



Effect of High Temperature Application on Mineral Matter Levels, Fatty Acids and Protein Fractions of White Cheese

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Abstract

The aim of this study was to increase the yield of white cheese by applying high temperature to milk. The average yield was determined as 17.58% in high-temperature white cheese samples and 16.40% in the control white cheese sample. During ripening periods, the average degree of ripening in cheese samples treated with a high temperature and control cheese samples was determined as 17.3% and 18.3%, respectively. It was determined that the average butyric acid amount (1.743%) white cheese samples treated with a high temperature was higher than that of the control samples (1.589%). The reason for the low rate of free fatty acids in this study may be due to the inactivation of the natural lipase enzyme of milk as a result of the high temperature applied to milk. It was determined that as the ripening times increased, the amount of both α -casein and β -casein decreased, whereas the protein degradation products increased.

Keywords: White cheese, High temperature, Starter culture, Casein fractions, Free fatty acids, Minerals

Yüksek Sıcaklık Uygulamasının Beyaz Peynirin Mineral Madde, Yağ Asitleri ve Protein Fraksiyonlarına Etkisi

Öz

Bu çalışmanın amacı süte yüksek sıcaklık uygulaması yaparak yapılan beyaz peynirin randımanını artırmaktır. Ortalama randıman yüksek sıcaklık uygulanan beyaz peynirlerde % 17.58, kontrol beyaz peynirde ise %16.40 olarak saptanmıştır. Olgunlaşma süresince yüksek sıcaklık uygulaması ve kontrol peynir örneklerinde ortalama olgunlaşma derecesi sırasıyla %17,3 ve %18,3 olarak belirlenmiştir. Yüksek sıcaklık uygulanmış beyaz peynir örneklerindeki ortalama butirik asit miktarının (%1,743) kontrol örneklerinden (%1,589) daha yüksek olduğu belirlenmiştir. Bu çalışmada serbest yağ asitleri oranının düşük olmasının nedeni süte yüksek ısı işlem uygulanması sonucu sütün doğal lipaz enziminin inaktif olmasından kaynaklanabilir. Olgunlaşma süresi arttıkça α -kazein ve β -kazein miktarının azalmasına karşılık parçalanma ürünlerinin arttığı belirlenmiştir.

Anahtar Kelimeler: Beyaz peynir, Yüksek sıcaklık, Starter kültür, Kazein fraksiyonları, Serbest yağ asitleri, Mineraller

1. Introduction

High temperature application causes protein denaturation and interactions occur between denatured proteins and casein micelles, minerals and fat globules. These interactions have both positive and negative effects on cheese production. While there is an increase in cheese yield according to denatured proteins, the interactions between them and casein micelles, this prevents coagulation and creates a weak clot structure with a long coagulation time (Singh & Waungana, 2001). In a research 5 different pasteurization norms were used and it was observed that norms other than the 10 min norm at 68°C caused an increase in the clotting time of cow's milk. It is estimated that this increase is due to the interaction of β -lactoglobulin and κ -casein, which are denatured by heat, making enzyme-substrate complex formation more difficult and decreasing the concentration of calcium ions (Koçak & Devrim, 1989). Many studies have been made on the use of culture in white cheese production (Karakuş et al., 1992; Tunail, 1999).

The fat loss in whey in cheeses made from pasteurized milk is less than in cheeses made from raw milk (Cankara & Karacaoğlu, 1983). It has been determined that the amount of dry matter passing into the whey is high when raw milk is used in making white cheese, and that the amount of dry matter in the whey is the lowest in cheese pasteurized at 85°C for 15 s and produced by adding 0.03% CaCl₂ (Şakiroğlu & Üçüncü, 1986). the effects of different pasteurization temperatures on the chemical, microbiological and sensory qualities of cheese were examined in a study by Nizamlioğlu et al. (1998). Researchers tested the cheese samples made from pasteurized milk at 65°C for 15 minutes and at 75°C for 10 minutes and at 85°C for 5 minutes.

The aim of this research was to determine the effect of different pasteurization applications on cheese quality in the production of brined white cheese.

2. Material and Method

2.1. Establishment of the experiment

In order to produce white cheese, milk standardized to 3% fat content was heated at 85°C for 5 min. and 15 min. After being pasteurized, it was cooled to 37°C. Thermophilic and mesophilic cultures were added to the pasteurized and cooled milk and incubated for 10 minutes. Subsequently 0.03-0.04% CaCl₂ was added and left for 20 minutes (pH 6.0-6.1). Liquid rennet was added and left for 90 minutes. Coagulation was achieved over a period of time. The clot that was ripe for cutting was broken and pressure was applied for 2 hours. After removing the whey, the cheeses (pH 5.8-5.9) were cut and kept in pasteurized brine with 14% bome degree for 4 hours. Cheeses whose pH levels dropped to 5.1-5.2 were placed in 2 kg boxes and pasteurized brine and adding 12.5% bome degree and ripened at +4 °C for 2 months. Traditional white cheese was used as a control application, the milk was pasteurized at 68 °C for 30 minutes, mesophilic culture and 0.015% CaCl₂ were added. Some physical and chemical analyzes were performed on the 2nd, 15th, 30th and 60th days of storage and fatty acids, casein fractions and mineral matter analyzes were performed on the 2nd (fresh) and 60th days. White cheese production was repeated twice. The treatments applied in white cheese production and sample numbers are given in Table 1. The production steps are given in Figure 1 and Figure 2.

Table 1. Treatments and sample numbers applied in cheese production

Pasteurization norm	Culture Type	CaCl ₂ (%)	Sample No
85°C / 5 min.	Thermophilic	0.03	1
		0.04	2
	Mesophilic	0.03	3
		0.04	4
85°C / 15 min.	Thermophilic	0.03	5
		0.04	6
	Mesophilic	0.03	7
		0.04	8
68°C /30 min. (cont.)	Mesophilic	0.015	9

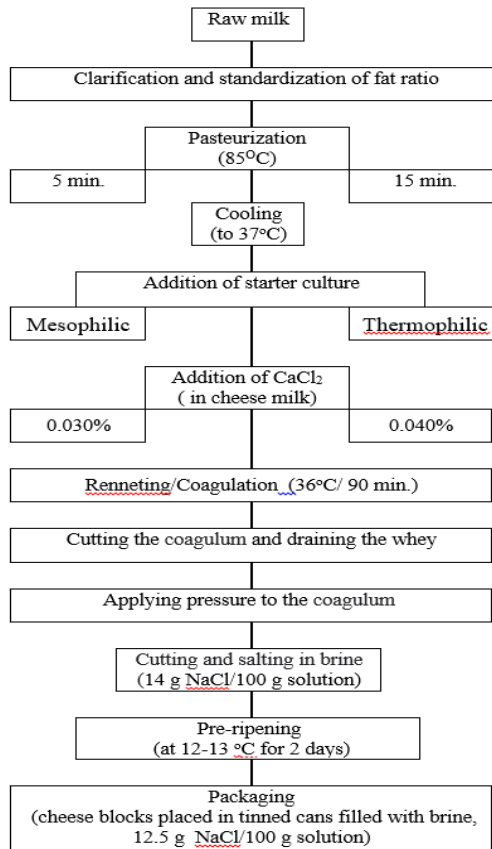


Figure 1. Experimental white cheese production steps

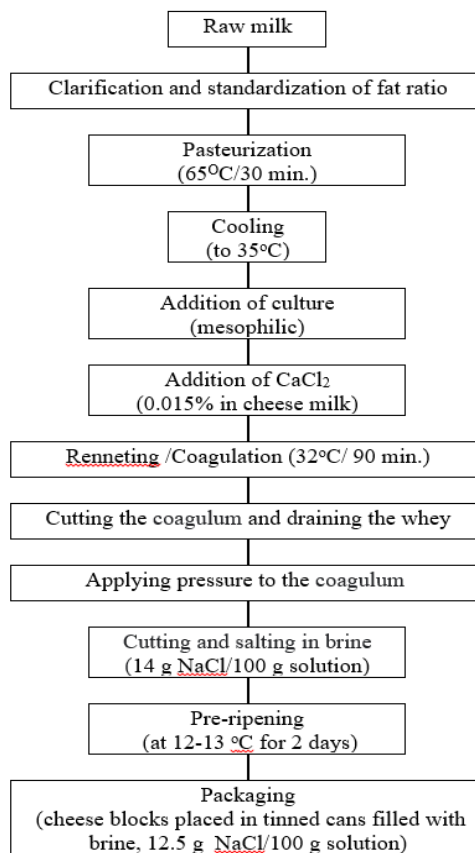


Figure 2. Control white cheese production steps

2.2. Methods

Nitrogen and water-soluble nitrogen content in white cheese samples was determined with the micro-Kjeldahl method. The degree of ripening was obtained by dividing the amount of water-soluble nitrogen in white cheese samples by the total amount of nitrogen (Kurt et al.,1996). Mineral contents of white cheeses were determined with the method specified by Naumann et al. (1983). The mini alkaline urea gel electrophoresis technique, specified by Creamer (1991), was used to determine the casein fractions of white cheese samples on the 2nd and 60th days of the ripening period. The analysis of free fatty acid, which plays an important role on the taste and aroma of cheese, was carried out by gas chromatography on the 2nd and 60th days of the ripening period (Akalin et al., 1998).

The research was carried out according to the "completely randomized block trial plan" in a factorial arrangement (2 pasteurization norms x 2 culture combinations x 2 CaCl₂ amount x 2 replications) (Yıldız & Bircan, 1994). Statistical analyzes were subjected to variance analysis with a package program and significant averages were compared with the Duncan multiple comparison test.

3.Results and Discussion

3.1 Physical and Chemical Analysis Results

3.1.1. Cheese yield

The highest yield was obtained from the cheese samples that were pasteurized at 85°C for 5 minutes and adding 0.03% CaCl₂ and thermophilic culture. The lowest yield (16.60%) was obtained from the white cheese sample pasteurized for 15 minutes at the same temperature and adding 0.04% CaCl₂ and mesophilic culture (Table 2). The average yield was determined as 17.58% in high-temperature treated white cheese samples and 16.40% in the control white cheese sample (Table 2). The yields obtained from white cheese samples treated with high temperatures were found to be higher than the control sample. This is due to the serum proteins being denatured and remaining in the cheese curd as a result of the high temperature application. Kurt & Çakmakçı (1991) reported that cheese yield is linked to milk composition, acidity, temperature application and the entire production stage. Dağdemir et al. (2003) and Pappa et al. (2006) reported that the use of different cultures had no effect on cheese yield.

Rynee et al. (2004) produced semi-fat Cheddar cheese from milk pasteurized at 72°C, 77°C, 82°C and 87°C for 26 s and analyzed after ripening. They reported that the denaturation rate of total serum proteins was 2.8%, 8.4%;20.2% and 34.1% respectively.

Hazir (1995) reported that applying heat to cow's milk at 80°C for 5 minutes and adding 0.04% CaCl₂ reduced the milk components lost with whey and therefore increased cheese yield. While Öksüz (1989) obtained the highest cheese yield of 20.033% from cheeses produced by adding 0.03% CaCl₂ to milk pasteurized at 77°C for 1 minute, Şakiroğlu (1986) reported that the highest cheese yield was obtained from cheese produced from milk pasteurized at 85°C for 15 s and adding 0.03% CaCl₂ which parallels our results.

Wolfschoon-Pombo (1997) reported that the cheese yield was 38kg/100kg when 0.01% calcium chloride was added to cheese milk,. He also stated that seasonal changes were observed and significant differences in yield occurred in the spring and summer months. Other studies have reported that high temperature application caused protein denaturation and that cheese yield increased according to denatured proteins (Guinee et al., 2004; Singh & Waungana, 2001). In their study, Celik et al. (2005) obtained the highest yield of cheese from milk that was subjected to high heat treatment which is also commensurate with the results of this study.

3.1.2.Nitrogen ratio

Nitrogen ratio is a parameter used to determine the amount of protein in cheese and calculate the degree of ripening along with water-soluble protein. Protein has the largest share in cheese solids after fat. The nitrogen content of the cheese samples varied between 1.39-2.58% (Table 2). As a result of variance analysis, the difference between CaCl₂ additions ($p<0.05$), different culture usage and maturation times ($p<0.01$) was found to be significant. The nitrogen rate in white cheeses was determined as $1.970\pm 0.023\%$ in applications with thermophilic culture and $2.116\pm 0.023\%$ in applications with mesophilic culture. The nitrogen content showed a significant ($p<0.01$) decrease during ripening and reached the lowest level on the 60th day. The highest nitrogen content (2.58%) in the present study was determined in fresh cheese samples pasteurized at 85°C for 15 min and supplemented with mesophilic culture and 0.03% CaCl₂.

In a study carried out by Gürsel et al. (1987) in which thermophilic culture and 0-0.02-0.03-0.04-0.05% CaCl₂ was added to the milk pasteurized at $72\pm 1^\circ\text{C}$ for 2 ± 0.3 min., the highest nitrogen content was achieved by adding 0.03% calcium chloride. In the control white cheese sample, the highest average nitrogen rate was obtained from fresh cheese as 2.60%, and this rate was found to be higher than that of the value determined in the trial cheese samples (Table 2). This may be due to the fact that the dry matter content of the control white cheese samples was higher than the trial white cheese samples. Lau et al. (1989) investigated the effect of pasteurization temperature on the amount of fat and protein and reported that as the pasteurization temperature increased, the amount of nitrogen remaining in the cheese increased as well. This finding did not parallel the results of this research.

3.1.3. Proportion of water-soluble nitrogen

The water-soluble nitrogen ratio uses to express ripening in cheese; They are fractions consist of small molecular weight nitrogenous components such as protein, short-chain peptide, ammonia, free amino acids and urea. The water-soluble nitrogen value varies depending on the protein and water content of the cheeses. The lowest and highest water-soluble nitrogen content in high-temperature white cheese samples was determined as 0.17% and 0.59%. In the control white cheese sample, the lowest amount of water-soluble nitrogen was determined as 0.29% and the highest was 0.51% (Table 2).

The lowest water-soluble nitrogen rate (0.17%) was found at 85°C / 5 min. pasteurization norm. The highest water-soluble nitrogen rate (0.59%) was determined at 85°C/15 min norm. As seen in Figure 3, at the beginning of the ripening, the water-soluble nitrogen rate in white cheeses produced with both cultures gave approximate values, and as the ripening period extended, a significant increase in the water-soluble nitrogen rate was observed. The increase in the amount of the water-soluble nitrogen was greater in cheeses produced with mesophilic culture. This can be sourced from high proteolysis. Guizani et al. (2006), Dağdemir and Özdemir (2008), Göncü and AlpKent (2005) and Özdemir (1990) reported in their studies that the rate of water-soluble nitrogen increases as ripening periods increase.

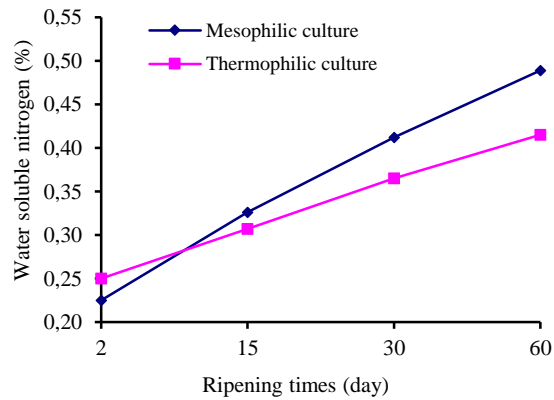


Figure 3. Different culture x ripening time interaction of water-soluble nitrogen in the cheese samples

3.1.4. Degree of ripening

The lowest and highest degree of ripening in samples were determined as 7.01% and 29.01%, respectively (Table 2). Likewise, the lowest (8.8%) and highest (29.0%) ripening degrees in control samples were determined in fresh and 2-month-ripened cheeses, respectively (Table 2). The ripening degrees of white cheese samples showed a significant increase in parallel with the increase in the amount of water-soluble nitrogen during ripening (Göncü & AlpKent, 2005). The average ripening degree of high temperature applied cheese samples and control cheese samples was determined as 17.3% and 18.3%, respectively (Table 2). This is probably due to the higher water content of white cheese samples treated at high temperatures. Çelik et al. (2005) reported that the ripening index of cheeses produced from milk treated with high temperatures was higher. It was different from our result.

3.2. Mineral Substance Analysis Results

Mineral matter (potassium, sodium, phosphorus, calcium and magnesium) analysis results of high temperature applied white cheese samples are given in Table 3.

3.2.1. Amount of calcium

The calcium content of white cheese samples treated with high temperature was between 455.51-1182.88 mg/100 g, the average was detected as 768.64 mg/100 g, and the calcium content in white cheese samples decreased as the ripening time increased. While the average amount of calcium in fresh cheeses (day 2) was 949.61±33.63 mg/100g, this amount decreased to 575.04±33.63 mg/100g on the 60th day of ripening. Other studies have reported that the amount of Ca in cheese decreases during ripening which parallels our results (Cichoscki et al., 2002; Sağun et al., 2005). In the production of high-temperature white cheese, the amount of calcium obtained in applications when 0.03% CaCl₂ was added was 686.34±33.63mg/100g while the average amount of Ca was 838.31±33.63 mg/100g, and in samples reinforced with 0.04% CaCl₂.

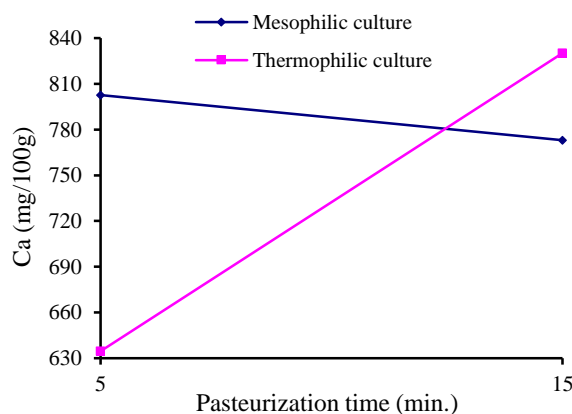


Figure 4. Pasteurization time x culture addition interaction regarding Ca content of cheese samples

Table 2. Physical and chemical analysis results of trial white cheese samples

Past. Norm	Starter culture	CaCl ₂ %	Ripening times (day)	Nitrogen (%)	Water soluble nitro. (%)	Ripening degree (%)	Efficiency (%)	
85°C / 5 min.	Thermophilic	0.03	2. (fresh)	2.06	0.26	12.67	17.85	
			15.	2.04	0.30	12.36		
			30.	1.83	0.36	21.52		
			60.	1.75	0.39	23.32		
		0.04	2. (fresh)	2.23	0.24	10.51		17.15
			15.	1.99	0.28	11.66		
			30.	1.98	0.37	19.51		
			60.	1.88	0.41	21.38		
	Mesophilic	0.03	2. (fresh)	2.20	0.24	10.89	16.95	
			15.	2.11	0.25	11.89		
			30.	1.90	0.26	14.10		
			60.	1.71	0.40	28.39		
		0.04	2. (fresh)	2.38	0.17	7.01	16.60	
			15.	2.16	0.48	22.16		
			30.	2.14	0.56	23.42		
			60.	1.90	0.59	29.01		
85°C / 15 min.	Thermophilic	0.03	2. (fresh)	2.17	0.23	12.92	18.50	
			15.	2.12	0.34	17.18		
			30.	1.97	0.37	17.63		
			60.	1.72	0.43	20.49		
		0.04	2. (fresh)	2.39	0.27	10.67	18.20	
			15.	2.09	0.32	14.30		
			30.	1.92	0.37	20.46		
			60.	1.39	0.44	25.92		
	Mesophilic	0.03	2. (fresh)	2.58	0.24	9.09	18.45	
			15.	2.09	0.30	14.81		
			30.	1.92	0.44	21.43		
			60.	1.86	0.49	23.65		
		0.04	2. (fresh)	2.36	0.25	8.48	16.95	
			15.	2.24	0.27	13.03		
			30.	2.20	0.39	17.86		
			60.	2.09	0.48	25.25		
65° C/ 30 min. (control)	Mesoph.	0.015	2. (fresh)	2.60	0.29	8.81	16.40	
			15.	2.13	0.30	13.16		
			30.	1.97	0.36	20.07		
			60.	1.69	0.51	29.41		

As seen in Figure 4, the Ca content in samples treated at higher temperatures for a longer time and using thermophilic culture was higher than those that were treated with mesophilic culture. In the control white cheese sample, the calcium content was determined as 1008.21 mg/100g on the 2nd day of ripening (fresh) and 509.01 mg/100g on the 60th day, and the average was determined as 758.61 mg/100g. It was determined that the average calcium content of white cheese samples treated with high temperature was higher than that of the control samples.

3.2.2. Amount of potassium

The average potassium content of white cheese samples treated with high temperature was determined as 114.67 mg/100g (Table 3). The potassium content of white cheese samples decreased as the ripening time increased. The average amount of potassium in the trial white cheese samples decreased during storage, and in fresh white cheeses (2nd day), this amount was determined as 138.94±4.83 mg/100g. The average potassium content was determined as 106.92±4.83 mg/100g and 121.26±4.83 mg/100g in the samples added with 0.03% and 0.04% CaCl₂, respectively. It was determined that the potassium content in the white cheese samples produced by adding a high amount of CaCl₂ (0.04%) was higher than the content of the other application (0.03%). The potassium content of control white cheese samples ranged between 87.16-159.21 mg/100g and the average was determined as 123.19 mg/100g (Table 3). The average potassium content (114.67 mg/100g) of white cheese samples subjected to the high temperature application was lower than that of the control samples. Demirci (1989) reported the potassium amount of white cheese samples as 114.6±13.41 mg/100g, and Özdemir (1990) reported it as 110-170 mg/100g.

3.2.3. Amount of magnesium

The magnesium content of white cheese samples to which high temperature was applied varied between 39.21mg/100g and 58.94 mg/100g ((Table 3). The magnesium content of the samples decreased in parallel with the prolongation of the ripening period. In the trial fresh white cheeses (2nd day), the average Mg was 56.58 ± 1.23 mg. /100g, while in ripened white cheeses (60th day) it was determined as 41.92 ± 1.23 mg/100g. Sağun et al. (2005) and Prieto et al. (2002) reported that there was a significant decrease in the amount of Mg during ripening. The Mg amounts detected in this research were higher than the values determined by Sağun et al. (2005) and Özdemir (1990).

The magnesium content of control white cheese samples varied between 43.77-60.38 mg/100g and the average was determined as 52.08 mg/100g. The average magnesium content of high temperature treated white cheese samples (49.23 mg/100g) was found to be lower than that of the control samples (52.08mg/100g). (Table 3). Demirci (1989) determined the magnesium content of white cheeses as 39.6 ± 3.48 mg/100g which is lower than the results of this research.

3.2.4. Amount of phosphorus

The phosphorus amount of the samples treated at high temperatures varied between 589.20-1378.73 mg/100g, and the average was determined as 892.55 mg/100g (Table 3.3). The graph of the interaction is given in Figure 3.3. The phosphorus content (793.95 ± 55.58 mg/100g) of white cheeses produced from pasteurized milk was higher. The phosphorus content of white cheeses produced by adding 0.03% calcium chloride was determined as 758.89 ± 55.58 mg/100g, and the phosphorus content of white cheeses produced by adding 0.04% CaCl₂ was 1003.35 ± 55.58 mg/100g. As the CaCl₂ ratio used in the production of white cheese increased, the phosphorus content also increased. The phosphorus content of fresh (2nd day) white cheeses (1009.91 ± 55.58 mg/100g) was found to be higher than the phosphorus content of ripened (60th day) white cheeses (752.33 ± 55.58 mg/100g). Other researchers have also reported a decreasing in the amount of P during ripening of cheese which parallels our findings (Cichoscki et al. 2002; Prieto et al. 2002). The P amounts obtained in the study calculated by Özdemir (1990) and Sağun et al. (2005) were higher than the values determined.

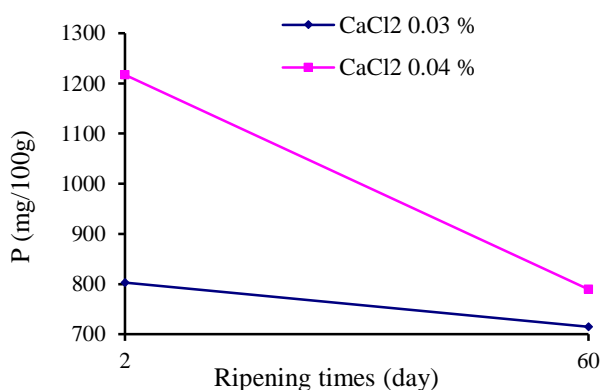


Figure 5. Pasteurization time x CaCl₂ addition interaction of phosphorus of cheese samples

As seen in Figure 5, the highest phosphorus content was determined in fresh white cheese samples (day 2) to which 0.04% CaCl₂ was added. At the end of storage, there was a highly increase in the amount of phosphorus in both CaCl₂ ratios and a decrease in the P amount. The phosphorus content of control white cheese samples ranged between 855.10-1025.68 mg/100g and the average was determined as 940.39 mg/100g. The average phosphorus content (892.55 mg/100g).

3.2.5. Amount of sodium

The sodium amount of white cheese samples treated with high temperature varied between 1335.02 mg/100g and 3606.61 mg/100g, and the average was determined as 2378.64 mg/100g (Table 3). The Na content of white cheeses produced by adding mesophilic and thermophilic cultures was 2560.57 ± 99.46 mg/100g, respectively. The average was determined as 2173.67 ± 99.46 mg/100g. As the ripening time of the cheese samples increased, the sodium content also increased. Na content was determined as 1674.70 ± 99.46 mg/100g in fresh white cheeses and 3059.54 ± 99.46 mg/100g in ripened white cheeses. This was due to the increase in the amount of Na as a result of salt intake as the ripening time of the cheese increased. Sağun et al. (2005) reported that the Na content of cheeses increased as the ripening period increased and that the Na amount, which was 2628.50 ± 94.45 mg/100g at the beginning of ripening, increased to 3459.50 ± 47.61 mg/100g on the 30th day and decreased slightly on the 90th day to 3379.50 ± 54.40 . The findings of Sağun et al. (2005) parallel our results. Özdemir (1990) reported an average content of 1627 mg/100g Na in cheeses ripened for three months. As seen in Figure 6, while the Na content was at the same level at the beginning of ripening in both culture uses, the Na content increased as the ripening period increased and it was determined that the Na content was at the highest level in the applications using mesophilic culture.

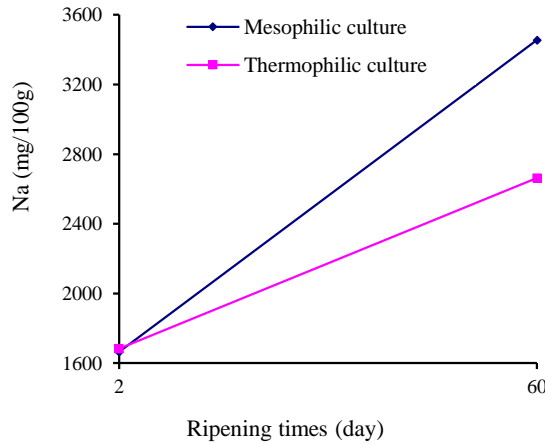


Figure 6. Different starter culture x ripening time interaction regarding Na content of cheese samples

The sodium content of control white cheese samples ranged between 1422.80-2968.70 mg/100g and the average was determined as 2195.75mg/100g. It was determined that the average Na content (2378.64 mg/100g) of white cheese samples treated with high temperature was higher than that of the control white cheese samples (Table 3).

Table 3. Mineral substance analysis results of cheese samples

Past. Norm	Starter culture	CaCl ₂ %	Ripening times (day)	Mineral substances (mg /100 g)				
				K	Na	P	Ca	Mg
85 °C / 5 min.	Thermophilic	0.03	2. (fresh)	122.72	1431.34	589.20	706.07	57.53
			60.	89.99	2595.94	710.92	455.51	43.76
		0.04	2. (fresh)	142.61	1655.09	743.58	856.33	56.37
			60.	94.41	2881.19	738.49	556.66	41.31
	Mesophilic	0.03	2. (fresh)	109.95	1335.02	858.91	959.08	57.87
			60.	82.53	3559.64	635.41	512.63	43.57
		0.04	2. (fresh)	156.37	2017.67	1378.73	1168.96	57.19
			60.	89.15	3366.78	696.37	569.55	40.56
85°C / 15 min.	Thermophilic	0.03	2. (fresh)	131.51	1478.11	948.27	849.89	54.40
			60.	82.09	2707.76	891.82	656.85	39.73
		0.04	2. (fresh)	146.67	1528.81	1369.31	1182.88	51.59
			60.	88.60	3111.13	794.98	630.81	39.21
	Mesophilic	0.03	2. (fresh)	145.21	1540.45	815.26	811.49	58.94
			60.	91.44	3606.61	621.34	539.18	41.79
		0.04	2. (fresh)	156.46	1770.64	1376.04	1062.17	58.71
			60.	95.79	3287.79	929.31	679.14	45.41
65°C/ 30 min. (control)	Mesophilic	0.015	2. (fresh)	159.21	1422.80	1025.68	1008.21	60.38
			60.	87.16	2968.70	855.10	509.01	43.77

3.3. Fatty Acids Analysis Results

The fatty acid analysis results of white cheese samples are given in Table 4. Fatty acids (especially short-chain ones; C4, C6, C8) are the main factors in the formation of cheese flavor (Scott, 1981). However, the excess of short-chain fatty acids creates a rancid taste defect and each one provides a separate undesirable aroma. Fatty acids are the most important and effective taste and aroma elements

of many cheese types. In cheeses, fatty acids with 4 or more carbon atoms are formed as a result of lipolysis of milk fat and/or breakdown of amino acids during ripening (Urbach, 1993). Lipolysis occurs according to the unique lipase enzyme or microbial lipase enzyme of milk. However, the majority of fatty acids (C4-C20) are produced by lipolysis of triglycerides, and some (C2-C6) are produced by the degradation of lactose and amino acids (Curioni & Bosset, 2002).

Butyric acid (C4) plays an important role on the aroma of semi-hard cheeses (Woo et al. 1984). The butyric acid amount of white cheese samples treated with high temperature varied between 1.522-1.982% and the average was determined as 1.743% (Table 4). The interaction of pasteurization time x CaCl₂ is shown in Figure 7. The average butyric acid rate was determined as 1.671±0.032% in the application using mesophilic culture and as 1.812±0.032% in thermophilic culture applications.

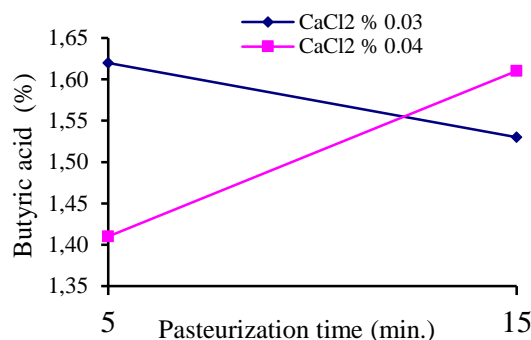


Figure 7. Pasteurization time x CaCl₂ addition interaction on butyric acid ratio of cheese samples

The butyric acid rate of white cheeses produced using 0.03% CaCl₂ was higher than the butyric acid rate of white cheeses supplemented with 0.04% CaCl₂. It was determined that the butyric acid rate of white cheeses treated with 0.03% CaCl₂ was lower than that of cheeses treated with 0.04%. The % butyric acid content of control white cheese samples was 1.779% on the 2nd day of ripening (fresh) while it was determined as 1.398% on the 60th day. The average butyric acid content determined in the high-temperature treated white cheese samples (1.743%) was found to be higher than that of the control samples (1.589%). Akalın et al. (1998) determined the butyric acid ratio in cheeses produced with different production methods as 2.48% and Dağdemir and Özdemir (2008) as 2.164-2.645%, which are higher than the results of this research.

Caproic acid (C6) plays an important role on the aroma of semi-hard cheeses (Woo et al. 1984). The caproic acid content in white cheese samples treated with high temperatures varied between 1.576-2.005% and average was determined as 1.718% (Table 4). The average caproic acid content in control white cheese samples was determined as 1.772%. While the caproic acid content was 1.892% at the beginning of ripening, it decreased to 1.652% on the 60th day. The average caproic acid content of white cheese samples treated with high temperature was found to be lower than the control sample. Akalın et al. (1998) reported the caproic acid rate in white cheeses as 2.48% and Dağdemir and Özdemir (2008) reported it as 2.093-2.689%, which is higher than the results of this research.

The caprylic acid (C8) rate in white cheese samples treated with high temperatures varied between 0.883-1.207% and average was determined as 1.032% on (Table 4). While the caprylic acid rate in the trial cheeses produced by adding 0.03% CaCl₂ was 0.99±0.3%, it was determined as 1.07±0.3% in those treated with 0.04% CaCl₂. As the caprylic acid content of control samples on day 2 (fresh) was 1.166%, the content on day 60 was determined as 1.087% and the average was 1.127%. The value found in the control white cheese samples was higher than the white cheese samples treated with high temperatures (Table 4). Akalın et al. (1998) reported the caprylic acid rate in white cheese samples produced using different production methods as 2.77%, and Dağdemir and Özdemir (2008) reported it as 1.102-1.709%.

The capric acid (C10) rate in white cheese samples treated with high temperatures varied between 1.940% and 2.570%, and the average was determined as 2.248% (Table 4). The capric acid content of control white cheese samples varied between 2.569-2.483% and was determined to be 2.526% on average during storage. The capric acid ratio determined in control white cheese samples was higher than in samples treated with high temperature (Table 4). Akalın et al. (1998) reported the capric acid rate in white cheeses as 6.04% and Dağdemir and Özdemir (2006) reported capric acid as 3.276-2.272%, which is higher than the research findings.

The rate of lauric acid (C12) in white cheese samples subjected to high temperatures varied between 2.492% and 3.156%, and the average was determined as 2.776%. The lauric acid content of control white cheese samples varied between 3.090% - 3.107% and the average was determined to be 3.099%. The lauric acid rate determined in control white cheese samples was found to be higher than in white cheese samples treated with high temperatures (Table 4).

In control white cheese samples, the ratios of myristic, palmitic, stearic, oleic, linoleic, linolenic and arachidic acid were 11.635-11.699%, respectively; 34.770-34.976%; 10.645-10.701%; 26.236-26.748%; 0.228-0.747%; 0.375-0.725% respectively; It was determined that the ratios varied between 0.229-0.242%. Mallatou et al. (2003) reported that in the cheeses they produced using cow, sheep and goat milk, the total amount of free fatty acids was significantly higher in those produced from cow's milk and that palmitic and oleic acid rates were at the highest level in all cheeses during ripening. Guizani et al. (2006) reported that lipolysis occurred during 30 days of ripening in semi-hard cheeses produced from pasteurized milk and that palmitic, oleic, myristic, capric and lauric acids were the most important fatty acids. The rate of free fatty acids in cheeses varies according to temperature, number of lipolytic microorganisms enzymes, water content (Park, 2001), ripening time and different production methods (Larrayoz et al., 1999; Poveda &

Cabezas, 2006). Free fat acids decrease with the increase of the pasteurization temperature (Rynne et al., 2004; Buffa et al., 2001). The degree of lipolysis is determined by the amount of free fatty acids that increases during ripening (Contarini & Toppino, 1995; Mallatou et al., 2003). One study reported that due to high temperature application, the fat content of cheese samples decreased, the water content increased, and no significant change was observed in the free fatty acid ratio (Park, 2001). In addition, since the high salt content in cheeses is a limiting factor for enzyme and microorganism activity, the degree of lipolysis decreased and therefore no significant change was observed in the rate of free fatty acids (Escriche et al., 2000; Mallatou, et al., 2003).

Another reason for the low rate of free fatty acids in this study may be due to the inactivation of the natural lipase enzyme of milk as a result of the high temperature application to milk. Koçak et al., (1987) reported that the free fatty acid ratio of cheeses produced from pasteurized milk for a long time was lower than those produced from raw milk, and this may be due to the inhibition of the natural lipase enzyme of milk as a result of heat application. McSweeney (2004) reported that pasteurization temperature significantly inactivated the natural lipoprotein lipase of milk.

3.4. Casein Fractions

Electrograms of the white cheese samples are given in Figures 3.6 and 3.7. Fresh (2nd day) white cheese samples produced by pasteurization for a period of time and by adding 0.03% to 0.04% CaCl₂ after adding thermophilic culture are shown with numbers 1-4, while fresh (2nd day) white cheeses produced by adding mesophilic culture are shown with numbers 5-8, control.

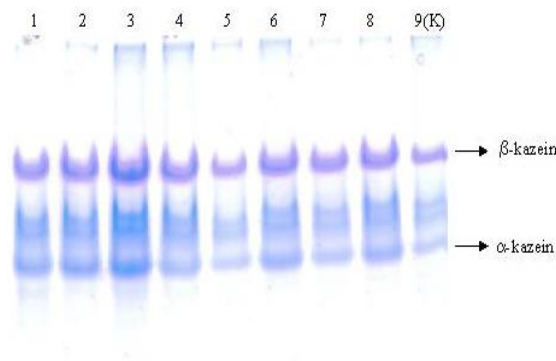


Figure 3.6. Urea polyacryl amide gel electrophoresis photographs applied to fresh (2nd day) white cheeses

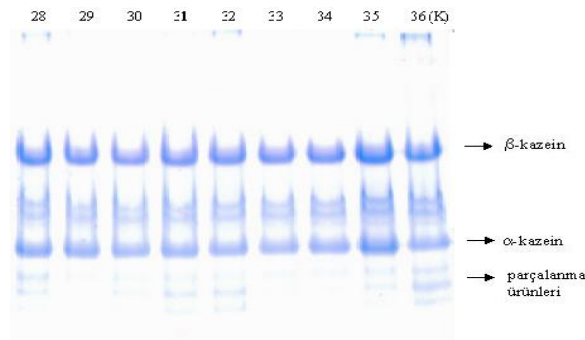


Figure 3.7. Photographs of urea polyacryl amide gel electrophoresis applied to ripe (60th day) white cheeses

An examination of the electrograms revealed that the amount of both α -casein and β -casein decreased during ripening. During ripening, α -casein and β -casein bands gradually weaken, and in parallel, degradation products increase. This situation results with the increase in the amount of water-soluble protein during ripening (Table 2). In the early stages of ripening, the degradation rate of α -casein is higher than that of β -casein (Rynne et al. 2004). Kalit et al., (2005) determined that during the smoking process of Tounj cheese, which lasted 2-3 days, α 1-casein started to decompose, while β -casein was hydrolyzed to a lesser extent by the effect of plasmin, and they suggested that the degradation of this casein fraction could be a ripening indicator for similar cheeses. Chymosin rapidly hydrolyzes α 1-casein, resulting in the formation of peptides roughly denoted as α 1-I casein. Plasmin, which is resistant to heat treatment, may also contribute to the hydrolyzation of casein (Gobbietti et al., 2002; Kalit et al., 2005). Mallatou et al., (2004) reported that mainly α 1-casein undergoes hydrolysis during the 20-day period after production until it is placed in the cold room. Benfeldt et al. (1997) stated that α 2-casein and β -casein are hydrolyzed by plasmin and are affected by the heat treatment applied to milk, while α 1-casein and para-k-casein are probably hydrolyzed by other enzymes such as rennet, and they are not affected by the heat treatment applied to milk. During the ripening of the cheese, the salt content in the brine affects casein hydrolysis. It has been reported that as the salt content in the brine increases from 4% to 8%, the hydrolyzation of β -casein in cheese made from goat's milk was affected more than α -casein (Thomas & Mills, 1981; Veloso et al., 2004; Psoni, et al. 2006).

Veloso et al. (2004) determined that the α -casein fraction degraded more rapidly in cheeses produced from sheep's milk, but the change in the α -casein fraction during the ripening of cheeses produced by mixing 20% cow's milk with sheep's milk was similar to the cheese produced from cow's milk.

Pasteurization temperature has a very important effect on the degradation of α -casein and β -casein (Gaya et al., 1990). The degradation rate and rate of β -casein varies depending on the pasteurization temperature. Researchers examining the ripening of different cheese varieties reported that plasmin activity decreased due to the application of high pasteurization temperatures and the degradation rate of β -casein decreased relatively (Rynne et al., 2004). Veloso et al. (2004) determined that the degradation of the β -casein fraction in all cheeses produced from cow's milk, sheep's milk and their mixtures was not as high as that of α -casein. Similar results were reported by Awad (2006) on Ras cheese and by Hayaloğlu et al. (2004) in white cheese. Benfeldt et al. (1997) determined that plasmin activity was negatively affected. The same researchers reported that less degradation was observed in cheeses produced from milk subjected to high temperatures and long-term heat treatment, especially in the β -casein and α s2-casein fractions during ripening due to the decrease in plasmin activity, and no difference was observed in the degradation of the α s1-casein fraction, probably due to the rennet effect.

4. Conclusions and Recommendations

The high-grade heat treatment of milk and the addition of starter culture and CaCl₂ are applications that significantly increase yield in the production of white cheese. The degree of ripening of cheese in this study increased in parallel with the storage period. The reason for the low free fatty acid content in the cheeses treated with a high temperature may be due to the inactivation of the natural lipase enzyme of the milk as a result of the high heat treatment applied to the milk and the inability of the starter to generate sufficient lipolytic activity. An increase in the amount of Na and a decrease in the amounts of K, P, Ca and Mg minerals was observed in the cheese samples during the ripening period.

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Table 4. Fatty acid analysis results of white cheese samples

Past. Norm	Starter culture	CaCl ₂ %	Ripening times (day)	Fatty acids (%)											
				Butyric (C4)	Caproic (C6)	Caprylic (C8)	Capric (C10)	Lauric (C12)	Myristic (C14)	Palmitic (C16)	Stearic (C18)	Oleic (18:1)	Linoleic (18:2)	Linolenic (18:3)	Arachidic (C20)
85°C / 15 min.	Thermophilic	0.03	2.	1.982	1.615	0.946	2.167	2.718	10.774	33.727	11.785	28.018	1.284	0.436	0.244
			60.	1.829	1.723	0.988	2.162	2.669	10.574	32.935	12.017	28.850	0.320	0.668	0.241
		0.04	2.	1.850	1.758	1.065	2.293	2.799	10.802	33.309	11.588	27.691	1.844	0.426	0.238
			60.	1.774	1.760	1.051	2.258	2.767	10.749	32.867	12.046	28.951	0.256	0.653	0.249
	Mesophilic	0.03	2.	1.694	1.787	1.095	2.332	2.842	11.047	32.416	12.575	27.123	1.168	0.477	0.258
			60.	1.689	1.576	1.009	2.278	2.789	10.815	31.843	11.585	29.576	0.323	0.865	0.239
		0.04	2.	1.522	1.674	1.057	2.350	2.921	12.076	36.756	11.524	22.510	1.231	0.529	0.289
			60.	1.659	1.669	1.020	2.219	2.715	10.445	31.745	9.055	27.617	0.243	0.636	0.200
85°C / 15 min.	Thermophilic	0.03	2.	1.816	1.604	0.883	1.940	2.492	10.669	33.871	11.591	28.716	1.296	0.437	0.225
			60.	1.606	1.628	0.995	2.140	2.625	10.181	31.710	11.871	28.227	0.259	0.658	0.265
		0.04	2.	1.791	1.762	1.083	2.340	2.846	10.894	32.319	11.678	28.945	1.204	0.447	0.233
			60.	1.850	1.712	1.021	2.211	2.732	10.585	32.654	12.046	28.920	0.263	0.695	0.248
	Mesophilic	0.03	2.	1.617	1.661	0.983	2.159	2.700	10.707	32.503	11.840	30.055	0.752	0.425	0.230
			60.	1.664	1.724	1.046	2.283	2.792	10.704	32.336	11.880	29.115	0.267	0.875	0.249
		0.04	2.	1.913	2.005	1.207	2.570	3.156	12.284	34.025	8.830	27.077	0.840	0.601	0.293
			60.	1.607	1.679	1.034	2.249	2.761	10.629	32.103	11.820	29.081	0.857	0.868	0.248
65°C / 30 min.	Mesophilic	0.015	2.	1.779	1.892	1.166	2.569	3.107	11.635	34.770	10.645	26.236	0.747	0.375	0.229
			60.	1.398	1.652	1.087	2.483	3.090	11.699	34.976	10.701	26.748	0.228	0.725	0.242

References

- Akalın , A. S., Kınık , Ö., & Göncü, S. (1998). İzmir piyasasında satılan bazı peynir çeşitlerinde yağ asitleri kompozisyonunun belirlenmesi üzerine araştırmalar. *Gıda*, 23(5), 357-363.
- Awad, S. (2006). Texture and flavour development in Ras cheese made from raw and pasteurized milk. *Food Chemistry*, 97, 394-400.
- Benfeldt, C., Sorensen, J., Ellegård, K.H. & Petersen, T.E., 1997. Heat treatment of cheese milk: Effect on plasmin activity during cheese ripening. *Int. Dairy J.*, 7, 723-731.
- Buffa, M., Guamis, B., Pavia, M., & Trujillo, A. J. (2001). Lipolysis in cheese made from raw, pasteurized or high-pressure-treated goats' milk. *Int. Dairy J.*, 11(3), 175-179.
- Cankara, M., & Karacaoğlu, Y. (1983). Beyaz peynir yapımında sütün standardizasyonu ve pastörizasyonunun önemi. *Beyaz Peynir Sempozyumu*. İzmir: Karınca Matbaacılık, s155.
- Cichoski, A. J., Valduga, E., Valduga, A. T., Tornadizo, M. E., & Fresno, J. M. (2002). Characterization of prato cheese, a brazilian semi-hard cow variety: evolution of physico-chemical parameters and mineral composition during ripening. *Food Control*, 13, 329-336.
- Contarini, G., & Toppino, P. M. (1995). Lipolysis in Gorgonzola cheese during ripening. *Int. Dairy J.*, 5(2), 141-155.
- Creamer, L. K. (1991). Electrophoresis of Cheese., *Bulletin of the IDF*, no. 261, s. 14-28.
- Curioni, P. M., & Bosset, J. O. (2002). Key odorants in various cheese types as determined by gas chromatography-olfactometry. *Int. Dairy J.*, 12, 959-984.
- Çelik, Ş., Bakırcı, İ., & Özdemir, S. (2005). Effects of high heat treatment of milk and brine concentration on the quality of Turkish white cheese. *Milchwissenschaft*, 60(2), 147-151.
- Dağdemir, E., Çelik, Ş., & Sarkar, S. (2003). The effect of some starter cultures on the properties of Turkish White cheese. *International Journal of Dairy Technology*, 56, 215-218.
- Dağdemir, E., & Özdemir, S., (2008). Technological characterization of the natural lactic acid bacteria of artisanal Turkish White Pickled cheese, *International Journal of Dairy Technology*, 61, 2, 133-140.
- Demirci, M. (1989). Taze Beyaz peynirlerimizin mineral madde miktarları ve enerji değerleri. *Doğa Türk Tarım ve Ormanlık*, 13(3b), 952-958.
- Escrive, I., Fuentes, C., Gonzalez, C., & Chiralt, A. (2000). Development of medium volatility compounds in manchego-type cheese as affected by salt content and salting method. *Journal of Food Composition and Analysis*, 13(5), 827-836.
- Gaya, P., Yedina, M., Rodriguez-Marin, M. A., & Nufjez, M. (1990). Accelerated ripening of ewes' milk, manchego cheese: the effect of elevated ripening temperatures. *Journal of Dairy Science*, 73(1), 26-32.
- Gobbietti, M., Morea, M., Baruzzi, F., Corbo, M. R., Matarante, A., Considine, T., & Fpx, P. F. (2002). Microbiological, compositional, biochemical and textural caharacterization of Caciocavallao Pugliese cheese during ripening. *Int. D. Int. Dairy J.*, 12, 511-523.
- Göncü, A., & Alpkent, Z. (2005). Sesory and chemical properties of white pickled cheese produced using kefir, yoghurt or a commercial cheese culture as a starter. *Int. Dairy J.*, 15, 771-776.
- Guinee, T. P., Mulholland, C. M., Mullins, C. M., O'Callaghan, D. J., & Kelly, J. (2004). Effect of pasteurization temperature and time on cheddar cheesemaking efficiency. *IDF Symposium on Cheese: Ripening, Characterization & Technology*. Pragu, Czech Republic.
- Guizani, N., Attabi, Z. A., Kasapis, S., & Gaafar, O. (2006). Ripening profile of semi-hard standard goat cheese made from pasteurized milk. *International Journal of Food Properties*, 9(3), 523 - 532.
- Gürsel, A., Ergül, E., Gürsoy, A., & Erdoğan, G. N. (1987). Kalsiyum klorürün taze beyaz peynirin bazı nitelikleri üzerine etkisi. *Gıda*, 5, 293-298.
- Hayaloğlu, A.A., Guven, M., Fox, P.F., Hannon, J.A., & McSweeney, P.L.H., 2004. Proteolysis in Turkish White-brined cheese made with defined strains of Lactococcus. *Int. Dairy J.*, 14, 599-610.
- Hazır, M. (1995). *Beyaz peynir üretiminde değişik ısıl işlemin ve farklı CaCl2 katımının peynir kalitesine etkisi. Yüksek Lisans tezi. Çukurova Üniversitesi, Adana.* Yüksek Lisans tezi. Çukurova Üniversitesi, Adana.
- Kalit, S., Havranek, J. H., Kaps, M., Perko, B., & Curik, V. C. (2005). Proteolysis and the optimal ripening time of Tounj cheese. *International Dairy Journal*, 15, 619-924.
- Karakuş, M., Borcaklı, M., & Alperden, İ. (1992). Beyaz peynirin olgunlaşma sürecinde laktik asit bakterileri. *Gıda*, 17(6), 363-369.
- Koçak, C., Gürsel, A., Ergül, E., & Gürsoy, A. (1987). Farklı Tuzlama Yöntemlerinin Beyaz Peynirde Uçucu Yağ Asitleri Oluşumuna Etkisi. *Gıda*, 12(3), 179-184.
- Koçak, C., & Devrim, H. (1989). Isıl işlemin inek ve koyun sütlerinin peynir mayası ile pıhtılaşma yeteneği üzerine etkisi. *Gıda*, 14(1), 3-8.
- Kurt, A., & Çakmakçı, S. (1991). Some applications of increasing cheese yield. *Food Chemistry*, 5, 49-52.
- Kurt, A., Çakmakçı, S., & Çağlar, A. (1996). *Süt ve Mamülleri Muayene Analiz Metotları Rehberi*. , Erzurum. Erzurum: Atatürk Üniv. Ziraat Fak., Yayınları No : 257, .
- Larrayoz , p., Martínez , M. T., Baron, L. J., Torre, P., & Barcina, Y. (1999). The evolution of free fatty acids during the ripening of Idiazábal cheese: influence of rennet type. *European Food Research and Technology*, 210(1), 9-12.
- Lau, Y. K., Barbano, D. M., & Rasmussen, R. R. (1989). Influence of milk pasteurization on cheddar cheese yield and proteolysis during aging. *J Dairy Sci.*, 72(1), 124-125.
- Mallatou, H., Papa, C. E., & Boumba, V. A. (2004). Proteolysis in Teleme cheese made from ewes, goats or a mixture of ewes and goats milk. *Int. Dairy J.*, 14, 977-987.

- Mallatou, H., Papa, E., & Massouras, T. (2003). Changes in free fatty acids during ripening of Teleme cheese made with ewes, goats, cows or a mixture of ewes and goats milk. *Int. Dairy J*, 13(2), 211-219.
- McSweeney, P. L. (2004). Biochemistry of cheese ripening. *Int. J. Dairy Tech*, 2(3), 27-144.
- Naumann, C., Bassler, R., Seibold, K., & Barte, C. (1983). Die Chemische Untersuchung Von Futtermittein. *J. Neumann Neudamm*, 10, 6, Germany.
- Nizamlioğlu, M., Keleş, A., Atasever, M., Kayardı, S., & Gürbüz, Ü. (1998). Beyaz peynir üretiminde pastörizasyon sıcaklığının kalite üzerine etkisi. *Veteriner Bilimleri Dergisi*, 14(2), 5-13.
- Öksüz, Ö. (1989). *Beyaz peynir randımanına kalsiyum klorür kullanımının etkisi üzerinde bir araştırma*. Yüksek Lisans Tezi. Trakya Üniversitesi Fen Bilimleri Enstitüsü.
- Özdemir, S. (1990). *Koyun Sütünün Hidrojen Peroksit (H₂O₂) ve Potasyum Sorbatla Muhafaza Edilebilme İmkanları ve Bu Sütlere Starter Kültür Katılarak Yapılan Taze ve Olgunlaştırılmış Beyaz Peynirlerin Bazı Kalite Kriterleri*. Doktora Tezi, Atatürk Üniv. Ziraat Fakültesi s 115.
- Pappa, E. C., Kantarakis, I., Anifantakis, E. M., & Zerfiridis, G. K. (2006). Influence of types of milk and culture on the manufacturing practises, composition and sensory characteristics of Teleme cheeseduring ripening. *Food Control*, 17, 570-580.
- Park, Y. W. (2001). Proteolysis and lipolysis of goat milk cheese. *J Dairy Sci.*, 84, 84-92.
- Poveda, J. M., & Cabezas, L. (2006). Free fatty acid composition of regionally-produced Spanish goat cheese and relationship with sensory characteristics. *Food Chemistry*, 95(2), 307-311.
- Prieto, B., Franco, I., Prieto, J. G., & Bernardo, A. (2002). Compositional and Physico-chemical Modifications during the Manufacture and Ripening of León Raw Cow's Milk Cheese. *Journal of Food Composition and Analysis*, 15(6), 725-735.
- Psoni, L., Tzenetakis, N., & Litopoulou-Tzanetaki, E. (2006). Characteristics of Batzos cheese made from raw, pasteurized and /or pasteurized standardized goat milk and native culture. *Food Control*, 17, 533-539.
- Rynne, N. M., Beresford, T. P., Kelly, A. L., & Guinee, T. P. (2004). Effect of milk pasteurization temperature and in situ whey protein denaturation on the composition, texture and heat- induced functionality of the half-fat Cheddar cheese. *Int. Dairy J*, 14(11), 989-1001.
- Sağun, E., Tarakçı, Z., Sancak, H., & Durmaz, H. (2005). Salamura otlu peynirde olgunlaşma süresince mineral madde değişimi. *YYÜ Vet Fak Derg*, 16(1), 21-25.
- Scott, R., 1981. Cheese ripening. *Cheese Making Practice*. Second Edition. Elsevier Applied Science Publishers. London and Newyork.
- Singh, H., & Waungana, A. (2001). Influence of heat treatment of milk on cheesemaking properties. *Int. Dairy J.*, 11, 543-551.
- Şakiroğlu, S., & Üçüncü, M. (1986). Beyaz peynir yapımında kalsiyum klorürün süzme süresi, peynir suyu ile olan bazı besin maddeleri kayıpları ve peynir randımanına etkisi. *E.Ü. Mühendislik Fak. Dergisi Seri B*, 4(1), 37-49.
- Thomas, T. D., & Mills, O. E. (1981). Proteolytic enzymes of starter bacteria. *Neth. Milk Dairy*, 35, 255-273.
- Tunail, N. (1999). Microflora of the Intestine/Biology of the Enterococcus spp. R. K. Robinson içinde, *Encyclopedia of Food Microbiology* (s. 1365-1373). Academic Press UK.
- Urbach, G. (1993). Relations between cheese flavour and chemical composition. *Int. Dairy J.*, 3, 389-422.
- Veloso, A. C., Teixeira, N., Peres, A. M., Mendonça, A., & Ferreira, I. M.P.L.V.O., I. L. (2004). Evaluation of cheese authenticity and proteolysis by HPLC and urea-polyacrilamide gel electrohoresis. *Food Chemistry*, 87, 289-295. <https://doi.org/Veloso, A. C. A., Teixeira, N., Peres, A., M.,>
- Wolfschoon-Pombo, A. F. (1997). Influence of calcium chloride addition to milk on the cheese yield. *Int. Dairy J*, 7(4), 249-254.
- Woo, A.H., Kollodge, S., & Lindsay, R.C. (1984). Qualification of major free fatty acids in several cheese varieties. *J Dairy Sci*. 67:874-878.
- Yıldız, N., & Bircan, H. (1994). *Araştırma ve Deneme Metotları*. Atatürk Üniv. Ziraat Fak., Yayın No: 305, IV. Baskı, Erzurum.