PAPER

A COMPARATIVE STUDY ON THE EFFECT OF HIGH HYDROSTATIC PRESSURE ON RIPENING OF TURKISH WHITE CHEESE FROM DIFFERENT MILK SPECIES

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ABSTRACT

High pressure treatment has diverse effect on cheeses depending on their characteristics. In this study, pressure application on Turkish White cheese (300 and 450 MPa/5 min) and the changes during ripening were investigated. The 450 MPa pressure process showed an enhanced effect on proteolytic and lipolytic activity of cheeses. Besides, 450 MPa pressure treatment was very effective on the microbiological profile, but the other treatment condition exhibited a more moderate antimicrobial effect. Although, the total mold-yeast were detected after high-pressure treatment, their existence to a considerable degree was seen at the end of storage.

Keywords: high pressure, cow cheese, goat cheese, ripening, Turkish White cheese

1. INTRODUCTION

The ripening of cheese is an expensive process because of the high storage cost, so the reduction in storage cost without affecting the quality of the product would provide significant savings to the cheese industry (EL SODA AND AWAD, 2011). A reduction in the financial cost of a large quantity of cheese during storage, providing sufficient space for a new product by a fast cycle of stock can be ensured by accelerating ripening. Cheese ripening increases by elevated storage temperature, addition of exogenous enzyme or cheese slurries and modified microorganism usage in the dairy industry. Recently, the high-pressure treatment on cheese to accelerate ripening has been scientific and of commercial interest to numerous researchers (SALDO *et al*., 2002; O'REILLY *et al*., 2000). It has been reported in previous studies that high hydrostatic pressure (HHP) has been applied to cheese for destroying pathogenic and spoilage bacteria, reducing salting time, allowing the release of starter enzymes and changes in enzyme activity to reduce ripening time without changing cheese quality (SALDO *et al*., 2002). In the event of pressurization process, the breakdown of proteins structure affects textural development, aromatic compound formation and proteolysis by releasing amino acids. In the previous studies, the accelerating effect of HHP treatments on cheese ripening was reported as follows: alteration in enzyme configuration, structural changes in the protein matrix by increasing activity of proteases, as well as bacterial lysis which aid the release of microbial enzymes.
There have been various studies on the effect of HHP on cheese such as Mozzarella (SALDO *et al*., 2002; O'REILLY *et al*., 2000), Gouda (MESSENS *et al*., 2000), cheddar (RYNNE *et al*., 2008), sheep milk cheese (JUAN *et al*., 2007) and goat milk cheese (CAPELLAS *et al*., 2001). These researches showed that HHP affects cheese quality and ripening depends on cheese variety, chemical and physicochemical properties of cheeses, pressure level, processing time, and temperature conditions. Certain pressure parameters may lead to variable changes in composition, quality properties and texture of different cheeses (O'REILLY *et al*., 2001).
Although, a good number of researches were published on the cheese ripening properties after applying high hydrostatic pressure, no information has been found on ripening properties of Turkish White cheese under pressurization effect. The studies on Turkish White cheese have focused on the pressurization effect on microbial inactivation of pathogenic bacteria (*L. monocytogenes*), total mesophilic aerobic bacteria (TMAB), total molds and yeasts, Lactococcus, Lactobacillus and coliform bacteria (*Enterobacteriaceae)* in cheese (EVRENDİLEK *et al*., 2008), salt distribution of cheese during ripening (KOCA *et al*., 2018), as well as textural and microstructural changes after pressure treatment (KOCA *et al*., 2011). This study focused on the effect of pressure on ripening properties and hence microbiological changes because the diverse effects of HHP on cheese depend on milk species, composition, structure, and quality. There has been insufficient information on the effect of high pressure on the proteolysis and lipolysis properties of Turkish White cheese during ripening. In accordance, it was aimed to determine the effects of moderate level pressure treatment on the chemical, physicochemical, and biochemical changes of Turkish White cheese made from goat and cow milk during the ripening period.

2. MATERIALS AND METHODS

2.1. Cheese production

Full-fat cow and goat milk were obtained from two local dairy farms (İkizler Süt and Bolana, Bolu, Turkey) and cheeses were produced from 100 liters of pasteurized milk in two different vats. After pasteurizing of raw milk at 65°C for 30 min, the milk was cooled to 32°C. Mesophilic starter culture (*Lactococcus lactis* subsp. *cremoris* and *Lactococcus lactis* subsp. *lactis*) (DVS-R-704, Chr. Hansen) at a rate of 0.2% and $CaCl_2$ about 0.02% were added into pasteurized milk. Then liquid rennet (10g/100L cheese milk (CHY-MAX, Chr. Hansen) was supplemented as a coagulant when pH reached6.40, and coagulation was completed within 90 min. The coagulum was cut (1 cm cubes) and rested in the whey for 5 min. The curds were transferred into 7x7 cm molds, and the whey was drained spontaneously at room temperature for 8 hours until whey drops were stopped. The cheese blocks were taken in brine (14 g/100g NaCl) for 12 h at room temperature. Both goat and cow cheese samples were then packaged into airtight and watertight plastic boxes and were separated into three groups depending on the pressure treatment (i) control, (ii) 300 MPa for 5 min and (iii) 450 MPa for 5min for HHP application. After the HHP process, they were stored at +4°C for two months and examined at 0, 30, 60 days of storage.

2.2. High-pressure treatment

Pilot-scale high-pressure food processor unit (Avure Technologies, OH, USA) with one-liter pressure chamber was used. Vacuum packaged samples were processed with 300 and 450 MPa pressures for 5 min, while process temperature was kept below 6 ºC during the HHP application. Control samples without pressure application were packaged the same way as the HHP samples.

2.3. Microbiological analyses

TMAB (ISO, 2013), mold and yeast (ISO, 2004a), coliform (ISO, 2006), mesophilic lactic acid bacteria (ISO, 1998) and psychrotrophic bacteria (ISO, 2005) were determined in duplicate according to ISO (International Organization for Standardization) standards.

2.4. Physicochemical analyses

Chemical properties of cheese samples were determined with respect to International Dairy Federation (IDF) standards for total solid (ISO, 2004b), fat content (IDF, 2009), protein content (IDF, 2014), salt content (IDF, 2006), and titratable acidity (IDF, 2012). A pH meter (pH-720, Inolab, Germany) was used to measure pH value of the homogenate (10 g cheese sample+10 ml distilled water). Minolta CR-400 (Konica Minolta Sensing, Inc., Osaka, Japan) equipment was used for color measurements of cheese in D65 mode as L*, a*and b*.

2.5. Nitrogen fractionation determination

Water-soluble nitrogen (WSN) and Trichloroacetic acid-soluble nitrogen (TCA-SN 12%) fractions were prepared by KUCHROO and FOX (1982) and POLYCHRONIADOU *et al*.

(1999), respectively. The nitrogen contents of the soluble extracts were carried out using the Kjeldahl method (IDF 2014) and the ripening index (RI) was presented as a percentage of WSN to total cheese nitrogen. The acid degree value (ADV) of the samples was found in meq KOH/100g fat according to CASE *et al*. (1985).

2.6. Statistical analyses

The changes for 2 months-storage were determined by General Linear Model Repeated Measures. Analysis of Variance (ANOVA) and Tukey's multiple comparison tests were used to determine differences between cheese samples in different treatment groups by SPSS version 23 (SPSS Inc., Chicago, USA) package program. SIMCA (Soft independent modeling of class analogy) was used for the grouping of cheese samples based on properties under various pressure. The classes were observed to be significantly different from each other when the interclass distances were above 3.

3. RESULTS AND DISCUSSION

3.1. Microbiological properties of cheeses

The effect of high hydrostatic pressure processing on the microbial properties of cheese samples was shown in Table 1. Coliform bacteria were not found in both (control and pressurized) cow and goat cheese samples at 1/10 dilution. TMAB, lactococci and lactobacilli counts showed a significant decrease in bacterial growth at high pressure treated cheese samples (P<0.05). While aerobic mesophilic bacteria count in cow and goat control cheeses were around 9.13 and 9.6 log CFU/g respectively, average 2-3 log decreasing by 300 MPa and 4-6 log decreasing for 450 MPa pressure were observed in HHP-treated cow and goat cheese samples. The effect of high pressure on Lactococci and Lactobacilli counts were higher due to elimination of the all starter culture at 450 MPa pressure, processing nearly above the mesophilic bacteria counts. Besides, 300 MPa HHP-treated cheese samples showed significant decrease in microbial counts of lactic acid bacteria (P<0.05). Lactobacilli were affected by HHP more than lactococci in the study.
The lactobacilli were the most affected bacteria group from pressurization processing both in cow and goat cheeses. Although, total mold/yeast could not be determined for both control and pressure treated samples, their presence increased at the end of the storage and reached about 5.5 log levels at 60 days of storage. Growth of yeasts and molds in HHP treated samples compared to the control samples was delayed in goat cheese, but these microorganisms reached about 5 log levels during the storage period. EVRENDİLEK *et al*. (2008) noticed that total yeast and mold after 300-600 MPa high-pressure treatments were below the detection limit, so they could not be detected. Similarly, psychrotrophic bacteria in cow cheese were significantly detected at the end of the storage period (P<0.05). However, psychrotrophic bacteria was not found in all goat cheese samples during the storage period DARYAEI *et al*. (2008) reported the growth of yeast at 6 weeks of cheese samples treated under similar high-pressure parameters. Sublethal injury experiments regarding high pressure applications indicated that high pressure damaged the microorganism population more severely and it took longer to recover (O'REILLY *et al*., 2000). This fact may explain the existence of molds and yeasts counts in cheeses treated at 300 and 450 MPa at 60 days. Pressurization processing showed higher microbial reduction

effect in goat cheese as compared to cow cheese, this shows that the type of cheese affects the microbial inactivation (O'REILLY *et al.*, 2001).

Table 1. Microbiological changes during ripening (at 4ºC) of the cheeses after high pressure treatment at 300 and 450 MPa for 5 min (log cfu/g).

Cheese type	Microbial Group	Day	Treatment		
			Control	300 MPa	450 MPa
Cow cheese	TMAB	1	9.13±0.03[a]	7.24±0.02[b]	5.72±0.04[c]
		30	8.60±0.11[a]	7.07±0.06[b]	4.00±0.10[d]
		60	8.78±0.15[a]	7.41±0.61[b]	4.32±0.62[d]
	Lactobacilli	1	8.61±0.170[a]	N.D.	N.D.
		30	4.96±0.08[b]	3.51±0.11[d]	N.D.
		60	4.64±0.11[c]	3.06±0.44[e]	N.D.
	Lactococci	1	9.00±0.09[a]	6.82±0.27[b]	N.D.
		30	5.00±0.11[c]	3.79±0.09[e]	N.D.
		60	4.78±0.14[c]	4.28±0.73[d]	N.D.
	Mold/Yeast	1	N.D.	N.D.	N.D.
		30	N.D.	N.D.	N.D.
		60	5.32±0.10[a]	5.58±0.300[b]	5.41±0.10[c]
	Psychrotrophic bacteria	1	N.D.	N.D.	N.D.
		30	N.D.	N.D.	N.D.
		60	5.66±0.16[a]	5.75±0.13[a]	8.69±0.19[b]
Goat cheese	TMAB	1	9.6±0.07[a]	5.78±0.16[d]	3.67±0.09[g]
		30	7.68±0.16[b]	6.66±0.73[c]	4.29±0.66[f]
		60	6.04±0.05[d]	4.84±0.34[e]	3.30±0.25[g]
	Lactobacilli	1	9.03±0.11[a]	N.D.	N.D.
		30	4.91±0.10[b]	3.20±0.48[c]	N.D.
		60	0.50±1.00[d]	1.00±1.16[d]	N.D.
	Lactococci	1	9.69±0.17[a]	3.35±0.24[d]	1.19±1.38[e]
		30	5.67±0.09[b]	4.64±0.11[b]	N.D.
		60	4.27±0.17[d]	3.47±0.29[d]	N.D.
	Mold/Yeast	1	N.D.	N.D.	N.D.
		30	5.34±0.21[a]	1.46±1.695[b]	N.D.
		60	6.00±0.09[a]	5.67±0.11[a]	5.28±0.89[a]
	Psychrotrophic bacteria	1	N.D.	N.D.	N.D.
		30	N.D.	N.D.	N.D.
		60	N.D.	N.D.	N.D.

Values represented by mean ± standard deviation.

[a,b,c]Different superscript in the same microbial group indicates significant differences ($p<0.05$). N.D. = not determined in 1/10 dilution.

3.2. Physicochemical properties of cheeses

Pressure application did not significantly affect the total solids, protein, and fat contents of both cow and goat cheese samples (Fig. 1). The total solid content of the cheeses was found lower than HHP-treated Turkish White cheese pressurized up to 400 MPa for 5, 10 and 15 min reported by KOCA *et al*. (2011) and EVRENDİLEK *et al*. (2008) due to probably applying different pressing time and load in production. Moreover, a significant increase in total solid, protein, and fat contents was found in cow's milk cheeses on day 60 of ripening ($P<0.05$), while there were significant decreases in all parameters for goat cheeses ($P<0.05$). The high beta casein content of goat milk produces a firm and hard structure when processed in Turkish White cheese due to the long period of time and spontaneously straining of whey. The differences in structural properties were influenced by high hydrostatic pressure at different levels.

The placement of brine into cheese causes an increase in moisture content, in contrast, changes in para casein network due to HHP causes a decrease in moisture content. Moreover, SALDO *et al*. (2001) reported the existence of higher amount of bound water in HHP-treated cheese despite presence of same moisture content in control cheese. This phenomenon causes high moisture content in HHP-treated cheese during ripening. This fact also explains the reason for decrease in protein and fat content of goat cheese samples during ripening period. Also, the decrease in protein and fat contents may be as a result of the diffusion of proteolysis products and fat from the cheese into brine (HAYALOĞLU *et al*., 2002).

The goat cheese samples were higher dry solids content as compared to cow cheeses; therefore, goat cheeses resulted in higher moisture content by diffusion of brine into cheese with pressurization. On the other hand, cow cheese was not as firm as goat cheese, and pressure process was affected by the protein networks via breaking down. As a result, the HHP treatment might cause slight water expulsion and result to a decrease in moisture content in the pressure treated cheeses (HUPPERTZ *et al*., 2006). Compared to control samples, less water content was reported in La Serene cheese treated under 300-400 MPa HHP at 50 days (GARDE *et al*., 2007). While the higher water holding capacity was identified in high pressure treated ewes milk cheeses during ripening. None of changes were found for moisture content of goat cheeses (CAPELLAS *et al*., 2001). After the HPP treatment, structure of paracasein matrix of cheese plays an important role in the composition of cheese via acidity development and salt distribution (MOSCHOPOULOU *et al*., 2010). The quantity of salt in cheese samples increased both in control and pressurized samples during ripening due to salt diffusion from brine into cheese during storage. KOCA *et al*. (2011) reported an increase in the amount of salt in pressurized and unpressurized Turkish White cheeses at various pressure levels until the 14th day of ripening.

The titratable acidity as lactic acid basis showed a slight reduction by increasing the pressure level, whereas, pH values of the cheese samples increased by pressuring process (Table 2). These results were in agreement with results reported by KOCA *et al*. (2011) in 50-400 MPa high pressure treated Turkish White cheese. The pH-enhancing effect of high pressure on various cheeses was reported by some authors (MESSENS *et al*., 1998; MOSCHOPOULOU *et al*., 2010). The pH value in both cow and goat cheese samples showed a tendency to decrease at the ripening period. The carriage of colloidal calcium phosphate in two- sides may create these temporary changes in pH values (MOSCHOPOULOU *et al*., 2010). Besides, the usage of lactic acid, the formation of alkaline

compounds by degradation of big molecules and proteins may be the result of reducing effect (MESSENS *et al*., 1998).

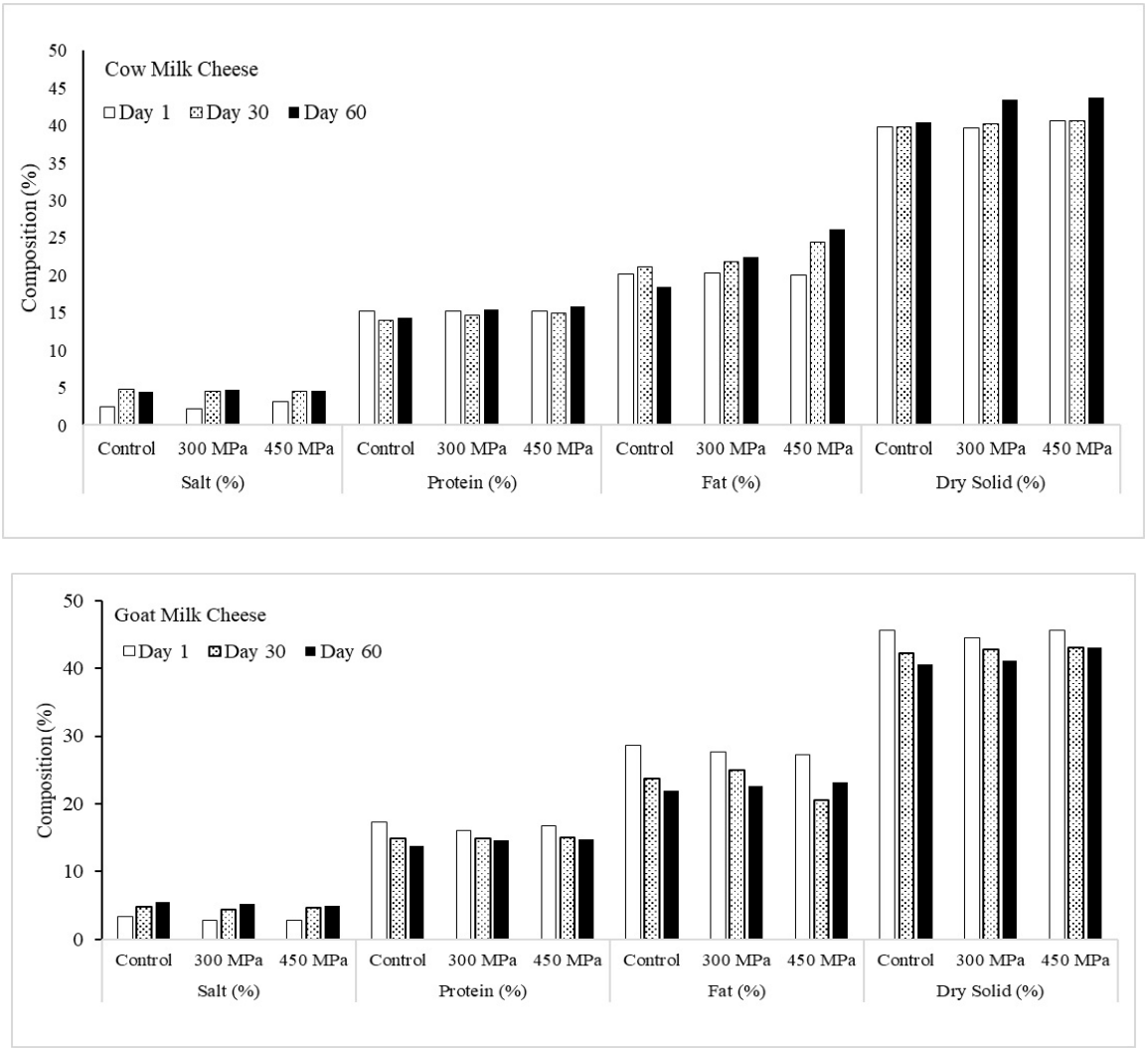

Figure 1. Effect of HHP treatment (300 and 450 MPa for 5 min) on compositional changes in cow and goat cheese samples during ripening.

The color properties (L*, a* b* value) of high hydrostatic pressure treated cheese samples is given in Table 2. The high-pressure process did not affect the L* (lightness) and b* (blue-yellow) values of the cow cheese samples significantly (P>0.05), whereas, there was a small change in goat cheese (P<0.05). Besides, a* (green-red) color parameter tended to increase the greenish color due to release of the whey. The color variations of cheeses are mainly affected by cheese manufacturing techniques and quality properties of the fat phase. As a result of the biochemical reactions during the ripening period, the compositional and structural changes occur and can affect the color changes of various cheeses. The cheese structure is the result of hydrophobic interactions between caseins and the effects of high hydrostatic pressure on the non-covalent bond by their breakdown. Therefore, the cheese components produce a new structure of different rheological and color characteristics (SALDO *et al*., 2002).

Table 2. The physicochemical changes in control and in the pressurized cheeses during ripening.

Cheese type		Day	Control	300 Mpa	450 Mpa
Cow cheese	Titratable acidity (% LA)	1	0.58±0.02^{a}	0.57±0.00^{a}	0.56±0.03^{a}
		30	0.35±0.03^{b}	0.41±0.04^{c}	0.36±0.02^{b}
		60	0.38±0.02^{bc}	0.37±0.0^{bc}	0.37±0.02^{bc}
	pH	1	4.54±0.02^{ab}	4.61±0.00^{a}	4.65±0.01^{b}
		30	4.57±0.04^{ab}	4.61±0.04^{ab}	4.59±0.01^{ab}
		60	4.52±0.08^{a}	4.56±0.06^{ab}	4.58±0.08^{ab}
	L*	1	92.38±0.40^{a}	92.26±0.01^{a}	92.79±0.01^{a}
		30	92.90±0.14^{a}	92.62±0.15^{b}	93.11±0.81^{a}
		60	92.07±0.82^{a}	92.90±0.16^{c}	91.45±1.85^{a}
	a*	1	-2.46±0.08^{a}	-2.38±0.00^{a}	-2.89±0.01^{a}
		30	-2.37±0.24^{a}	-2.51±0.05^{b}	-2.81±0.21^{ab}
		60	-2.27±0.20^{a}	-2.24±0.03^{c}	-2.51±0.18^{b}
	b*	1	16.38±0.64^{a}	16.69±0.04^{ab}	17.65±0.01^{a}
		30	16.34±2.18^{a}	17.54±0.00^{a}	16.68±0.26^{ab}
		60	16.40±1.57^{a}	16.33±0.44^{b}	16.52±0.74^{b}
Goat cheese	Titratable acidity (% LA)	1	0.61±0.03^{a}	0.58±0.07^{a}	0.50±0.05^{b}
		30	0.38±0.02^{c}	0.35±0.04^{d}	0.38±0.03^{cd}
		60	0.34±0.02^{d}	0.39±0.00^{cd}	0.42±0.02^{c}
	pH	1	4.75±0.10^{a}	4.83±0.08^{ab}	4.92±0.04^{c}
		30	4.81±0.07^{ab}	4.87±0.05^{bc}	4.88±0.03^{bc}
		60	4.84±0.02^{b}	4.83±0.01^{ab}	4.79±0.01^{ab}
	L	1	94.27±0.27^{a}	92.82±0.13^{bc}	91.89±0.40^{d}
		30	93.16±0.41^{b}	92.37±0.50^{cd}	92.76±0.33^{bc}
		60	92.66±0.15^{bc}	94.22±0.40^{a}	93.29±0.37^{b}
	a*	1	-2.42±0.11^{ef}	-3.20±0.21^{b}	-3.49±0.14^{a}
		30	-2.34±0.05^{fg}	-2.54±0.15^{de}	-2.68±0.08^{d}
		60	-2.22±0.07^{g}	-2.70±0.02^{d}	-2.96±0.08^{c}
	b*	1	9.23±0.32^{a}	10.71±0.87^{b}	11.28±0.74^{b}
		30	9.55±0.28^{a}	9.04±0.12^{a}	9.09±0.23^{a}
		60	9.51±0.27^{a}	9.47±0.16^{a}	9.20±0.19^{a}

Values represented by mean ± standard deviation.
^{a,b,c} Different superscript in the same parameter indicates significant differences ($p<0.05$).

3.3. The changes in nitrogen fractionations

The WSN, TCA-SN value and RI were determined for the monitoring of proteolysis progress, and acid degree value (ADV) for evaluation of lipolysis and the results were given in Table 3. No significant difference ($P>0.05$) was found in WSN or TCA-SN levels between HHP-treated cheeses and control cheese for 60 days ripening period in cow cheese. In contrast, both WSN and TCA-SN value of goat cheeses were determined by application of 300 MPa pressure compared to 450 MPa in cheeses samples ($P<0.05$). Higher proteolysis was observed in 300 MPa HP treated cheeses compared to control and

450 MPa treated samples. The chymosin activity is important for cheese ripening, however, chymosin enzyme has been affected by high hydrostatic pressure depending on pressure force. While most of the peptides were produced rapidly under HP treatment at <300 MPa pressure. The liberation of other peptides was inhibited by pressurization at >300 MPa pressures (SCOLLARD *et al*., 2000).

Table 3. The effect of high-pressure treatment (300 and 450 MPa for 5 min) on proteolysis and lipolysis of the cheeses during ripening.

Cheese type			Control	300 Mpa	450 Mpa
Cow cheese	WSN (%)	1	0.024±0.00^{a}	0.029±0.00^{ab}	0.027±0.00^{ab}
		30	0.028±0.00^{ab}	0.032±0.00^{bc}	0.034±0.00^{cd}
		60	0.037±0.00^{de}	0.040±0.00^{e}	0.039±0.00^{e}
	Ripening Index	1	1.016±0.01^{a}	1.189±0.03^{abc}	1.147±0.00^{ab}
		30	1.291±0.09^{abc}	1.376±0.13^{cd}	1.441±0.09^{de}
		60	1.670±0.227^{e}	1.662±0.29^{de}	1.588±0.17^{de}
	TCA-SN (%)	1	0.006±0.00^{a}	0.008±0.00^{ab}	0.009±0.01^{abc}
		30	0.010±0.00^{bcd}	0.011±0.00^{bcde}	0.009±0.00^{bc}
		60	0.013±0.00^{de}	0.014±0.00^{e}	0.012±0.00^{cde}
	Acid degree Value	1	0.86±0.08^{ab}	0.56±0.040^{a}	0.67±0.02^{a}
		30	1.21±0.39^{c}	1.08±0.09^{bc}	1.02±0.01^{bc}
		60	1.16±0.21^{bc}	1.18±0.20^{bc}	1.26±0.22^{c}
Goat cheese	WSN (%)	1	0.025±0.00^{a}	0.030±0.00^{b}	0.027±0.00^{a}
		30	0.026±0.00^{a}	0.033±0.00^{c}	0.036±0.00^{cd}
		60	0.028±0.00^{a}	0.034±0.00^{c}	0.038±0.00^{d}
	Ripening Index	1	0.938±0.02^{a}	1.204±0.06^{c}	1.036±0.11^{ab}
		30	1.118±0.09^{bc}	1.421±0.06^{de}	1.512±0.08^{e}
		60	1.199±0.06^{c}	1.351±0.09^{d}	1.429±0.03^{de}
	TCA SN (%)	1	0.009±0.00^{a}	0.011±0.00^{a}	0.010±0.00^{a}
		30	0.010±0.00^{a}	0.012±0.00^{a}	0.011±0.00^{a}
		60	0.461±0.02^{c}	0.345±0.19^{bc}	0.268±0.12^{b}
	Acid degree Value	1	0.95±0.01^{ab}	0.99±0.04^{ab}	1.09±0.05^{b}
		30	0.80±0.12^{a}	1.15±0.18^{b}	1.09±0.03^{b}
		60	1.77±0.29^{c}	1.92±0.14^{c}	1.89±0.03^{c}

Values represented by mean ± standard deviation.

^{a,b,c} Different superscript in the same parameter indicates significant differences ($p < 0.05$).

The ripening index value of goat cheese samples was higher than cow cheese samples. The destabilization of casein micelles after high hydrostatic pressure processing may increase as a result of residual coagulant or indigenous milk proteinases activity (HUPPERT *et al*., 2004) and can cause enhancement effect on their sensibility to proteolytic enzymes. It means that plasmin can play an important role in proteolysis after pressurization. The enhancer effect of high hydrostatic pressure on proteolysis was reported in other cheeses under different pressures (O'REILLY *et al*., 2000; RYNNE *et al*., 2008; VOIGT *et al*., 2010).

Similar to proteolytic changes, ADV values were affected by high-pressure treatment in goat cheese samples (P<0.05), whereas, there was no significant effect found in cow cheese samples (P>0.05). ADV values of all cheese samples showed an increase during storage time. It is obvious that high-pressure treatment influences biochemical reactions during the ripening period of cheese. This phenomenon may occur via the direct effect of pressure on enzyme or reaction and may affect the release of enzymes of lactic acid bacteria. Besides the changes during ripening via biochemical reaction on compositional and structural properties of cheeses, HHP produces conformational changes in proteins and may affect enzyme modulation site or active site directly (ROVERE, 1995). These changes affect proteolysis or lipolysis and show enhancing and reducing effect on the ripening of various cheeses.

3.4. Overall composition comparison of cheeses

SIMCA of the overall properties of the control and high pressure treated cheeses are presented in Fig. 2. It showed the distinctive pattern and 6 well-defined cheese groups. SIMCA is a supervised classification method and provides a model based on the principal component analysis and uses the distance of the mean in each group for discrimination. The distance of mean in each cluster or group are known as interclass distance and if this value is higher than 3, it is significant for identification (KVALHEIM and KARSTANG, 1992). The interclass distance for all control and pressurized cheeses ranged between 3.74-17.04 (Table 4).

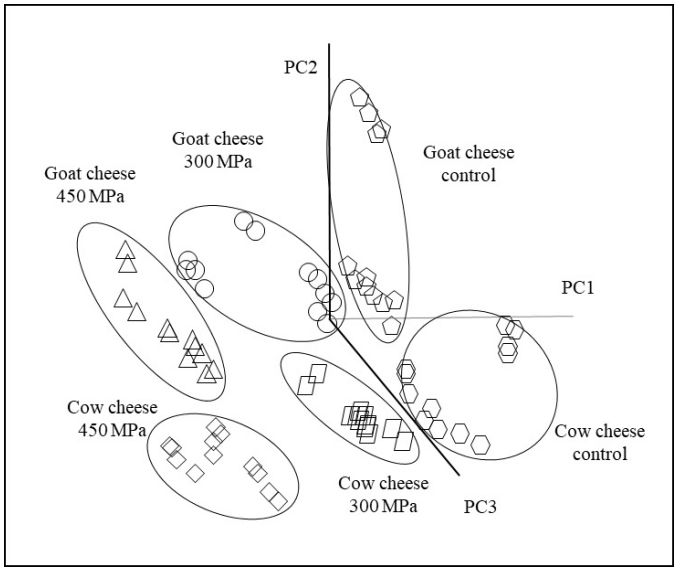

Figure 2. Soft independent modeling of class analogy (SIMCA) classification plot of cheese samples treated with high pressure at 300 and 450 MPa for 5 min. The all data were transformed into their centered and normalized mean prior to multiple analysis.

Table 4. Interclass distances between the goat and cow cheese treated with high pressure at 300 and 450 MPa for 5 min based on the SIMCA class projections.

Groups	Cow cheese control	Cow cheese 300 MPa	Cow cheese 450 MPa	Goat cheese control	Goat cheese 300 MPa	Goat cheese 450 MPa
Cow cheese control	0.00					
Cow cheese 300 MPa	3.74	0.00				
Cow cheese 450 MPa	7.38	6.89	0.00			
Goat cheese control	6.73	14.33	17.04	0.00		
Goat cheese 300 MPa	7.35	9.45	10.65	7.48	0.00	
Goat cheese 450 MPa	8.82	10.04	8.26	11.35	4.68	0.00

Interestingly, cow and goat cheese results showed good discrimination, although, both cheese types had similar results. The difference between goat and cow cheeses probably arises from results of the proteolysis and lipolysis test. When WSN and TCA-SN values of the cow cheese were not affected by high pressure application, pressurization showed enhancer effect on goat cheese samples, proteolysis and lipolysis properties. The SIMCA pattern showed that control, 300 MPa and 450 MPa pressurized samples of both cow and goat cheeses grouped in the same order and implying increase in pressure created a similar effect on the two cheese species.

4. CONCLUSION

The evaluation of the overall results obtained from the study showed that, two different levels of the high-pressure application on white cheeses samples produced from cow and goat milk had varying effects. This method shows the possibility of applying high-pressure treatment in the white cheese besides the predetermined reliability. Also, the microbial load of lactic acid bacteria is decreased by high-pressure practices. The HPP delayed the growth of yeasts/molds in goat cheese samples compared to the control groups at the end of the ripening period. Consequently, increase in the level of HPP provided significant decreasing effect on TMAB, Lactobacilli and Lactococci counts, and increasing effect on proteolysis and lipolysis. The fact that high-pressure has no significant difference in the chemical composition, but have positive results visually indicates the applicability of this technology.

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