 1.5–2.5 mm and a translucent zone around them were counted. Then, five susceptive colonies were chosen at random for each sample and evaluated for coagulase response before cfu/g values were calculated. For yeasts and molds, Yeast Extract Glucose Chloramphenicol Agar (YGCA, Merck 1.16000) was employed, and the petri dishes were cultured for 5 d at 25°C. The colonies growing on the medium were counted. Colony counts were performed using De Man Rogosa Sharpe Agar (MRS, Oxoid, CM1153) for lactobacilli and M17 Agar (Oxoid, CM0785) for lactococci.

Statistical Analysis

The investigation was done three times, and each analysis was carried out twice. The mean and standard deviation data were obtained with the Microsoft Excel application. Means with significant differences were compared using Duncan's multiple range tests and the SPSS v.15.00 program (Chicago, Illinois, USA) and P values.

RESULTS

Table 1 displays the laboratory results for clot samples obtained from raw Eve's milk. It was determined that the self-drained clot weighed 53.8% of the processed milk volume. It was discovered that 46.2% of the milk was separated from the clot as whey. The acidity of raw milk was 0.32%, but the self-drained clot was 0.08%. The pH of raw milk was 6.69, whereas it was measured at 6.67 in the clot.

Table 1. The analysis results of the raw milk used in cheese making and the clot that was self-drained for 15 min.

	pH	Acidity (Lactic acids, %)	Dry matter (%, w/w)	Protein (%, w/w)	Fat (%, w/w)	Lactose (%, w/w)	Minerals (%, w/w)	Density (%, w/w)	Freezing point (°C)	Conductivity (Ω ' cm')	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
Drained clot	6.7±0.1	0.1±0.01	34.4±3.4	ND	12.0±0.9	ND	ND	ND	ND	ND	53.8±2.1

Table 2 displays the results of microbiological analyses of raw milk. Pasteurization significantly reduced bacterial loads. Pasteurization makes milk more sanitary by considerably lowering the levels of coliforms, fecal coliforms, and coagulase-positive staphylococci. While the numbers of lactobacilli and lactic streptococci reduced, the natural lactic acid bacterial flora remained at an average of 2 log cfu/g (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	Coagulase positive staphylococci	Yeasts-moulds	Lactobacilli	Lactococci
Raw milk	5.5±0.2	4.5±0.4	3.7±0.3	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±0.1	2.1±0.3	1.8±0.2

The first testing aimed to determine the press weight. It was determined that pressing did not appreciably affect acidity or pH readings. The trial group (1C) with the press weight equal to the milk weight showed the greatest increase in dry matter (Table 3). However, it was decided that the 1C group samples should contain half of the milk's weight. Calculating the curd to fat ratios indicated that the fat ratio in the 1C group was 6.74%, rather than 7.74%, and 1% of the fat flowed into the whey. Therefore, group 1B (½ the weight of milk) was chosen. After pressing, this group's curd had an acidity of 0.13% (lactic acid), a pH of 6.68, 47.98% dry matter, 21.61% fat, and a curd efficiency of 40.3% (Table 3).

Table 3. Effects of the first press on the cheese making (Trial 1)

Trial 1 (Groups)		Acidity	pH	Dry matter (%)	Fat (%)	Yield (%)
1K (Control, self- drainage)	Before press	0.12	6.7	34.5±2.2	14.5±1.1	51.5±3.1
	After press	0.13	6.7	40.1±2.3	16.4±0.9	44.0±2.9
	Difference (%)	0.01	0.0	5.6	1.9	-7.5
1A (press weight was ¼ of the milk)	Before press	0.11	6.7	35.7±1.1	15.4±1.3	52.8±2.1
	After press	0.14	6.7	43.9±1.5	19.2±1.1	42.4±3.1
	Difference (%)	0.03	0.0	8.3	3.8	-10.4
1B (press weight was ½ of the milk)	Before press	0.1	6.7	36.2±2.1	16.3±1.6	53.5±2.2
	After press	0.13	6.7	48.0±1.9	21.61.4	40.3±2.6
	Difference (%)	0.03	0.0	11.8	5.4	-13.2
1C (press weight was equal to the milk)	Before press	0.11	6.7	36.5±2.5	15.6±1.4	52.3±1.9
	After press	0.13	6.7	52.0±2.2	22.4±1.7	37.0±1.2
	Difference (%)	0.02	0.0	15.5	6.7	-15.3

The second experiment found that the dry matter rate after pressing was 51.13% in the Control group and 52.31% in the hot water-added group (2A). The dry matter rise rate was higher in the other two groups (2A, 2B) compared to the control group ($p<0.05$). The fat rate following press was 16.39% in the Control group, 20.98 in the hot water group (2A), and 19.16 in the salty hot water group (2C). The salty hot water group lost considerably more fat ($p<0.05$). The fat rate following press was 16.39% in the Control group, 20.98 in the hot water group (2A), and 19.16 in the salty hot water group (2C). The salty hot water group lost considerably more fat ($p<0.05$). Following the analysis, the decision was made to add hot water to the curd. However, in the second trial (testing 3), hot water was not used because sour whey was found to be preferable (Table 4).

Table 4. Effects of processing clot with hot water and salty hot water on the cheese making (Trial 2).

Trial 2 (Groups)		Acidity	pH	Dry matter (%)	Fat (%)	Salt (%)	Yield (%)
2K (Control, no application)	Before press	0.09	6.8	33.2±0.9	10.6±1.1	1.5±0.1	54.3±3.2
	After press	0.09	6.8	50.1±2.4	16.4±1.4	1.4±0.1	35.0±3.3
	Difference (%)	0.00	0.0	18	5.8	-0.1	-19.3
2A (hot water added to the curd)	Before press	0.1	6.8	40.9±2.7	15.8±0.9	1.2±0.1	33.5±2.6
	After press	0.09	6.9	52.3±1.9	21.0±0.8	1.1±0.1	25.6±2.3
	Difference (%)	-0.01	0.1	11.5	5.2	-0.1	-7.9
2B (salty hot water added to the curd)	Before press	0.08	6.8	41.0±3.1	14.8±0.7	1.0±0.1	37.1±2.1
	After press	0.09	6.8	53.0±2.6	19.2±0.8	1.0±0.1	28.1±1.8
	Difference (%)	0.01	0.0	12.1	4.4	-0.1	-9.0

In the third experiment, the pH value after pressing in the Control group (3K) samples was 6.76, however, these values were found to be 6.75, 6.41, and 6.46 in the samples of hot water (3A), hot sour whey (3B), and sour whey (3C). There were no statistically significant differences between the 3K and 3A groups. The difference between these two groups and the other two (3B and 3C) was statistically significant ($p<0.05$). There was no statistical difference between the groups in terms of acidity readings. The Control group samples had lower dry matter levels compared to the other groups ($p<0.05$). Among the experimental group samples, the group that received hot water had the highest level of dry matter, but there was no statistically significant difference between the other two groups (3B, 3C). After pressing, the curd yield (in terms of curd to milk ratio, %) of the 3K, 3A, 3B, and 3C groups were found to be 32.1, 22.9, 20.8, and 28.2, respectively. The addition of hot water and hot sour whey improved the rate of whey drainage in the curd. Sour whey added to curd at 37˚C resulted in enhanced whey drainage compared to the control group. The increasing rate was statistically significant ($p<0.05$). Adding hot water and sour whey resulted in significantly enhanced whey drainage ($p<0.05$). Hot water and sour hot water significantly reduced fat levels in curd ($p<0.05$). The fat ratios (%) for the 3K, 3A, 3B, and 3C groups were 17.0, 20.1, 20.1, and 23.0, respectively (Table 5). In the testing, it was decided to add sour whey at 37˚C to the curd before pressing.

Table 5. Effects of processing clot with hot water, hot whey and sour hot whey on the cheese making (Trial 3)

Trial 3 (Groups)		Acidity	pH	Dry matter (%)	Fat (%)	Yield (%)
3K (Control, no application)	Before press	0.05	6.7	28.7±1.1	12.3±1.2	45.2±1.3
	After press	0.06	6.8	36.6±0.8	17.0±1.4	32.1±1.1
	Difference (%)	0.00	0.1	7.8	4.8	-13.1
3A (hot water added to the curd)	Before press	0.07	6.5	36.8±1.3	14.8±1.1	34.1±0.6
	After press	0.05	6.8	40.3±0.8	20.1±1.4	22.9±0.9
	Difference (%)	-0.02	0.2	3.5	5.3	-11.2
3B (hot sour whey added to the curd)	Before press	0.06	6.5	37.4±1.4	14.0±1.5	41.3±0.9
	After press	0.05	6.4	39.4±0.7	20.1±1.8	20.8±0.9
	Difference (%)	0.00	-0.1	2.1	6.1	-20.5
3C (sour whey added to the curd)	Before press	0.06	6.6	33.7±1.3	16.3±1.1	44.9±0.7
	After press	0.05	6.5	38.1±0.8	23.0±0.9	28.2±0.6
	Difference (%)	-0.01	-0.1	4.4	6.7	-16.7

In the fourth trial, the pH value after press in the Control group (4K) was 6.87, however these values were determined to be 6.73, 6.85, and 6.67 in the 4A, 4B, and 4C groups. No statistically significant difference was seen between the groups. There was no significant difference between the groups in terms of acidity, dry matter, fat, and curd yield ratios. It was discovered that adding herbs after the initial pressing will preserve the herbs in the cheese more vibrant and green (Table 6).

Table 6. Effects of herb addition time period on the cheese making (Trial 4).

Trial 4 (Groups)		Acidity	pH	Dry matter (%)	Fat (%)	Yield (%)
4K (Control, no herb added)	Before second press	0.06	6.8	40.4±1.9	20.2±0.9	51.9±2.6
	After second press	0.06	6.9	50.6±1.8	16.0±0.5	40.5±1.9
	Difference (%)	-0.01	0.0	-10.1	4.2	11.5
4A (herb added after clot cut)	Before second press	0.06	6.6	41.3±1.4	21.2±0.4	52.6±2.3
	After second press	0.07	6.7	52.1±1.3	16.8±0.6	41.3±1.9
	Difference (%)	-0.02	-0.1	-10.8	4.5	11.3
4B (herb added before first press)	Before second press	0.04	6.7	38.3±1.4	17.2±0.4	52.4±2.6
	After second press	0.07	6.9	53.1±1.4	14.8±0.3	39.6±2.4
	Difference (%)	-0.03	-0.2	-14.8	2.5	12.8
4C (herb added before second press)	Before second press	0.04	6.8	40.0±1.1	18.9±0.5	50.9±2.3
	After second press	0.07	6.7	51.6±0.9	16.1±0.3	39.2±1.2
	Difference (%)	-0.03	0.1	-11.7	2.8	11.7

The results of the fourth trial are shown in Table 7. The pH of the Control group (5K) samples after press was confirmed to be 6.9. The pH values of the groups that added starter to the milk (5A), the group that added sour whey to the curd (5B), and the group that added both starter and sour whey to the curd (5C) were 6.7, 6.9, and 6.7. In terms of acidity, the samples showed a maximum lactic acid level of 0.07% after the second press. Both pH and acidity levels did not result in a statistically significant difference between groups. All groups had significantly increased dry matter values compared to the control group ($p<0.05$). The dry matter value after press for the Control group (5K) samples was 48.1%. The dry matter values for groups 5A, 5B, and 5C were measured to be 53.9, 53.4, and 53.2, respectively. Control showed a considerable increase compared to the other three groups ($p<0.05$), but no difference was seen between the other three groups. All groups showed significant variations in fat rates ($p< 0.05$). Adding starter culture to the curd and treating it with sour whey before the second press resulted in the highest levels of dry matter (53.2%) and fat (22.01%) in the cheese curd after pressing. The investigation revealed that it was permissible to add starter culture to pasteurized milk before the coagulant inoculation, as well as to apply sour whey to the curd before the first press.

Table 7. Effects of starter culture and/or sour whey addition on the the cheese making (Trial 5).

Trial 5 (Groups)		Acidity	pH	Dry matter (%)	Fat (%)	Yield (%)
5K (Control, no appliacatio)	Before second press	0.04	6.9	34.4±1.7	9.0±0.2	35.0±1.9
	After second press	0.07	7.0	48.1±1.7	12.4±0.4	24.9±1.3
	Difference (%)	0.03	0.1	13.7	3.4	-10.1
5A (starter culture adde to the milk)	Before second press	0.04	6.9	34.7±1.4	8.8±0.3	30.9±1.2
	After second press	0.06	6.9	53.9±1.6	13.8±0.2	19.9±1.2
	Difference (%)	0.02	0.1	19.2	5.0	-11.0
5B (sour whey added to the curd)	Before second press	0.05	6.8	37.1±1.1	10.3±0.1	22.6±0.8
	After second press	0.06	6.9	53.4±1.1	21.4±0.1	15.8±1.0
	Difference (%)	0.01	0.1	16.3	11.1	-6.9
5C (starter culture and sour whey application)	Before second press	0.04	6.8	35.1±0.9	13.2±0.2	32.1±0.5
	After second press	0.07	6.8	53.2±0.6	22.2±0.1	17.9±0.3
	Difference (%)	0.03	0.0	18.1	11.9	-14.3

Table 8 presents the data from Trial 6. The average acidity values (as lactic acid, %) for the samples before the first press (6A), after the first press (6B), and after the second press (6C) were 0.08, 0.10, and 0.28, respectively. The pH levels were calculated to be 6.3, 6.3, and 5.5, respectively. After 12 h of the second press, acidity and pH development were detected. The average dry matter values for the 6A, 6B, and 6C analytical points were 34.8, 42.3, and 51.9, respectively. In the same order, the percentage fat values in the samples are 14.3, 20,5, and 23.7%. The second press resulted in a 17.1% rise in dry matter, 9.42% in fat, and 16.8% in curd weight loss (cheese yield) over the first press. During the cheese-making process, all values showed significant differences ($p<0.05$). Applying a second pressure to the starter culture and sour whey curd seems to be a highly effective application.

Table 8. Effects of the first and the second press on the cheese making (Trial 6).

Trial 6 (Groups)	Acidity	pH	Dry matter (%)	Fat (%)	Yield (%)
6A-Before the first press	0.08	6.5	34.8±1.6	14.3±1.1	34.8±3.1
6B-After the first press	0.10	6.3	42.3±1.7	20.5±1.4	24.5±2.9
Difference (6B-6A) (%)	0.02	-0.2	7.5	6.2	-10.3
6C-After the second press	0.28	5.5	51.9±1.2	23.7±0.4	18.0±1.2
Difference (6C-6B) (%)	0.20	-1.0	17.1	9.4	-16.8

Table 9 presents the findings from Trial 7. Adding salt to the curd before the first or second press had no effect on the acidity or pH values of the samples. At the same time, no significant effect of adding salt at varied rates ranging from 1 to 3% of the curd (w/w) on the acidity and pH of the samples was observed. Adding 1% salt to the curd before the second press yielded a 2.6% salt level in the cheese.

Table 9. Effects of the added salt rate (%) on the cheese making (Trial 7)

Trial 7 (Groups)	Herb and salt added before first press		Herb and salt added before second press		Herb and salt added before first press		Herb and salt added before second press	
Salt/curd rate (w/w)	Salt after first press (%	Salt in cheese, %	Salt after first press, %	Salt in cheese, %	Lactic a. after first press, %	Lactic a. in cheese, %	pH after first press, %	pH in cheese, %
7A (%1)	2.3	2.3	2	2.6	0.1	0.2	6.8	6.8
7B (%1.5)	2.9	2.9	2.6	3.2	0.1	0.2	6.8	6.8
7C (%2)	3.5	3.5	2.9	3.5	0.1	0.2	6.8	6.8
7D (%2.5)	3.8	4.1	3.5	3.8	0.1	0.2	6.8	6.8
7E (%3)	4.4	5.3	3.8	5.3	0.1	0.2	6.8	6.8

DISCUSSION AND CONCLUSION

According to the Turkish Food Codex Cheese Communiqué (18), cheeses, especially herby cheese, must be made, packed, and marketed in conformity with applicable laws. Cheese can only be sold in conditions that fulfill Communiqué's hygienic standards. According to the Communiqué, local cheeses may be marketed using their defined, registered, or local product designations. Cheese made from raw or fermented milk, or with curd that has not been boiled, cannot be sold as fresh. Such cheeses can be marketed after ripening for at least four months after manufacturing. Akyuz and Kurt (30) stated in 1984 that primitive conditions should be abandoned and cheese production should take place in sophisticated plants. Previous field investigations have demonstrated that, with the exception of those manufactured by industry today, standard, hygienic, and safe production does not occur even in other locally produced herby cheeses (2,12,15,34,35). Siirt herby cheese can be produced in a conventional, hygienic, and branded form, according to reports (7). To realize this potential, the challenges outlined above must first be addressed.

We feel that the ancient production methods of Siirt herby cheese have developed and evolved into numerous types today. According to interviews conducted in the city center, in addition to traditional production methods, many people and small businessmen manufacture cheese using fresh curds transported to the city from the plateaus, and the processing methods vary (28). It has been noticed that adding a large amount of salt to the cheese increases its durability, and that after soaking the cheese in salt for 3-5 d, the salt is absorbed and the water is released. It has also been claimed that raw milk cheeses are maintained in brine at room temperature for 5 d or longer, and that the humidity of crumbled curd is lowered by placing it under covers. In contrast to other herby cheeses, Siirt Herby Tulum Cheese does not include cacık. The Siirt Herby Tulum Cheese is made without mold cheese. After dry salting, cheese molds are rinsed in water to eliminate any surplus salt from the cheese. The mold cheese is crushed first, then carefully packed into the

container (7, 23, 28, 36). In this circumstance, the likelihood of the cheese becoming infected increases. Another possible cause of contamination is the use of raw milk in traditional production. We feel that it is difficult to prevent cheese contamination in unsanitary environments such as a home or an unregistered establishment. These techniques are likewise unsuitable for industrial production (36). Such production models are expected to pose a high risk of contamination. As a result, this study attempted to design a system suited for industrial production. The investigations resulted in the development of a system for producing and packaging within 24 h at the latest. However, more research on this new method is needed to understand the variables that may arise depending on milk, starter culture, and seasonal influences.

When milk is used in production without considering parameters like breed, age, race, season, and milk mixing ratios, which affect milk composition, product quality may differ. As a result, standardizing milk prior to cheese production is critical (4,19). A detailed study on this subject can help to advance cheese producing technologies. Normally, pasteurization has made milk safe. However, it was discovered that members of the native lactic acid bacterial flora survived in pasteurized milk at an average level of 2 log cfu/g (Table 2). Previous research has demonstrated that this quantity of lactic flora proliferates in long-ripened cheeses, such as 90-120 d, and functions nearly as a starter culture in fermentation and ripening (36). Nonetheless, the use of starter culture is recommended for more controlled fermentation and ripening. However, it is prudent to regard the procedure of acidifying raw milk by keeping it at room temperature and thereby turning it into cheese as suspect unless its accuracy is confirmed. Coliforms are the fastest growing category of microbes, and they are lactose-positive. The question of how this type of microbe spreads and secretes poison into cheese should also be addressed. Furthermore, the changes in the hygienic condition of the cheese following the acidification and/or ripening of curd produced by raw milk flora, pasteurized milk flora, and pasteurized milk flora with starter culture should be thoroughly explored.

Acidity and salt levels are the most efficient criteria for increasing whey drainage from Tulum Cheese curd during the pressing process. Heavy press causes fat loss from the curd. To avoid fat loss, the curd's temperature and press weight must be matched. This investigation found that the changes in acidity and pH values were not significant over the first 2 h of the period preceding the second press (Table 3). During this time period, the trial group (1C) with the highest dry matter increase had the same pressure weight as the milk. However, calculating the curd-fat ratio revealed that the fat ratio in the 1C group was 6.74%, when it should have been 7.74%, and 1% of the fat slipped into the whey. Therefore, group 1B (press at ½ the weight of milk) was favored. In this group, the curd acidity after pressing was 0.13% (lactic acid), pH 6.68, dry matter 47.98%, fat 21.61%, and curd efficiency (curd to milk) ratio 40.3%. The results showed that a single step press is insufficient for proper whey drainage during the first two h of cheese manufacturing. More press application and curd acidification are required for quick Tulum Cheese production.

When crumbled, herby cheeses break into min pieces, but when combined under slight pressure, they form clumps. To achieve this texture, the cheese must fully release its moisture and appear semi-dry. To manufacture such a semi-hard cheese with 45% dry matter and 20% fat, brine ripening, or ripening of dry salted crumbled curd at ambient temperature under high press weight for an average of 10 d before packing. During this stage, cheeses are held at around 20˚C, allowing acidity to build and ripening to occur (34,36). We believe that this lengthy production procedure, along with an excessive amount of human processing, will be unsuitable for hygienic and technological production. Previous investigations found that the acidity values of herby cheeses marketed in Siirt city center were at least 0.8; the maximum was 4.1, and the average was 1.9 (12). Other researchers who examined herby cheeses purchased at sales points found that the acidity levels of some samples were as low as 0.11% (30), 0.18% (27), and 0.24 (31). These values are exclusively found in curd cheese; it should be noted that their existence in ripened Tulum Cheese could be due to other factors. It has been reported that herby cheese samples taken from sales points had high acidity values of up to 2.42% (10,24,25,27,31). A research found that acidity (lactic acid, %) increased from 0.62% to 1.05% during the ripening process (30). Another prior study found that the acidity of Siirt herby cheese, made from Eve's milk, grew to 0.8% lactic acid levels during the 120-day ripening phase. In this investigation, acidity levels of 0.28 were determined in cheese that was ready to be packaged (Table 8). We found no existing research on the subject of Herby Tulum Cheese. At the end of this investigation, we discovered, maybe for the first time, that the cheese-making time period can be reduced to less than 24 h. Using both starter culture and sour whey in the procedure ensures proper acidity and whey drainage for Tulum Cheese production.

The Herby Cheese Standard (43) only includes moisture, dry matter, fat in dry matter, and salt in dry matter data. The Van Herby Cheese Geographical Indication Certificate (8) includes dry matter, fat, ash, and salt values. Both texts do not include pH or acidity values. The Turkish Food Codex Cheese Communiqué (18) does not mention cheese pH, acidity, or protein values. This suggests that there is no standard for acidity and pH in process development. The pH level of 20 pieces of Siirt Herby Tulum Cheese purchased and examined in Siirt province was at least 4.4, with a maximum value of 6.3 and an average value of 5.3 (12). Another prior study found that the pH of herby cheese declined from 4.89 to 4.52 over 90 d of ripening (44). Many other investigations have found that the pH level in herby cheese samples acquired from the sales point is at least 4.2, on average 5.3, and at most 6.8 (4,7,12,36 45,46). The pH of experimentally manufactured raw milk cheese was 5.50 when it was packaged (Table 8). We feel it is appropriate to establish legal restrictions for the pH of cheeses offered for sale after ripening in their packaging, such as herby cheeses.

Herby Tulum Cheese's chemical composition is identical to that of other Tulum Cheeses, despite the fact that its production processes differ. According to the Tulum Cheese Standard (47), the moisture level of Tulum Cheese should

not exceed 45% (50% for low-fat and fat-free varieties). However, the Herby Cheese Standard (43) requires a greater moisture content (maximum 60%) and a dry matter value of at least 45%. This value is comparable to the value of white cheese (18). The dry matter content of Siirt Herby Tulum Cheese samples prepared from Eve's milk has been reported to range between 41 and 46% (36). In their investigation of herby cheese samples collected from sales sites in Siirt city center, the researchers discovered that the dry matter level in cheeses was at least 34.6%, with a maximum of 57.9% and an average of 49.6% (28). The researchers discovered that there are considerable variances in dry matter ratios across the cheeses for sale. Other earlier investigations found significantly different values for dry matter rations in field samples. Specifically, the lowest values reported were 29.1% (45) and 36.26 (35), while the highest values were 60.59% (34) and 61.57 (27). Other investigations have reported results within this range (22,26,44). It demonstrates that the numbers shown above are not normal, and that Herby Tulum Cheeses with low dry matter content are also available for purchase. While herby cheeses manufactured from pasteurized milks were vacuum packaged and ripened for 90 d, there was no significant difference in the average dry matter (50%) and fat (28%) values (26). The dry matter value for this investigation was 51.87%. It was determined that the cheese with this value met the relevant legislative values given in Table 8. Based on this conclusion, we feel it is permissible to market herby cheeses with a dry matter standard of at least 45%, preferably 50%, similar to other Tulum Cheeses.

According to the Herby Cheese Standard (43), the amount of milk fat in the dry matter must be at least 45%, and the Van Herby Cheese Geographical Indication Certificate (8) specifies that the fat values (%) of this cheese must be at least 16.75, at most 19.21, and on average 17. It has been found that the average fat content in Siirt Herby Tulum Cheese samples made with Eve's milk is 18% (36). In their investigation of herby cheese samples collected from sales stations in Siirt city center, the researchers discovered that the fat level in the cheese's dry matter was at least 31.2%. The maximum fat content in dry matter has been found to be 63.5%, with an average of 46.8% (28). In carefully conducted investigations, at least 18.93% (24) and up to 19.50% (25) of herby cheese samples were shown to be viable. Fat levels were found to be as high as 56.28% (27) and 59.37% (12). In the other researches, it is discovered that the variance in fat content across Tulum Cheese samples collected from sales locations can be as much as 20-30% (5,14,27). In this investigation, the fat content of the cheese ready for packing was found to be 23.67% (Table 7, 8). This investigation concluded that cheese with these characteristics conforms with the aforementioned legal legislation values. We believe that it is appropriate to standardize the fat content of herby cheeses to at least 20% and no more than 25%.

The Cheese Communiqué (18) specifies a maximum salt concentration of 5% in dry matter in Tulum Cheese. Tulum Cheese should include no more than 2.25% salt. Salt content is reported at a maximum of 7.5% in the Herby Cheese Standard (43) and 6.9% in the Van Herby Cheese Geographical Indication document (Protected Designation of Origin, PDO). In their investigation of herby cheese samples collected from sales points in Siirt city center, researchers discovered that the salt level in the dry matter of the cheeses was at least 1.1%, with a maximum of 4.5% and an average of 2.9%. Considering the values published in earlier investigations, two research articles indicated that herby cheese samples obtained at the point of sale contained less than 3% salt (22,27). Other study studies have indicated that the percentage salt value in cheese samples collected at sales points is greater than 3% and, in most cases, greater than 10% (22,23,25-27,30,31,44). In this investigation, salt was added to the crumbled curd at a rate of 1% (w/w) of the curd weight after the herb was added but before the second pressing. The salt content of the cheese that was ready for packaging following the second pressing was discovered to be 2.63%. Using the same amount of salt before the first press, the salt content of the cheese was confirmed to be 2.3%. (Table 9). We also found that adding 1% salty sour whey made the curd 1% saltier after the first press (Table 4). In this experimental study, the cheese was manufactured with 2% salt for no more than 24 h. We feel that utilizing less salt in this proposed process model allows us to create hygienic cheese. More in-depth investigation into adding salt to the sour whey employed in our proposed method would shed more light on the problem.

In experimental experiments on herby cheeses, a variety of cheesemaking procedures were explored. For example, Kavaz et al. (45) soured raw milk at room temperature for 24 h before heating it at 90-95°C for 30 min to produce coagulum, and the clot was drained by placing it in a clot bag. The cheese was then packed after being seasoned with herbs and salt. In the study, no pressure was applied on the curd, hence the suspended straining time was not recorded. This production method has been utilized to study the changes generated by the herbs used in the creation of herby cheese during the ripening process. Because the applications and production processes in this study and ours are so different, it was deemed inappropriate to compare the findings. According to Tarakci et al. (46), milk was pasteurized at 65˚C for 30 min. A 1% starter culture was added to the pasteurized milk at 32˚C and left for 60 min before rennet inoculation and 90 min of coagulation. The herb was added to the curd at a rate of 2% of the milk used, after which the curds were drained. The whey drainage time was not provided in the study. After pressing for 2 h to drain the whey, the curds were cut into 7 × 7 × 5 dimensions and dry salted at 6% of their weight. After 2 d at ambient temperature, the salted cheeses were vacuum-packed and left to ripen at 4±1°C for 90 d. Our investigation used Herby Tulum Cheese rather than vacuum molded cheese. In our investigation, the curd was subjected to a two-stage pressure, with the herb and salt added to the crumbled curd before the second press. The two studies used distinct process applications.

Studies on Turkish Tulum Cheeses suggest a wide range of processing applications, as shown below. Çakır and Çakmakçı (50) studied the impact of black pepper on the ripening of Tulum Cheese. After the raw milk was fermented and the curd was broken, it was stored at 20°C for 24 h to allow it to naturally filter and enhance its acidity. The cheese has

been then crushed and packaged after being kept in a clot bag for 10 d and 15-18 d, respectively. Black pepper has also been added. Kurt and Akyuz (30) described how they made traditional Van herby cheese. According to the recipe, raw milk is fermented for two h, the curd is blended with herbs, and drained for three to four h. The curd is cut into 2 cm thick slices and dry salted. The molds, which are stored in salt for 3-4 d, were rinsed with plenty of water and set in cubes. The molds are filled with pre-prepared cacık, leaving no air space. The study describes the cheese packaged with Jaji (cacik in Turkish) and reports a production duration of about 5 d. Ocak et al. (19) and Tuncturk et al. (34) created herby cheese in both traditional and industrial styles using Eve's milk and various milk mixes. Raw milk is traditionally fermented at 32°C. The studies do not describe clot cutting. After cutting the curd, some whey was taken from the clot, although the exact amount was not specified. The curd was then subjected to a 2% milk press for 3 h. The curd from the press was sliced into 7 x 7 x 2 cm pieces and ripened in 14% (w/v) brine at 4°C for 180 d. In the study, where different processes were reported to be used in the traditional approach, only milk pasteurization and the addition of starter culture were specified when discussing an industrial method. In the study, brine ripening was carried out for up to 180 d. The study was reported in two successive journals (19,34). The original article said that on the second day of ripening for Eve's milk cheeses, the pH was 5.12, the acidity (lactic acids) was 0.92%, the dry matter was 46.67%, the salt was 3.63%, and the fat was 22.25%. Sagun et al. (47) ripened the cheese they made by pasteurizing cow milk in brine. Tarakci and Kucukoner (48) also pasteurized cow's milk, added starting culture, drained the clot, added herbs, and ripened the sliced cheese in brine after 2 h of pressing (pressing weight was not mentioned). Emirmustafaoglu and Coskun (44) also made herby cheese with starter culture from pasteurized cow's milk, matured it in brine, and vacuum packed it. This brine-ripened cheese could be Van Herby. However, Siirt herby cheese is not brine-ripened and has a distinct production style, with visual, physical, and scent elements similar to Turkish Tulum Cheeses. For this reason, it was deemed inappropriate to present our findings in light of the research articles whose technique sections were summarized above due to material and method incompatibility with our study.

In an experiment with Izmir Tulum Cheese, raw Eve's milk was utilized in manufacture. Pressure was used to extract the whey from the clot (25 kg.m-2). When the dripping ceased, the press was removed, and the curd was dry salted with 1.6% salt. Fermentation took place at 18-22°C for 24 h. The cheese molds were then pre-ripened in a 12% brine at 14-15°C for one week. In the trial, cheese production lasted at least 8 d (51). It also takes almost ten d to make traditional Tulum Cheese. Sengul and Cakmakci (52) conducted a study in which they investigated some features of Tulum Cheeses manufactured from raw and pasteurized cow's milk and aged in various packaging materials. The researchers discovered that raw milk cheese transferred more nutrients to whey during cheese production than pasteurized milk cheese. Hayaloglu et al. (53) created Şavak Tulum Cheese using raw Eve's milk in a traditional technique lasting over 10 d. The researchers left the raw milk at room temperature for one day to self-acidify. To our understanding, self-acidified raw milk cheeses may not be appropriate for technical, technological, hygienic, or standard manufacture. Because each milk's flora differs, the toxin-producing flora may introduce poisons into the milk. Furthermore, packing following a production procedure that lasts longer than 24 h may not be technologically recommended. Demir et al. (54) did not include information about the cheese manufacturing process in their study on the effects of potassium sorbate addition on Şavak Tulum Cheese. Arslaner and Turkmen (55) claimed that Erzincan Tulum Cheese did not achieve the economic value it deserved owing to a lack of manufacturing standards and did not contribute adequately to the region's socioeconomic development. An appropriate industrial production model has yet to be devised for Erzincan Tulum Cheese, a local cheese that is made and traded more than Siirt herby cheese.

Cheese's microbiota ensures that it ripens. The local flora causes fermentation and ripening in raw milk cheeses. Additionally, the microbiota of milk that survives pasteurization or becomes contaminated later plays a role in the pasteurized milk cheese process. However, with cheeses added as starter culture and/or adjunct culture, ripening proceeds in a more controlled manner, and the desired characteristic features are more visible in the cheese. During the cheesemaking process, the quantity of starter cultures increases significantly. However, the culture's viability declines with time due to lactose depletion, salt addition, low pH, and low ripening temperature. Starter autolysis releases nutritious and enzymatic microbial components into the cheese matrix. During maturation, the NSLAB count can rise to 8 log g/cfu in 3-9 months. Depending on the species and strain, the flora members' metabolic activities have been shown to induce flaws in cheese quality, unsuitability, or the production of typical cheese scents (56). Traditional cheeses are known to be made mostly from raw milk. Each of these cheeses is manufactured regionally and seasonally, based on the experience of the cheesemakers and the conditions in which they are made, all within their own historical processes. Furthermore, while these cheeses were traditionally consumed locally by their producers, they are now also consumed by city dwellers. Disadvantages may arise due to variances in customer sensitivity and the hygienic profile of the cheeses on sale.

To ensure hygienic and aromatic properties, the milk to be made into cheese must be pasteurized, followed by the addition of a starter and/or auxiliary culture. When viewed from this angle, it may be a more accurate technique to create the beginning culture from the original traditionally manufactured cheese samples. Such a starter culture can facilitate the technological creation of traditional cheese kinds. Because semi-hard cheeses, such as Tulum Cheeses, ripen in their packaging, raw milk may not be appropriate for use in manufacture. Tarakci et al. (46) created brined Van herby cheeses with starter culture (1:1 ratio *Lactococcus lactis subsp. lactis* and *L. lactis subsp. cremoris*) from Christina Hansens in Denmark. Yerlikaya and Akbulut (51) employed a

starter culture for Izmir Tulum Cheese that contained *L. lactis subsp. lactis* and *L. lactis subsp. cremoris* (1:1) (Maysa CM11, Mystarter, Tuzla-Istanbul). The researchers employed *Enterococcus faecium* and *Enterococcus durans* strains from the same type of raw milk cheese as auxiliary cultures. Researchers discovered that the bacteria, which had no detrimental effects on cheese, might be introduced to cheese to benefit from its probiotic characteristics. Arıcı and Şimşek (57) found high amounts of coliform bacteria and coagulase-positive *Staphylococcus aureus* in Tulum Cheese made from raw milk during the 16th week of ripening. Researchers discovered that using pasteurized milk and starter culture improved the cheese's sanitary quality. According to Ates and Patir (58), using a combination starter consisting of *Lactobacillus lactis subsp. lactis, L. lactis subsp. cremoris,* and *Leuconostoc mesenteries subsp. mesenteriodes* would have improved the profile of Tulum Cheese. Gulmez et al. (36) reported that using pasteurized milk can ensure the cheese's sanitary quality; however, raw milk cheeses cannot. Researchers made Siirt Herby Tulum Cheese from pasteurized milk without needing a starting culture. The samples were permitted to ripen at 4˚C for 120 d, in contrast to raw milk cheeses. The researchers discovered that, while the acidity and pH changes were weaker in raw milk cheeses than in raw milk cheese, a fermentative and/or ripening flora emerged and began to ripen the cheeses after the 30th day. We could not find a study on the use of starter cultures in Herby Tulum Cheeses. Although no defined starter or auxiliary culture was utilized in this investigation, a fermentative or ripening culture was created using the microflora of traditional Siirt herby cheeses sampled at retail establishments. Because the primary goal of the study was not to cultivate microorganisms, a poorly isolated culture was used. A mixed culture of unidentified lactic acid bacteria capable of growing and lowering the pH of milk and whey to 4 was employed as starter and whey souring cultures. So, selection and identification of the culture microorganisms appropriate for use in the herby tulum chese process have to be made in more extensively studied works. As the result of such studies, it could be useful to develop a starter culture that can be used in the industrial production of Siirt herby cheese. We believe that the culture to be used should also be specific to preserve the product's unique qualities.

We couldn't locate any process development studies on Siirt herby cheese yet. So, we profited from the analysis results of previous research that studied the status of cheese samples collected from sales locations (7,23,24,28,36,59). We attempted to create an industrially relevant method utilizing the legal reference values (8,40,49). The proposed process and associated parameter values are provided below.

The industrial manufacture of Siirt Herby Tulum Cheese involves the following stages:

a. Pasteurization: One min at 72˚C.

b. Add starter culture (3%) to milk at 37°C and wait 30 min.

c. Coagulum production: Process at 32°C for 90 min.

d. Clot preparation: Cut the coagulum into 1 x 1 x 1 cm pieces and let 45 min for syneresis.

e. Perform 15 min of self-drainage in a bundle-shaped straining clot.

f. To sour the clot, add equivalent weights of sour whey to the crushed curd and leave for 30 min.

g. Second self-drainage: 15 min in a bundle-shaped straining clot.

h. For the first press, apply half the milk weight to the curd in a bundle-shaped straining clot for 90 min.

i. To add salt and herbs, mix 1% of the curd's weight and 20% of the milk solids evenly into the crumbled curd.

j. The second press involves applying half the weight of milk to the curd in a bundle-shaped straining clot over a 12-hour period. Packaging: Crumbled cheese was packed tightly with no air gaps.

k. Ripening: As per rules (40, 43, 49).

As a result, and most likely for the first time, this study proposes a process design suitable for the industrial manufacturing of a typical Herby Tulum Cheese. With this system, it was discovered that cheese production may be completed within 24 h. It was thought that utilizing pasteurized milk and starter culture would minimize the salt content of the cheese. It was discovered that two-stage pressure application reduced fat loss in cheese. Adding sour whey to the curd after the first pressing improved the efficacy of the second pressing and helped achieve the necessary dry matter level (at least 45%) in the cheese. The cheese made meets the values specified in the legal regulations. Before implementing the suggested procedure, its adaptability to milk, climate, environment, and other factors influencing cheese quality should be thoroughly investigated. We believe that further research will lead to the development of this procedure, which will then be applied to various cheeses.

ACKNOWLEDGMENT

We thank the Siirt University Agriculture and Livestock Specialization Coordination Center for their efforts and financial support. This study was part of a project funded by Siirt University as part of the SİU specialized programs (Project No. 2022-İHTVET-04).

CONFLCT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

1. Türkiye İstatistik Kurumu. Yıllık Süt Üretimi. TÜİK Kurumsal (tuik.gov.tr). Alınma tarihi: 15.11.2023.
2. İzmen ER, Kaptan N. (1996). Doğu Illerinde Yapılan Mahalli Peynirlerden Otlu Peynirler Üzerine Araştırmalar. Ankara Üniv Ziraat Fakültesi Yayınları, 45 s, Ankara-Türkiye.
3. Durlu Özkaya F, Gün İ. (2007). Anadolu'da Peynir Kültürü. ICANAS 38 Uluslararası Asya ve Kuzey Afrika Çalışmaları Kongresi, Eylül, 10-15. Ankara-Türkiye.
4. Hayaloglu AA, Fox PF. (2008). Cheeses of Türkiye: 3 Varieties Containing Herbs or Spices. Dairy Sci Technol. 88: 245-325.
5. Örmeci Kart MÇ, Demircan V. (2014). Dünya'da ve Türkiye'de Süt ve Süt Ürünleri Üretimi Tüketimi ve Ticaretindeki Gelişmeler. Akademik Gıda. 12(1): 78-96 (article in Turkish with an English abstract).
6. Dağdelen, Ş. (2010). Otlu Peynire Katilan Önemli Ot Türlerinin Antimikrobiyel, Antioksidan Etkileri, Aroma Profili ve Bazi Kimyasal Özelliklerinin Belirlenmesi. Inönü Üniversitesi Fen Bilimleri Enstitüsü, Gıda Mühendisliği Bölümü, Malatya. (thesis in Turkish with an English abstract).
7. Doğan N. (2012). Siirt İlinde Üretilen Siirt Otlu Peynirinin Bazı Özelliklerinin Belirlenmesi, Yüksek Lisans Tezi, Harran Üniversitesi Fen Bilimleri Enstitüsü, 108s, Şanlıurfa. (thesis in Turkish with an English abstract).
8. Anon. (2018). Van Otlu Peyniri Menşe Tescili. Van Sanayi ve Ticaret Odası, Van (article in Turkish with an English abstract).
9. Ünsal A. (2003). Süt Uyuyunca - Türkiye Peynirleri. Yapı Kredi Yayınları, İstanbul-Türkiye. (Book in Turkish).
10. Akkoç Z. (2016) Otlu Peynirlerde Histamin Düzeyi ve Mikrobiyolojik Kalitenin Araştırılması. Yüksek Lisans Tezi. Fırat Üniversitesi Sağlık Bilimleri Enstitüsü, Elazığ. (thesis in Turkish with an English abstract).
11. Andıç S, Tuncçürk Y, Javidipour I, Gençcelep H. (2015). Farklı Otların Otlu Peynirin Biyojen Amin Içeriği ve Bazı Özellikleri Üzerine Etkisi. Gıda. 40(1): 1-8 (article in Turkish with an English abstract).
12. Şenel E, Yildiz F, Yetişemiyen A, Durlu-Özkaya F, Öztekin FŞ, Şanlı E. (2012). Evaluation of The Biogenic Amine Content and Some Chemical and Microbiological Properties of Urfa and Van Herby Cheeses. Kafkas Univ Vet Fak Derg. 2012; 18 (4): 537-544.
13. Bakırcı İ, Türel İ, Aksoy A, Coşkun H. (1998). Changes in Nitrate and Nitrite Contents of Herby Cheese with Different Herb Concentrations During Ripening. Bulletin of Pure and Appl Sci. 17(1): 1-7.
14. Özbek H, Aksoy H, Uğraş S, Öztürk G, Türkdoğan K, Tuncer İ. Van Otlu Peynirinin Sıçan Sindirim Sistemi ve Bazı Kan Parametreleri Üzerine Etkisi. Genel Tıp Derg. 2015; 15(1): 5-10 (article in Turkish with an English abstract).
15. Ocak E, Köse Ş. (2016). Van Otlu Peynirinin Üretimi ve Mineral Madde Içeriği. Gıda, 40(6): 343-348 (article in Turkish with an English abstract).
16. Türk Gıda Kodeksi (2011). Hayvansal Gıdaların Resmi Kontrollerine Ilişkin Özel Kuralları Belirleyen Yönetmelik. Gıda Tarım ve Hayvancılık Bakanlığı, Ankara-Türkiye.
17. Türk Gıda Kodeksi (2011). Mikrobiyolojik Kriterler Yönetmeliği (3 Mükerrer). Gıda Tarım ve Hayvancılık Bakanlığı, AnkaraTürkiye.
18. Türk Gıda Kodeksi (2017). Çiğ Sütün Arzına Dair Tebliğ (Tebliğ No: 2017/20). Gıda Tarım ve Hayvancılık Bakanlığı, Ankara.64
19. Ocak E, Tunçtürk Y, Javidipour I, Köse Ş. (2015). Farklı Süt Türlerinden Üretilen Van Otlu Peynirlerinde Olgunlaşma Boyunca Meydana Gelen Değişiklikler: Mikrobiyolojik Değişiklikler, Lipoliz ve Serbest Yağ Asitleri. YYÜ Tarım Bil. Derg. 25(2): 164-173 (article in Turkish with an English abstract).
20. Andic S, Genccelep H, Kose S. (2010). Determination of Biogenic Amines in Herby Cheese. Int J Food Prop. 13(6): 1300-1314.
21. Ekici K, Okut H, İşleyici Ö, Sancak YC, Tuncay RM. (2019). The Determination of Some Microbiological and Chemical Features in Herby Cheese. Foods. 11;8(1): 23-34.
22. Hallaç B. (2021). Bitlis Otlu Peynirlerinin Bazi Önemli Fizikokimyasal ve Biyokimyasal Özelliklerinin Gida Güvenliği Yönünden Incelenmesi. EJONS International J Math Eng Natural Sci, 5 (17): 139-147. (article in Turkish with an English abstract).
23. Hallaç B, Güçer Y, Kılınççeker O, Poyrazoğlu ES. (2021). Geleneksel Siirt Peynirlerinin Mikrobiyolojik Kimyasal ve Fiziksel Özelliklerinin Belirlenerek Halk Sağlığı Açısından Değerlendirilmesi. ADYÜTAYAM. 9(1): 61-72 (article in Turkish with an English abstract).
24. Ektiren D, Güneş S, Vardın H. (2020). Siirt ve Çevresinde Üretilen Otlu Peynirlerin Fizikokimyasal Mikrobiyolojik ve Duyusal Özelliklerinin Belirlenmesi. HRU Muh Derg. 5(3): 260-267 (article in Turkish with an English abstract).
25. İşleyici Ö, Akyüz N. (2009). Van Ilinde Satışa Sunulan Otlu Peynirlerde Mikrofloranın ve Laktik Asit Bakterilerinin Belirlenmesi. YYÜ Vet Fak Derg. 20(2): 59-64 (article in Turkish with an English abstract).
26. Tekinşen KK. (2004). Hakkâri ve Çevresinde Üretilen Otlu Peynirlerin Mikrobiyolojik ve Kimyasal Kalitesi. Vet Bil Derg. 20 (2): 79-85 (article in Turkish with an English abstract).
27. Oğur S, Duruk M. 2021. Bitlis Otlu Peynirinin Besin Kompozisyonunun ve Kimyasal Bileşiminin Standartlara Göre Değerlendirilmesi. Food and Health, 7(2): 91-102 (article in Turkish with an English abstract).
28. Gülmez M, Yıldız Bayhan K, Üner S. (2022). Technical, Physical, Chemical and Microbiological Analyses of Siirt Herby Cheese. Bozok Vet Sci. 3(2): 33-39.
29. Tunçtürk, M., Tunçtürk, R. (2020). Van Otlu Peyniri ve Yapımında Kullanılan Bitkiler ile İlgili Genel Bir Değerlendirme. ISUBÜ ZFD Türkiye 13. Ulusal, I. Uluslararası Tarla Bitkileri Kongresi Özel Sayısı:238-244.
30. Kurt A, Akyüz N. (1984). Van Otlu Peynirinin Yapılışı ve Mikrobiyolojik Fiziksel ve Kimyasal Nitelikleri. Gıda. 9(3): 141-146 (article in Turkish with an English abstract).
31. Coşkun H, Öztürk B. (2021). Otlu Peynirler Adı Altında Üretilen Peynirler Üzerinde Bir Araştırma. Gıda Müh Derg. 10: 19-23 (article in Turkish with an English abstract).
32. Durmaz H, Sagun E. (2004). Otlu Peynirlerin Üretim ve Olgunlaşma Sürelerinin Listeria Monocytogenes'in Üremesi Üzerine Etkileri. Vet Bil Derg. 20(2): 87-93. (article in Turkish with an English abstract).
33. İşleyici Ö, Sancak YC. (2005). Van Otlu Peyniri. YYÜ Sağlık Bil Dreg. 8(1-2): 48-58 (article in Turkish with an English abstract).
34. Tunçtürk Y, Ocak E, Köse Ş. (2014). Farklı Süt Türlerinden Üretilen Van Otlu Peynirlerinin Fiziksel ve Kimyasal Özellikleri Ile Proteoliz Profillerinde Olgunlaşma Sürecinde Meydana Gelen Değişimler. Gıda. 39(3): 163-170 (article in Turkish with an English abstract).
35. Kara S, Köse Ş. (2020). Geleneksel Yöntemle Üretilen Otlu Peynirlerin Bazı Kalite Özelliklerinin ve Biyoaktivitesinin Belirlenmesi. Gıda. 45(5): 942-953 (article in Turkish with an English abstract).
36. Gülmez M, Bayhan KY, Üner S. (2023). Efects of Pasteurized Sheep's Milk Use on Production and Maturation of Siirt Herby Cheese. Bozok Vet Sci. 4(1):1-11.

37. Turkish Standards. (1994). Rennet (TS 3844), Turkish Standards Institute, Ankara-Türkiye.
38. Sadler GD, Murphy PA. (2003). pH and Titratable Acidity. In: Food Analysis. p207-225, Springer, New York.
39. Türk Standartları. (2015). Peynir - Yağ Muhtevası Tayini - Van Gulik Yöntemi (TS ISO 3433). Türk Standartları Enstitüsü, Ankara. (article in Turkish).
40. Türk Standartları. (2014). Peynir ve İşlenmiş Peynir- Toplam Kuru Madde Içeriği Tayini (TS EN ISO 5534/AC). Türk Standartları Enstitüsü, Ankara. (article in Turkish).
41. Türk Standartları. (2007). Peynir ve Eritme Peynir Ürünleri- Klorür Miktarı Tayini- Potansiyometrik Titrasyon Metodu (TS EN ISO 5943). Türk Standartları Enstitüsü, Ankara. (article in Turkish).
42. Pouch DF, Ito K. (2001). Compendium of Methods for the Microbiological Examination of Foods. American Health Association, Washington DC.
43. Türk Standartları. (2016). Otlu Peynir Standardı (Standart No 13205). Türk Standartları Enst, Ankara. (article in Turkish).
44. Emirmustafaoğlu A, Coşkun H. (2012). Keçi Sütü Inek Sütü ve Bu Sütlerin Karışımından Yapılan Otlu Peynirlerde Olgunlaşma Boyunca Meydana Gelen Değişimler. Gıda. 37(4): 211-218 (article in Turkish with an English abstract).
45. Kavaz A, Bakırcı İ, Kaban G. (2013). Some Physico-chemical Properties and Organic Acid Profiles of Herby Cheeses. Kafkas Üniv Vet Fak Derg. 19 (1): 89-95.
46. Aydın E, Tarakçı Z. (2021). Effects of Different Types of Herbs on Colour and Texture Properties of Kashar Cheese. Food and Health. 7(2): 120-127.
47. Sağun E, Tarakçı S, Sancak H, Durmaz H. (2005). Salamura Otlu Peynirde Olgunlaşma Süresince Mineral Madde Değişimi. YYÜ Vet Fak Derg. 16(5): 21-25 (article in Turkish with an English abstract).
48. Tarakçı Z, Küçüköner E (2006). Farklı Yağ Oranına Sahip Sütten Üretilen Van Otlu Peynirlerinde Olgunlaşma Süresinde Meydana Gelen Değişiklikler. YYÜ Zir Fak Tarım Bil Derg. Ziraat Fakültesi, Tarım Bilimleri Dergisi (J. Agric. Sci.). 16(1): 19-24.
49. Anon. (2006). Tulum Peyniri Standardı (TS 3001). Türk Standartları Enstitüsü, Ankara. (article in Turkish).
50. Çakır Y, Çakmakçı S. (2018). Some Microbiological, Physicochemical and Ripening Properties of Erzincan Tulum Cheese Produced with Added Black Cumin (Nigella sativa L.). J Food Sci Technol. 55(4):1435–1443.
51. Yerlikaya O, Akbulut N. (2019). Potential Use of Probiotic Enterococcus Faecium and Enterococcus Durans Strains in Izmir Tulum Cheese as Adjunct Culture. J Food Sci Technol. 56(4): 2175–2185.
52. Şengül M, Çakmakçı S. (1996). Çiğ Ve Pastörize Inek Sütünden Yapılan Ve Farklı Ambalaj Materyallerinde Olgunlaştırılan Tulum Peynirlerinde Bazı Kalite Kriterleri. Süt Teknol Derg. 1: 13-21.
53. Hayaloglu AA, Cakmakci S, Brechany EY, Deegan KC, McSweeney PL. (2007). Microbiology, Biochemistry, and Volatile Composition 0f Tulum Cheese Ripened in Goat's Skin or Plastic Bags. J Dairy Sci. 90(3): 1102-21.
54. Demir P, Öksüztepe G, İncili GK, İlhak Oİ. (2017). Vakum Paketli Şavak Tulum Peynirlerinde Potasyum Sorbatın Kullanımı. Kafkas Üniv Vet Fak Derg. 23(1): 23-30.
55. Arslaner and Türkmen (2020). Erzincan Tulum Peyniri. TURJAF. 8(4): 932-940.
56. Blaya J, Barzideh Z, LaPointe G. (2018). Symposium review: Interaction of Starter Cultures and Nonstarter Lactic Acid Bacteria in the Cheese Environment. J Dairy Sci. 101(4): 3611-3629.
57. Arıcı M, Şimşek O. (1991). Kültür Kullanımının Tulum Peynirinin Duyusal, Fiziksel-Kimyasal ve Mikrobiyolojik Özelliklerine Etkisi. Gıda. 16 (1): 53-62.
58. Ateş G, Patır B. (2001). Starter Kültürlü Tulum Peynirinin Olgunlaşması Sırasında Duyusal, Kimyasal ve Mikrobiyolojik Niteliklerinde Meydana Gelen Değişimler Üzerine Araştırmalar. Fırat Üniversitesi Sağlık Bilimleri Dergisi, 15 (1): 45-56.
59. Koyuncu M, Tunçtürk Y. (2020). Evaluation of the Quality Characteristics of Siirt Herby Cheese: A Traditional Turkish Variety. JIST. 10(2): 1023-1029.

✉ **Corresponding Author:**
Murat GÜLMEZ
Siirt University, Faculty of Veterinary Medicine, Department of Food Hygiene and Technology, Siirt, TÜRKİYE
E-posta: murat.gulmez@siirt.edu.tr