Turkish Journal of Agriculture - Food Science and Technology, 14(9): 2473-2482, 2026
DOI: https://doi.org/10.24925/turjaf.v14i9.2473-2482.8886

Turkish Journal of Agriculture - Food Science and Technology

Available online, ISSN: 2148-127X | www.agrifoodscience.com | Turkish Science and Technology Publishing (TURSTEP)

Determination of Some Physicochemical and Microbiological Properties of Van Herby Cheeses Produced Using Dry Salted and Brined Methods and Offered for Sale in Istanbul Province

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ARTICLE INFO

Research Article

Received : 11.03.2026
Accepted : 13.05.2026

Keywords:
Herby cheese
Chemical properties
Microflora
Brined cheese
Staphylococcus ssp

ABSTRACT

The aim of this study was to determine the physicochemical and microbial properties of Van Herby cheese, traditionally produced at home using various wild herbs and raw milk, and offered for sale in the Istanbul market, and to evaluate the results according to the Turkish Food Codex (TFC) cheese and microbiology regulation. The findings revealed statistically significant variations in total solids, protein, and titratable acidity across the herby cheeses tested. Thirty Van Herby cheese samples (15 dry salted and 15 brined) were randomly collected from retail outlets and delivered to the laboratory under cold chain conditions. The physicochemical properties of the cheese samples were evaluated using established analytical methods. Total aerobic mesophilic bacteria (TAMB) were counted on Plate Count (PC) agar, yeasts and molds on Rose Bengal Chloramphenicol (DRBC) agar, and *Staphylococcus aureus* on Baird Parker (BP) agar, *Coliform bacteria* was enumerated on Violet Red Bile (VRB) agar, while *Listeria monocytogenes* was dedected by enrichment in Half Fraser (HF) broth, colony formation on PALCAM agar, and biochemical tests. None of the analayzed sample tested positive for *L. monocytogenes* or *Salmonella* spp. The mean bacterial load of the dry salted herby cheese were 5.16±1.15 log CFU g-1 for viable TAMB, 2.19±0.28 CFU g^{-1} for *Staphylococcus aureus*, 4.29±0.33 log CFU g^{-1} for *Coliform bacteria*, 4.03±0.80 log CFU g^{-1} for mold and 4.53±0.95 log CFU g^{-1} for yeast. However, the mean bacterial load of the brined cheeses were 5.23±0.49 log CFU g^{-1} for TMAB, 3.94±0.50 log CFU g^{-1} for *Staphylococcus aureus*, 3.45±1.01 log CFU g^{-1} for *Coliform bacteria*, 4.10±1.66 log CFU g^{-1} for mold and 4.50±1.38 log CFU g^{-1} for yeast. The mean total solids, protein, fat, salt, ash, pH, and titratable acidity values of dry-salted cheese samples were found to be 47.17±0.86%, 17.51±0.56%, 24.25±1.08%, 5.94±0.26%, 1.02±0.01%, 4.66±0.03%, and 1.54±0.08%, respectively, while the average values for brined cheeses were determined to be 49.72±1.00%, 18.50±0.57%, 22.54±0.80%, 6.36±0.18%, 1.12±0.02%, 4.79±0.05%, and 1.53±0.03%, respectively. When the findings were evaluated, it was determined that the mold-yeast, *Coliform bacteria*, and *Staphylococcus aureus* loads of the samples did not comply with the TFC microbiological criteria regulation, and that one sample did not comply with the TFC cheese regulation in terms of total solids content and two samples did not comply in terms of salt content.

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Introduction

Cheese is one of the most diverse dairy products in human nutrition, due to its high protein content (3–40 %) and rich composition of calcium, phosphorus, magnesium, zinc, and vitamins A, B2, B6, and B12 (Söylemez Milli et al., 2025). This diversity is shaped by many factors such as the type of milk used, production technology, ripening time, and plant materials added to the product. Van Herby cheese, which holds a special place among Turkey's traditional cheese varieties, is one of the seven regional products from Van province that has a geographical indication registration (registration nu, 405), and is produced mainly in Van, but also in Diyarbakır, Muş, and Bitlis provinces (Çelik et al., 2008; Söylemez Milli et al., 2025; TPTO, 2018). Produced using traditional methods for over 200 years, this cheese is notable for its use of natural aromatic herbs, its production primarily based on raw sheep's milk, and its unique ripening technique (Çelik et al., 2008).

While sheep's milk is primarily used in the production of Van Herby cheese, a mixture of goat and/or cow's milk may also be preferred in some productions. The following herbs, which grow naturally in and around Van and are known locally as sirmo/sirik (*Allium schoenoprasum* L.), heliz (*Ferula orientalis* L.), mendo (*Antriscus nemorosa*), mountain mint (*Mentha spicata*), thyme (*Thymus migricus*), and siyabo (*Ferula* sp.), are added at a rate of 2%. According to Coşkun (2024), İşleyici and Sancak (2005) and TPTO (2018), the manufacture of this cheese requires the use of six herbs in accordance withgeographical indication regulations. The other 13 herbs were (*Lepidium sativum* L.), cunk (*Ranunculus polyanthemos* L.), coven (*Saponaria officinalis*), dere otu (*Anethum graveolens* L.), tarak otu (*Dipsacus laciniatus* L.), yarpuz (*Menthae pulegium* L. *püjan*), hiltit (*F. longipedunculata*), catir (*Thymus vulgaris* L.), reyhan (*Ocimum basilium*), ciris (*Radix eremuri*), it sogani/hagiz (*Allium fuscoviolaceum*), catlangus/kormen (*Allium scorodoprasum* L. subsp. *rotundum*) and kuzu kulagi *Rumex acetosella* L.) may optionally be used.. These herbs not only give the cheese its distinct look and fragrance, but they also influence its microbiological profile via their antibacterial qualities and exert a natural biopreservative effect. In mountainous locations with limited availability of fresh herbs owing to severe winter circumstances, cheese is eaten as a rich source of vitamins and bioactive components, benefiting public health (Çelik et al., 2008; Söylemez Milli et al., 2025).

In the production of Van Herby Cheese, both commercially produced liquid rennet and traditional rennet prepared from sheep's abomasum can be used. Traditional cheese rennet is prepared by adding black pepper, ginger, cinnamon, cloves, powdered sugar, and water to sheep's stomachs, and is produced in quantities sufficient for use throughout the season. The rennet is added to raw milk heated to approximately 30°C and allowed to curdle for 1-2 hours. The resulting curd is placed in cloth bags and strained. After curd formation, 0.5–3.0 kg of sliced herbs are added to each batch of curd made from 100 kg of milk and blended to achieve a homogeneous distribution. This is followed by pressing, hand-cutting into blocks, salting, filling containers after eliminating air pockets, and three months of maturing (TPTO, 2018).(. Çelik et al. (2008) reported that the production procedure has a significantl effect on the texture and sensory qualities of the product. The production stages of Van Herby cheese are shown in Figure 1.

In recent years, research aimed at transforming cheese into a functional food has focused on the use of plant-based ingredients with strong antioxidant activity. Herb added to cheese can affect various physicochemical properties such as total solids, acidity, and color factors, all of which can influence customer preferences. Aromatic herbs such as mint (*Mentha* sp.), thyme (*Thymus* sp.), and wild garlic (*Allium* sp.), along with spices like cumin, black pepper, cinnamon, ginger, and chili peppers, enrich the product's aroma profile, extend its shelf life, and contribute to the production of safer and healthier products by suppressing the growth of pathogenic microorganisms (Setyawardani et al., 2022; Sulejmani et al., 2020). The use of plant-based additives is becoming increasingly common for purposes such as providing flavor diversity, reducing salt concentration, and supporting the prevention of physical defects. This practice holds a significant place in traditional cheese production in Türkiye, as well as in parts of Spain, Portugal, and Central Italy (Tuscany, Lazio, and Umbria) (Sulejmani et al., 2020). In the microbial flora of Van Herby cheese, microorganisms such as *Enterococcus*, *Lactobacillus*, *Leuconostoc* and *Bacillus* species, as well as yeasts such as *Debaryomyces hansenii* and *Candida zeylanoides*, were detected (Söylemez Milli et al., 2025). In another study, Ekici et al. (2019) determined the total aerobic mesophilic bacteria counts of Herby cheese samples to be between 4.0 and 8.90 log CFU g^{-1}, LAB counts ranged from less than 1 and 7.0 log CFU g^{-1}, coliform bacteria counts ranged from less than 1 and 6.08 log CFU g^{-1}, *Enterobacteriaceae* counts ranged from less than 1.00 and 5.81 log CFU g^{-1}, *Staphylococcus aureus* counts ranged from less than 1.00 and 2.60 log CFU /g^{-1}, and mold-yeast counts between 3.70 and 8.05 log CFU /g^{-1}. Coagulase-negative *Staphylococci* are a component of the normal human microbiota and rarely cause infections. However, they cause various infections, such as meningitis, which leads to high rates of mortality and morbidity in immunocompromised individuals and newborns. *Staphylococcus capitis*, *Staphylococcus warneri*, and *Staphylococcus epidermidis* are among the microorganisms that cause meningitis (Azimi et al. 2020).

The aim of this study was to determine the physicochemical and microbial properties of Van Herby cheese, traditionally produced at home using various wild herbs and raw milk, and to evaluate the results according to the Turkish Food Codex cheese and microbiology regulation (2024).

Materials and Methods

Materials

In this study, 30 cheese samples were obtained from various sales points in the Istanbul market, 15 brined and 15 dry-salted cheese samples. The cheese samples were transferred to the laboratory in sterile packaging and under cold chain conditions (3–6°C), and analyses were performed upon arrival. All analyses were performed in duplicate.

Methods

Chemical Analysis

To determine the chemical composition of Van Herby cheese samples, total solids , fat, salt, ash, protein, pH, and titratable acidity values were determined. The pH measurements were taken using a calibrated digital pH meter. The total protein content of the cheeses was determined by the Kjeldahl method, the ash content by burning the cheese sample, and the titratable acidity (lactic acid %) by the titrimetric method (AOAC, 2000). The fat (%) content of the cheese was determined by the Gerber method (Anonymous, 1969). The salt (%) content was determined by the Mohr method (Anonymous, 1988). The pH of the cheese slurry, which was weighed from 20 g of cheese samples, crushed in a mortar, and homogenized by adding 20 mL of demineralized water, was measured with a pH meter (Milwaukee Mw150, Germany) calibrated with fresh pH 4.0 and pH 7.0 standard buffer solutions (Yalman et al., 2017).

Microbiological Analyses

Ten g of Van Herby cheese samples were weighed into stomacher bags, and then 90 mL of 2% sodium citrate was added.

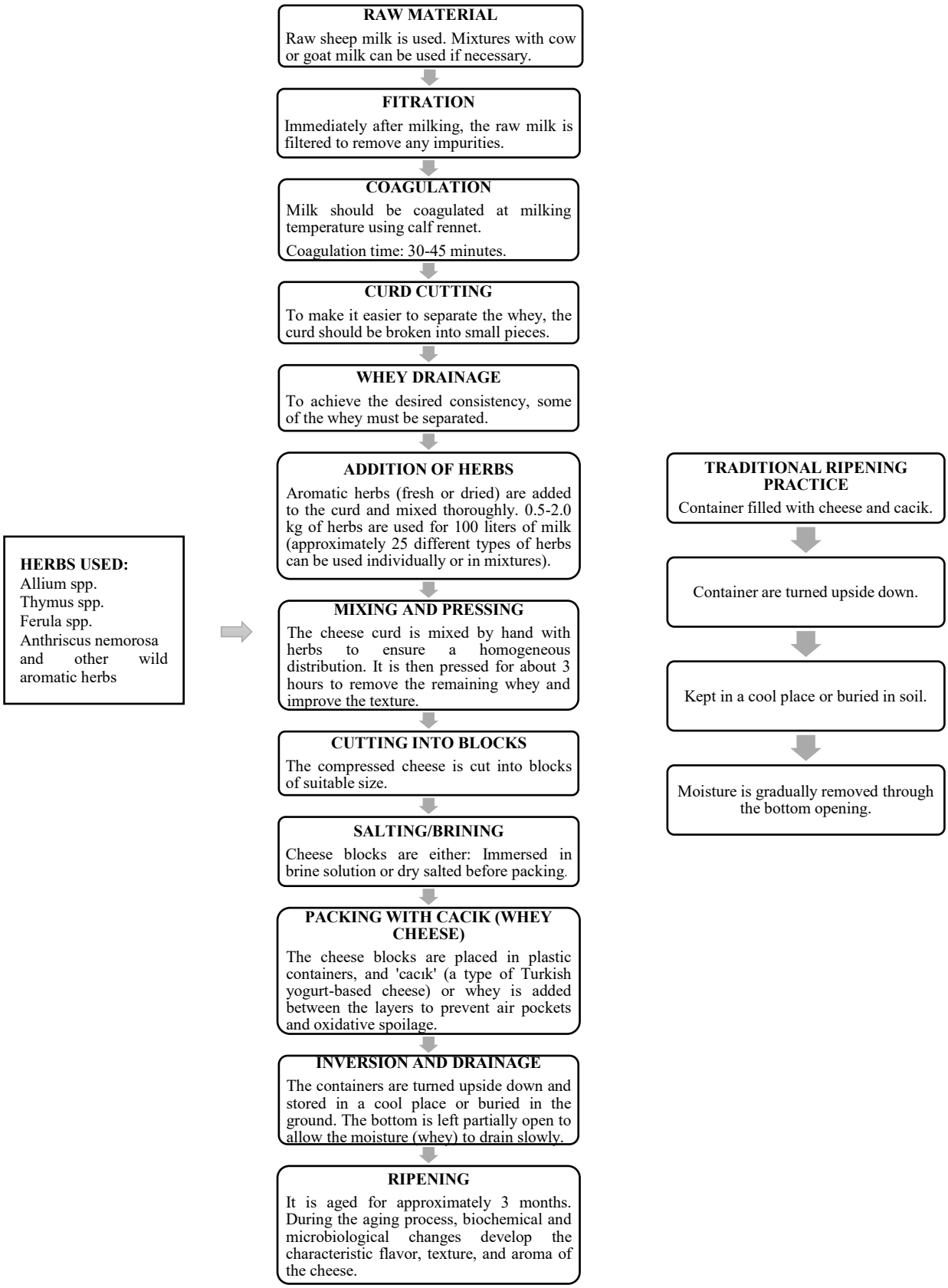


Figure 1. Production flow chart of Van Herby cheese (Tarakci et al., 2004)

The samples were then homogenized in the stomacher bags for 90 seconds. After homogenization, decimal dilutions up to 10^{-7} were prepared, and inoculations were made from these dilutions into sterile petri dishes. To evaluate total viable aerobic mesophilic bacteria (TAMB), Plate Count agar (PCA, Biokar, France) plates were incubated at 35 - 37°C for 48 hours. For yeasts and molds, Dichloron Rose-Bengal Chloramphenicol (DRBC) agar (Biokar, France) plates were incubated at 25°C for five days. For *Staphylococcus* spp., Baird Parker agar (BPA, Biokar, France) plates were incubated at 37°C for 48 hours. Colonies formed in petri dishes after incubation were counted (Ekici et al., 2019).

Listeria monocytogenes was dedected by enrichment in Half Fraser broth (HFB, Oxoid, England), followed by inoculation onto PALCAM agar (Oxoid, UK), and incubation at 37°C for 24 hours. Typical colonies were determined by biochemical tests for species identification (Kaptan, 2016). *Escherichia coli* was inoculated onto VRB agar (Biokar, France) and incubated at 35-37°C for 48 hours (Özdikmenli Tepeli and Demirel Zorba, 2017).

Statistical Analysis

All statistical analyses were performed using the IBM SPSS Statistics 22.0 software (IBM Corp., 2022). Descriptive statistics for all physicochemical and microbiological parameters were calculated and expressed as mean ± standard error (SE), together with minimum and maximum values. The study was designed to compare two independent production methods of Van Herby cheese, namely dry salted and brined cheeses. Therefore, differences between the two groups were evaluated using the independent samples t-test. Statistical significance was accepted at $p < 0.05$ (Kalaycı et al., 2023). The statistical model used for comparison of the two production methods was as follows:

$$Y_{ij}= \mu+M_i+e_{ij} \quad (1)$$

where:

Y_{ij}, represents the observed value of the related physicochemical or microbiological trait, μ is the overall overall population mean, M_i is the fixed effect of the production method (i=1, dry-salted cheese; i=2, brined cheese), and e_{ij} is the random residual error.

Correlation analyses were performed to determine the relationships among the physicochemical characteristics of Van Herby cheese samples. Correlation coefficients (r) were interpreted according to both direction and magnitude of the relationships, and statistical significance levels were evaluated at $p < 0.05$ and $p < 0.01$.

Results and Discussion

Chemical properties of cheese samples

Some basic chemical properties of Van Herby cheese samples produced by dry salted and brined methods are comparatively presented in Table 1. According to the obtained analysis results, the production technique showed statistically significant differences, particularly in total solids, protein, and titratable acidity ($p < 0.05$). The differences between the pH values of cheese samples were not statistically significant ($p > 0.05$). However, the slightly higher mean pH observed in brined samples (4.79±0.05) compared to dry salted samples may be associated with differences in buffering capacity or acid development kinetics. Also amino acid decarboxylase activity is highly dependent on pH conditions and tends to increase under acidic environments, showing maximum activity within the pH range of 4.00–5.50. The pH values of ripened herby cheeses, which are close to alkaline, can be explained by the conversion of lactic acid into carbon dioxide (Ekici et al., 2019). Previous studies on herby cheeses have reported pH values within similar ranges. For instance, Söylemez Milli et al. (2025) determined the mean pH of brined and dry-salted Van Herby cheeses as 4.68±0.57 and 5.11±0.76, respectively. On the other hand, other researchers reported similar results in our results (Akel and Alemdar, 2016; Ektiren et al., 2020; Koyuncu and Tunçtürk, 2020; Sulejmani et al., 2020).

The mean titratable acidity values of brined and dry-salted cheeses were 1.50±0.03% and 1.58±0.08%, respectively. When compared with literature data, our values were slightly higher than those previously reported (Akel and Alemdar, 2016; Ektiren et al., 2020; Koyuncu and Tunçtürk, 2020). For instance, Akel and Alemdar (2016) reported 1.41±0.03% titratable acidity. Furthermore, the titratable acidity values reported by Koyuncu and Tunçtürk (2020) and Ektiren et al. (2020) were similar to the values in our study. The relatively higher acidity in the present study may be attributed to differences in fermentation duration, starter culture usage, or salt concentration. Ekici et al. (2019) reported that ripened herby cheeses either had higher organic acid levels or lower pH values. From a biochemical perspective, the increase in titratable acidity may be associated with intensified lactose fermentation by lactic acid bacteria and the accumulation of organic acids during ripening. Simultaneously, proteolytic degradation and amino acid catabolism can partially buffer pH reduction, explaining why cheeses with relatively high acidity may still exhibit moderate pH values.

In terms of total solids content, the mean total solids values (48,92±0.86%) of dry-salted cheeses were significantly higher than those of brined cheeses (47.72±1.00%) ($p < 0.05$). The maximum total solids content in samples dry salted was 64.50%, indicating the formation of a denser structure due to moisture loss and salt diffusion. Increasing the dry matter content leads to a firmer texture and a longer shelf life. The higher total solids and protein contents observed in dry-salted cheeses may mechanistically be related to enhanced whey expulsion and reduced moisture retention during ripening. Salt applied directly to the cheese surface promotes osmotic dehydration, leading to concentration of casein and fat components within the cheese matrix. This denser protein network may also contribute to reduced proteolytic diffusion and altered textural properties during maturation. In previous studies on herby cheeses have reported a wide range of total solids content values depending on production and salting methods. Oğur and Duruk (2021) reported total solids content of 47.78±2.20% and 54.83±2.77% in brined Bitlis Herby and dry-salted cheese samples, respectively. Similarly, Söylemez Milli et al. (2025) observed the total solids content values for dry salted and brined Van Herby cheeses as 54.41±4.80% and 62.60±3.20%, respectively. Protein content was significantly higher in brined cheeses (17.34 ±0.38%) compared to dry salted samples (18.66±0.69 %) ($p < 0.05$). This difference may be associated with the concentration effect caused by serum expulsion during brining. Higher protein content enhances the nutritional value and contributes to improved structural integrity. When compared with the literature, Oğur and Duruk (2021) reported that the protein percentages for dry type and brine type Bitlis Herby cheeses were 22.24±1.81% and 16.94±2.68%, respectively, which are similar to the values in our study.

Table 1. Statistical analysis of the physicochemical properties of dry-salted and brined Van Harby cheese samples

Parameters		Dry-salted Van Herby Cheese (n=15)	Brined Van Herby Cheese (n=15)	Significance
pH	Min	4.20	4.43	
	Max	5.00	5.35	NS
	Mean	4.66±0.03	4.79±0.05	
Titratable Acidity (%)	Min	1.04	0.77	
	Max	2.34	2.07	S*
	Mean	1.58±0.08a	1.50±0.03b	
Total Solids (%)	Min	39.59	37.31	
	Max	64.50	57.11	S*
	Mean	48.92±0.86a	47.72±1.00b	
Protein (%)	Min	9.52	12.33	
	Max	26.73	20.83	S*
	Mean	18.66±0.69a	17.34±0.38b	
Fat (%)	Min	17.50	13.00	
	Max	35.00	30.00	NS
	Mean	24.25±1.08	22.54±0.80	
Salt (%)	Min	4.00	4.00	
	Max	9.00	9.00	NS
	Mean	5.94±0.26	6.36±0.18	
Ash (%)	Min	0.28	0.39	
	Max	2.32	2.28	
	Mean	1.06±0.10	1.12±0.02	NS

S*: Statistically significant (P<0.05); NS: Statistically not significant (p > 0.05)
a,b: Differences between values shown with different lowercase letters are statistically significant.

When compared with the literature, Oğur and Duruk (2021) reported that the protein percentages for dry type and brine type Bitlis Herby cheeses were 22.24±1.81% and 16.94±2.68%, respectively, which are similar to the values in our study. On the other hand, Koyuncu and Tunçtürk (2020) reported protein values slightly lower than those in our study, while Sulejmani et al. (2020) reported slightly higher values.

Fat content did not differ significantly between production methods (p > 0.05). The mean fat content of dry-salted cheeses was determined to be 24.25±1.08%, while the mean fat content of brined cheeses was determined to be 22.54±0.80%. Although dry-salted samples showed slightly higher fat levels, the difference was not statistically significant, suggesting similar milk composition was used in both production methods. Sulejmani et al. (2020) reported that the total solids content of herby cheeses ranged from 18.25% to 30.11%. Söylemez Milli et al. (2025) and Ektiren et al. (2020) reported higher values than the mean fat percentages in our study. However, the fat values reported by Akel and Alemdar (2016) were slightly lower than the results obtained in our study, but similar to those reported by Koyuncu and Tunçtürk (2020) and Oğur and Duruk (2021).

Similarly, salt and ash contents did not differ significantly between groups (p > 0.05). Mean salt values were 6.36±0.18% for brined cheeses and 5.94±0.26% for dry salted cheeses.

Although brined cheeses had slightly higher salt content, the difference was not statistically significant. The high salt content may be due to the cheeses being left in brined for a long time or being kept in a brined with a high salt content. Söylemez Milli et al. (2025) reported 7.58±0.98% (brined) and 5.81±1.20% (dry salted), while Akel and Alemdar (2016) reported higher values (8.36±0.33%). The results of this study are higher than those reported by Koyuncu and Tunçtürk (2020) and close to those of Ektiren et al. (2020). While Oğur and Duruk (2021) reported rates of 5.58±1.34% for the dry type and 4.94±1.95% for the brine type, Tekinşen (2004) reported a rate of 10.10% for the dry type Hakkari Herby cheese, which is significantly higher than the findings in our study.

The mean ash values of brined and dry salted cheeses were 1.12±0.02% and 1.06±0.10%, respectively, indicating that mineral composition was not markedly influenced by production method. Generally, the findings demonstrate that the production technique significantly affects dry matter, protein content, and titratable acidity, while having limited influence on fat, salt, ash, and pH values. Brining appears to promote a more concentrated and nutritionally enhanced matrix, whereas dry salting preserves a similar fat and mineral ratio. These differences can lead to variations in water activity levels, texture development, and ripening characteristics, resulting in diverse quality profiles in Van Herby cheese.

According to the Turkish Food Codex Cheese Regulation (2024), the minimum total solids content for cheeses and similar varieties ripened in brined should not exceed 40%, and the maximum moisture content should not exceed 60%. In this study, the majority of samples complied with the moisture limit in the regulation, remaining below the 60% threshold (Fig 2).

However, only one of the brined cheese samples was found to exceed the legal limit with a moisture content of 62.65%, while the others were largely close to or below the maximum permitted value. Generally, the cheese samples can be considered compliant with the Turkish Food Codex in terms of moisture content. However, moisture levels above 60% can increase susceptibility to microbial growth or spoilage of the product and lead to a softer texture due

to increased water activity. In particular, the brined cheese sample with a moisture content of 62.65%, which has high moisture and salt content, may indicate insufficient standardization of both production and processing procedures. Such variability can affect both product safety and physicochemical stability, highlighting the importance of process control in conventional cheese production systems. These findings emphasize the inherent variability associated with traditional Van Herby cheese manufacturing, where differences in milk composition, salting duration, herb addition, ripening temperature, and brine concentration may substantially affect product composition and quality characteristics. According to the Turkish Food Codex Cheese Regulation (2024), the maximum salt level in total solids for brine-ripened cheeses and similar products cannot exceed 7.5%. The salt levels in most cheese samples were below the permitted 7.5% limit (Fig. 3). However, in several cheese samples, both soaked in brined and dry salted, salt levels were found to be slightly above the permitted limit. These data indicate that the salt content of most samples meets the Turkish Food Codex standards. The reason for the high salt content in some samples may be due to unoptimized brined concentration, long soaking time, or inadequate control of salt diffusion kinetics. In particular, in cheeses produced using traditional methods, such as Van Herby's, the lack of consistent production processes leads to slightly higher salt levels in soaked cheeses compared to dry salted cheeses.

These findings highlight the need for effective management of brined parameters and salt diffusion processes to maintain regulatory compliance and product homogeneity.

Pearson correlation analysis was used to determine the relationship between the basic components of Van Otlu cheese samples. The findings are given in Table 2.

Pearson correlation analysis revealed several important relationships among the physicochemical properties of Van Herby cheese samples produced by dry salted and brined methods. The strongest correlation was observed between pH and acidity, showing a highly significant negative relationship ($r = -0.764$, $p < 0.01$)). This result indicates that increasing acidity is directly associated with decreasing pH values during cheese ripening, reflecting normal fermentation and organic acid accumulation processes. Ash content showed a significant positive correlation with pH ($r = 0.437$, $p < 0.05$) and a significant negative correlation with acidity ($r = -0.425$, $p < 0.05$).

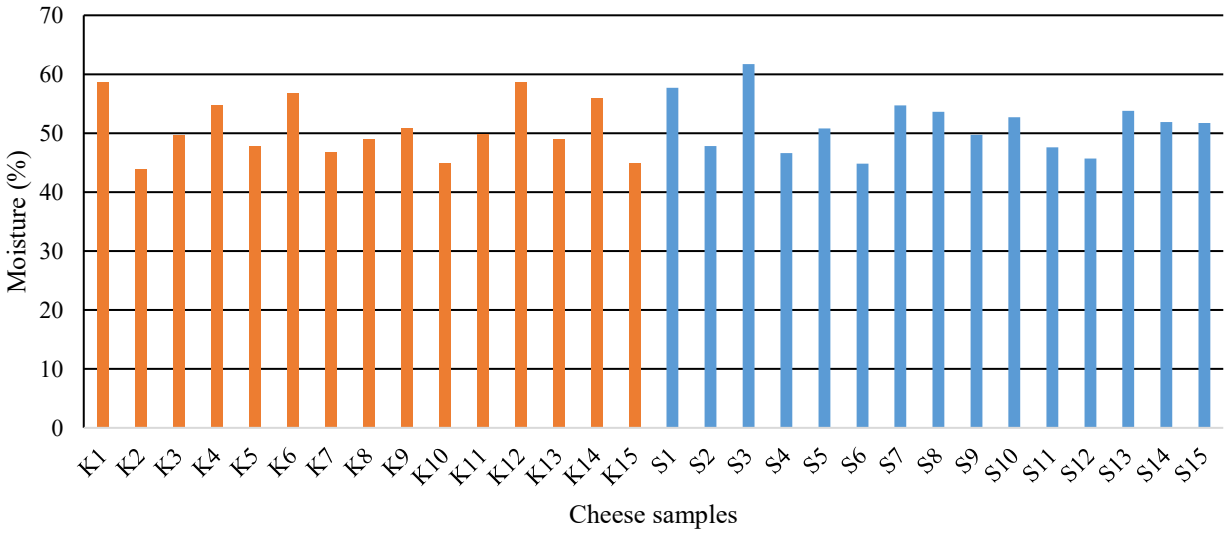
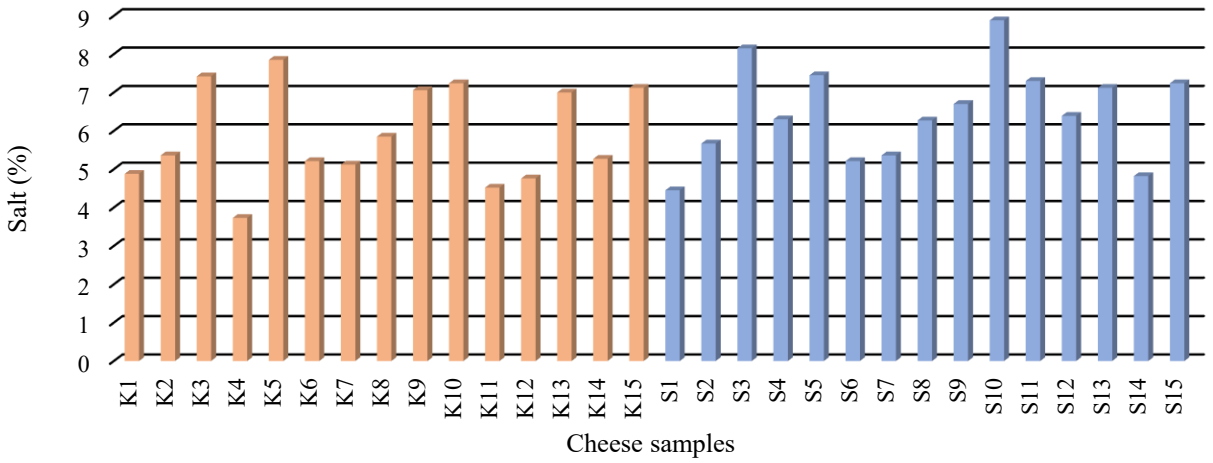


Figure 2 Moisture content percentages of Van Herby cheese



Figre 3 Salt content percentages of Van Herby cheese

Table 2. Correlation of the basic components of Van Herby cheese samples

Correlation								
		Total Solids	Ash	Salt	Fat	Protein	pH	Acidity
Total Solids	Pearson r	1.000	0.144	0.219	0.312	0.135	0.090	-0.038
	p	.	0.449	0.246	0.093	0.477	0.636	0.842
	n	30	30	30	30	30	30	30
Ash	Pearson r	0.144	1.000	-0.015	-0.075	0.046	0.437*	-0.425*
	p	0.449	.	0.935	0.693	0.810	0.016	0.019
	n	30	30	30	30	30	30	30
Salt	Pearson r	0.219	-0.015	1.000	-0.363**	0.189	0.161	0.116
	p	0.246	0.935	.	0.048	0.318	0.650	0.543
	n	30	30	30	30	30	30	30
Fat	Pearson r	0.312	-0.075	-0.363**	1.000	-0.161	-0.086	0.235
	p	0.093	0.693	0.048	.	0.394	0.598	0.211
	n	30	30	30	30	30	30	30
Protein	Pearson r	0.135	0.046	0.189	-0.161	1.000	-0.054	0.237
	p	0.447	0.810	0.318	0.150	.	0.684	0.068
	n	30	30	30	30	30	30	30
pH	Pearson r	0.090	0.437*	0.189	0.100	-0.086	1.000	-0.764**
	p	0.636	0.016	0.316	0.598	0.650	.	0.000
	n	30	30	30	30	30	30	30
Acidity	Pearson r	-0.038	-0.425*	0.116	-0.295	0.235	-0.764**	1.000
	p	0.842	0.019	0.543	0.113	0.211	0.000	.
	n	30	30	30	30	30	30	30

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 3. Microbiological properties of Van Herby cheese samples produced using dry salting and brining methods

Parameters		Dry salted Van Herby Cheese (n=15)	Brined Van Herby Cheese (n=15)	Turkish Food Codex Criteria (2025)
TAMB	Min	2.30	4.41	NS
	Max	6.74	5.95	
	Mean	5.16±1.15	5.23±0.49	
Staphylococcus aureus	Min	<2	<2	≤ 10^3 CFU/g
	Max	2.47	3.56	
	Mean	2.19±0.28	3.94±0.50	
Coliform bacteria	Min	<1	<1	
	Max	4.69	4.86	
	Mean	4.29±0.33	3.45±1.01	
Yeast	Min	1.47	2.95	≤ 10^3 CFU/g
	Max	5.82	6.57	
	Mean	4.53±0.95	4.50±1.38	NS
Mold	Min	<1	<1	NS
	Max	4.83	6.49	
	Mean	4.03±0.80	4.10±1.66	
Listeria monocytogenes	-	ND	ND	Absent in 25 g (or <100 CFU/g during shelf life)
Salmonella spp.	-	ND	ND	

NS, Not specified; ND, Not detected

These findings suggest that mineral-rich cheese samples may exhibit lower acid development due to the buffering effect of mineral components within the cheese matrix. A significant negative correlation was also found between salt and fat content ($r = -0.363$, $p < 0.05$). This suggests that the relationship may be due to the effects of moisture loss and changes in compositional concentration that may occur during ripening. Although total solids showed positive correlations with fat and protein contents, these relationships were not statistically significant ($p > 0.05$).

Overall, the results demonstrate that acidity-related parameters and mineral composition play major roles in determining the physicochemical characteristics and ripening behavior of traditional Van Herby cheese.

Microbiological properties

The microbiological properties of Van Herby cheese samples produced using dry saltied and brined methods are given in Table 3. Total aerobic mesophilic bacteria (TAMB) counts ranged from 2.30 to 6.74 log CFU g^{-1} in dry salted samples and from 4.41 to 5.95 log CFU g^{-1} in

brined samples. The average TAMB value was determined to be 5.16 ± 1.15 log CFU g^{-1} for dry salted cheeses and 5.23 ± 0.49 log CFU g^{-1} for brined cheeses.It was determined that cheeses produced by both methods have a comparable overall microbial load. The lower minimum value reported in salted samples indicates a more stable and homogeneous microbial load. Higher microbial load differences (higher standard deviations) among dry salted samples may indicate inadequate production and storage conditions or non-standardized production. Such microbiological variability is commonly considered an indicator of inconsistent hygienic practices and insufficient environmental control during artisanal cheese production. Variations in ambient temperature, ripening conditions, and sanitation protocols may significantly influence microbial succession and final product quality.The TAMB counts in Van Herby cheese samples are generally consistent with values researhed in the literature. A study by Söylemez Milli et al. (2025) on 5 dry salted and 5 brining Van Herby cheeses revealed that the TAMB count ranged from 4.14 to 6.57 log CFU g^{-1} in dry salted cheeses and from 3.17 to 6.66 log CFU g^{-1} in brined cheeses. In our study, the mean values obtained for both brining and dry salted Van Herby cheeses were found to be within this range. However, it was determined that the values obtained in our study were lower than the mean values obtained in the literature (Ekici et al. 2019; Ektiren et al. 2020; Gülmez et al. 2022; Yaman et al. 2019). The mean *Staphylococcus aureus* count was 2.19 ± 0.28 log CFU g^{-1} in dry salted samples, while it increased significantly to 3.94 ± 0.50 log CFU g^{-1} in brine-preserved samples. The increased amounts detected in brine-preserved cheeses indicate potential contamination related to production cleanliness or personnel usage practices. The presence of *Staphylococcus* spp. is generally associated with low hygiene standards, and numbers approaching 4 log CFU g^{-1} are particularly concerning due to the risk of enterotoxin formation. From a public health perspective, the presence of elevated *Staphylococcus* counts is important because *staphylococcal* enterotoxins are heat stable and may remain active even if subsequent thermal treatments are applied. Consumption of contaminated cheeses may therefore pose a potential risk of foodborne intoxication. Additionally, the brined environment may be associated with the presence of salt-tolerant *Staphylococcus* species. The predominance of Staphylococcus spp. in brined cheeses may mechanistically be associated with the selective pressure created by elevated salt concentrations. Salt-tolerant strains can survive and proliferate under reduced water activity conditions, whereas more sensitive competing microorganisms may be inhibited. This ecological shift can facilitate the persistence of halotolerant pathogenic flora during ripening.

Ekici et al. While (2019) reported an average of 0.11±0.04 log CFUg^{-1} *S. aureus* in Van Herby cheeses, Akel and Alemdar (2016) documented an average of 0.53±0.17 log CFU g^{-1} coagulase-positive *S. aureus* in white cheeses. Their findings are lower than those obtained in our study. On the other hand, Yaman et al. (2019) and Gülmez et al. (2022) found higher results than in our study. These data show that the microbiological quality of the raw materials used in cheese production, as well as the production and hygiene conditions, play a role in *Staphylococcus* contamination.

Coliform bacteria counts were 4.29 ± 0.33 log CFU g^{-1} in dry salted samples and 3.45 ± 1.01 log CFU g^{-1} in brined samples. The detection of elevated coliform levels further suggests insufficient sanitation during milking, curd handling, or post-processing stages. In traditional dairy systems, contamination may originate from inadequately cleaned equipment, poor personnel hygiene, or the use of raw milk without effective microbial control measures. The relatively lower numbers in samples in brined suggest that the high salt concentration and low water activity have a partial inhibitory effect on coliform bacteria. Nevertheless, the persistence of coliform bacteria in both cheese groups indicates that salting alone is insufficient to ensure microbiological safety. The detection of *Coliform bacteria* may reflect inadequate hygienic control and represents a potential indicator of fecal contamination and public health concern. *Listeria monocytogenes* microorganism was not found in any of the cheese samples produced using either the dry salting or brined methods. When examining the literature data regarding coliform bacteria counts in cheese samples, Ekici et al. (2019) reported an mean coliform bacteria count of 3.57±0.11 log CFU g^{-1} in Van Herby cheeses. In our study, the mean value obtained for dry salted cheese was higher than this value, while the mean value obtained for brined cheese was lower. The mean value for brined Van Herby cheeses obtained in our study was higher than the mean coliform count of 1.84 log CFU g^{-1} reported by Ektiren et al. (2020) for brined Siirt Herby cheeses. In contrast, the mean values determined in our study for both cheese types were lower than the 4.6±2.8 log CFU g^{-1} value reported by Gülmez et al. (2022) for Siirt Herby cheeses. Both cheese types in our study had higher coliform counts than the 0.10±0.05 log CFU g^{-1} reported by Akel and Alemdar (2016) for Feta cheeses.

Yeast counts were similar in both groups, mean 4.53 ± 0.95 log CFU g^{-1} in dry salted cheeses and 4.50 ± 1.38 log CFU g^{-1} in brined cheeses. This similarity indicates comparable development of fermentative microflora under both production methods. Although yeasts can enhance flavor development, their excessive proliferation can lead to surface deterioration. Excessive yeast and mold development may also indicate inadequate environmental hygiene and uncontrolled storage humidity. Particularly under traditional ripening conditions, airborne fungal contamination and poor ventilation may accelerate spoilage-related microbial growth. Mold counts were measured as 4.03 ± 0.80 log CFU g^{-1} in dry salted samples and 4.10 ± 1.66 log CFU g^{-1} in brined samples. The highest value recorded in brined samples was 6.49 log CFU g^{-1}, which can be attributed to storage variability or surface contamination, suggesting that these factors can significantly affect mold growth in cheese products. When cheese samples were evaluated in terms of mold and yeast counts, Ergün et al. (1992) reported values ranging from 1.48 to 6.00 log CFU g^{-1} in Van Herby cheeses. The results obtained in our study were determined within this range for both dry salted and brined cheeses. When these results are evaluated generally, it can be said that the mold and yeast counts obtained in our study are largely consistent with the values reported in the literature.

The results of this study and the differing findings of many other studies (Ekici et al., 2019; Ektiren et al., 2020; Gülmez et al., 2022; Söylemez et al. 2025; Yaman et al., 2019) can be attributed to the non-standardized production of plant-based cheeses and the presence of both matured and unmatured cheeses produced under unhygienic and variable storage conditions on the market (Ekici et al., 2019). Traditional small-scale cheese production systems often lack standardized starter cultures, controlled ripening environments, and uniform salt diffusion processes. Consequently, considerable batch-to-batch variation may occur in both physicochemical composition and microbiological quality parameters.

Mold growth is frequently observed in traditionally ripened cheeses, particularly those matured under non-standardized climatic conditions. Generally, the microbiological data show that average mesophilic bacteria and yeast-mold levels are within the ranges typically reported for traditional cheeses. However, attention should be paid to coliform and *Staphylococcus* spp. levels in terms of hygiene and food safety. . Although salting appears to have a limited inhibitory effect on coliform bacteria, it does not completely prevent the proliferation of salt-resistant microorganisms, particularly *Staphylococcus* spp. Increased variability and rising average coliform levels in dry salting indicate a lack of sufficient standardization in the production processes. As a result, both production techniques require improved microbiological quality, superior raw milk quality, strict hygienic processing conditions, the application of controlled starter cultures, and homogeneous ripening and storage conditions. Implementing these measures is essential to guarantee product safety, regulatory compliance, and product quality in traditionally produced Van Herby cheese. Considering that traditional herby cheeses are generally produced from raw milk and frequently marketed under artisanal conditions, microbiological hazards remain an important food safety concern. The implementation of standardized hygienic practices and controlled ripening technologies is therefore essential to reduce consumer exposure to pathogenic and spoilage microorganisms.

Conclusion

This study critically analyzes the physicochemical and microbiological properties of dry-salted and brined Van Herby cheeses produced using traditional techniques and sourced from the Istanbul market, while also examining their compliance with the Turkish Food Codex Cheese Regulation (2024). The findings show that the production process has a significant effect on total solids, protein content, and titratable acidity ($p < 0.05$), but does not significantly affect pH, fat, salt, and ash values ($p > 0.05$). Brined cheeses have slightly higher mean total solids content (47.72%) and protein content (17.34%) compared to dry-salted cheeses (48.92% and 18.66%, respectively). This suggests that the brined method may increase the concentration of the matrix during ripening due to moisture loss and salt dispersion. Assessment under the Turkish Food Codex Cheese Regulation (2024) showed that most cheese samples met the minimum total solids criterion (≥ 40%) and the maximum moisture threshold (≤ 60%).

The some sample was above the permitted moisture limit (62.65%), while a few samples were close to the legal maximum range. This indicates potential heterogeneity in moisture regulation throughout production. Meanwhile, the salt concentration of most cheese samples was within the permitted threshold of 7.5%. However, some samples were observed to have salt content slightly above the legal limit. This points to excessive salting practices related to non-standardized brined concentration, prolonged brining time, or uncontrolled salt diffusion. High salt concentrations can reduce water activity and inhibit microbial growth, while excessive salinity can negatively affect sensory quality, nutritional balance, and legal compliance.

Correlation analysis showed that acidity-related parameters and mineral composition were among the main factors influencing the physicochemical properties of Van Herby cheese. In particular, the strong negative correlation between pH and acidity confirmed the close relationship between acid development and ripening characteristics in traditionally produced cheeses.

Microbiological analyses showed that TAMB counts were comparable between dry salted and brined cheeses. This indicates similar overall microbial loads characteristic of traditional cheeses produced from raw milk. However, *Staphylococcus aureus* levels were found to be slightly higher in brined samples. This suggests that processing hygiene or manual handling may have led to contamination and a risk of enterotoxin production. In contrast, *Coliform bacteria* counts in dry salted cheeses were found to exceed the legal limit. These findings may indicate fecal contamination or inadequate hygiene control during processing. On the other hand, *Listeria monocytogenes*, a bacterium associated with foodborne illnesses, or *Salmonella* spp., encompassing many species known to cause food poisoning, were not detected in any of the samples. This observation is significant in demonstrating the absence of this important foodborne pathogen and compliance with regulatory limitations. Yeast and mold counts were comparable between production techniques and consistent with ranges documented in the literature for traditional herby cheeses. This profile also represents the characteristic fermentation and ripening microbiota of these products. The results show that Van Herby cheeses generally meet moisture criteria and possess microbial characteristics similar to traditional fermented dairy products. However, the presence of hygiene indicator bacteria, including *Coliform bacteria* and *Staphylococcus* spp., can be considered critical indicators of quality and safety risks. These findings underscore a lack of standardization in traditional production methods regarding hygienic processing and ripening regulations. To guarantee product safety, regulatory compliance, and homogeneous quality, the adoption of advanced process control strategies encompassing standardization of salting and brining parameters, the use of premium raw milk, strict hygienic production conditions, and regulated ripening and storage environments is essential. The use of starter cultures and advanced sanitation techniques can reduce unwanted microbial contamination while preserving the classic flavor characteristics of Van Herby cheese. These improvements are necessary to strengthen the sustainability, marketability, and geographical indication value of this important traditional dairy product.

Declarations

Conflict of Interest

The authors declare no conflict of interest

Author's Contribution

Ogün Değirmenici: Material collection, investigation, formal analysis, and writing the original draft

Musa Yalman: Project administration, supervision, conceptualization, methodology, review and editing

Acknowledgments

This article is derived from *Ogün Değirmenici* Master's Thesis.

References

Akel, E., & Alemdar, S. (2016). Microbiological and chemical quality of Feta Cheeses consumed in Van. *Turkish Journal of Agriculture - Food Science and Technology*, *4* (11), 999-1005. https://doi.org/10.24925/turjaf.v4i11.999-1005.950

Anonymous. (1969). Netherlands Standard NEN 3059, 2nd edition. Butyrometric determination of the fat content of cheese (Gerber-van Gulik method). *Netherlands Milk and Dairy Journal, 23* (3), 214-220.

Anonymous. (1988). IDF 12B, Determination of salt content (Morh Method).

Anonymous. (2024). Turkish Food Codex Cheese Regulation (Regulation nu: 2015/6), Ministry of Agriculture and Forestry, (Official Gazette, Nu: 29261), Ankara, Türkiye.

Anonymous. (2025). Turkish Food Codex Microbiological Criteria Regulation (Regulation nu: 41291), Ministry of Agriculture and Forestry, (Official Gazette, Nu: 32812), Ankara, Türkiye.

AOAC. (2000). Official Methods of Analysis of AOAC International. Official Method 920.124 Acidity of Cheese. Titrimetric Method.. Vol. 2, 17th ed., Gaithersburg, USA.

Azimi, T., Mirzadeh, M., Sabour, S., Nasser, A., Fallah, F. & Pourmand, M.R. (2020). Coagulase-negative *Staphylococci* (CoNS) meningitis: a narrative review of the literature from 2000 to 2020. *New Microbe and New Infec*t, *37*, 100755. https://doi.org/10.1016/j.nmni.2020.100755

Coşkun, H. (2024). Otlu peynir (2.Baskı). Astana Yayınları.

Çelik, S.E., Ozyurek, M., Altun, M., Bektasoglu, B., Guclu, K., Berker, K.I., Ozgokce, F. & Apak, R. (2008). Antioxidant capacities of herbal plants used in the manufacture of Van Herby cheese: 'Otlu Peynir'. *International Journal of Food Properties*, *11*, 747-761, https://doi:10.1080/10942910701594210

Ergün, Ö, Kamil, B., Sağun, E. (1992). The Microbiological Quality and The Mould Flora of Van Otlu (Grassy) Cheese. *Journal of Yuzuncu Yil University Veterinary Faculty*, *3* (1-2), 53-59. https://izlik.org/JA37US49XU

Ekici, K., Okut, H., Isleyici, O., Sancak, Y.C., & Tuncay, R.M. (2019). The Determination of some microbiological and chemical features in Herby cheese. Foods, 8(23), 1-11. https://doi:10.3390/foods8010023

Ektiren, D., Gunes, S., & Vardin, H. (2020). Determination of physicochemical, microbiological and sensory properties of Herbed Cheese produced in Siirt region. Harran University Journal of Engineering, 5(3), 260-267. https://doi.org/10.46578/humder.775365

Gülmez, M., Bayhan, K.Y. & Üner, S. (2022). Technical, physical, chemical and microbiological analyses of Siirt Herby Cheese. *Bozok Veterinary Sciences*, *3* (2), 33-39. https://izlik.org/JA52FF26GC

İşleyici, O. & Sancak, Y.C. (2005). Van Herby Cheese. *Journal Of Health Science of Yuzuncu Yil University*, *8* (1-2), 48-58. https://izlik.org/JA28CD38LC

Kalaycı, N., Ürkek, B., Öztürk, F., Şengül, M., & Çiftçi, E. (2023). Determination of elemental contents and microbiological and chemical properties of Çökelek cheeses consumed in Turkey. *Biological Trace Element Research*, *201*, 3069–3076, 2023. https://doi.org/10.1007/s12011-022-03374-5

Kaptan, B. (2016). Prevalence of *Listeria* spp. and *L. monocytogenes* in home made Pottery Cheese. *Journal of Tekirdag Agricultural Faculty*, *13* (01), 80-87. https://izlik.org/JA67ET68SJ

Koyuncu, M., & Tuncturk, Y. (2020). Evaluation of the quality characteristics of Siirt Herby Cheese: A traditional Turkish variety. *Journal of the Institute of Science and Technology*, *10* (2), 1023-1029. https://doi.org/10.21597/jist.635902

Oğur, S., & Duruk, M. (2021). Evaluation of nutritional composition and chemical composition of Bitlis Herby Cheese according to standards. *Food and Health*, *7* (2), 91-102. https://doi.org/10.3153/FH21011

Özdikmenli Tepeli, S., & Demirel Zorba, N.N. (2018). Frequency of extended-spectrum β-lactamase (ESBL)– and AmpC β-lactamase–producing *Enterobacteriaceae* in a cheese production process. *Journal of Dairy Science*, *101* (4), 2906-2914. https://doi.org/10.3168/jds.2017-13878

Söylemez Milli, N., Ondul Koc, E. Encu, S.B., & Cakir, I. (2025). Microbial characterization of Van Herby Cheese using MALDI-TOF MS and evaluation of starter culture potential of selected lactic acid bacteria. *Journal of Food*, *50*, 780-797. https://doi.org/10.15237/gida.GD25067

Setyawardani, T., Sumarmono, J., & Dwiyanti, H. (2022). Preliminary investigation on the processability of low-fat herbal cheese manufactured with the addition of moringa, bidara, and bay leaves extracts. *IOP Conference Series: Earth and Environmental Science*, *1012*, 012081. https://doi.org/10.1088/1755-1315/1012/1/012081

SPSS (2022). IBM SPSS Statistics 22.0 for Windows. Armonk, NY. IMB Corp.

Sulejmani, E., Sahingil, D., & Hayaloglu, A.A. (2020). A comparative study of compositional, antioxidant capacity, ACE-inhibition activity, RP-HPLC peptide profile and volatile compounds of herbal artisanal cheeses. *International Dairy Journal*, *111*, 104837. https://doi.org/10.1016/j.idairyj.2020.104837

Tarakçı, Z., Coşkun, H. & Tunçtürk, Y. (2004). Some properties of fresh and ripened herby cheese, a traditional variety produced in Turkey. *Food Technology and Biotechnology*, *42* (1) 47–50.

Tekinşen, K.K. (2004). Microbiological and chemical quality of Herb Cheese manufactured in Hakkari. *Eurasian Journal of Veterinary Sciences*, *20* (2), 79-85. https://izlik.org/JA36MT69KJ

TPTO (2018). Turkish Patent and Trademark Office. Van Herby cheese. https://ci.turkpatent.gov.tr/cografi-isaretler/detay/38299 (Erişim Tarihi: 03.11.2025).

Yalman, M., Guneser, O., & Karagul Yuceer, Y. (2017). Evaluation of some physical, chemical and sensory properties of Kasar cheese and its processed and anlogue types. *Journal of Agricultural Sciences*, *23* (1), 63-75. https://izlik.org/JA44JA92BS

Yaman, H., Yasli, B., Cakir, I., Tuncturk, Y. & Coskun, H. (2012). Chemical and microbiological properties of brined herbs used in Herby Cheese production. *Journal of Academic Food, 10* (1), 53-56. https://izlik.org/JA33JK83FH