YYÜ TAR BİL DERG
(YYU J AGR SCI)
2014, 24(1): 70-78

Geliş Tarihi (Received): 04.06.2013
Kabul Tarihi (Accepted): 09.11.2013

Araştırma Makalesi/*Research Article (Original Paper)*

The Effect of Homogenization, $CaCl_2$ Addition and Pasteurization on White Cheese and Whey Composition

Elvan OCAK[1*], Seval ANDIÇ[1], Yusuf TUNÇTÜRK[1]

[1]: Yüzüncü Yıl University, Architecture and Engineering Faculty, Department of Food Engineering, 65080 Van, Turkey
e-mail: elvanocak@yyu.edu.tr

Abstract: In this study it was aimed to determine the effect of different homogenization pressure, pasteurization process and $CaCl_2$ addition on White cheese and whey composition. Pasteurization process increased ash and calcium content of cheeses, on the contrary to these, dry matter, ash, ash in dry matter and calcium content of whey decreased depending on pasteurization. The pH degree was lower in raw milk cheeses at draining stage and this caused more calcium loss from cheese curd of raw samples. Adjusted yield of cheeses increased in homogenized, pasteurized and $CaCl_2$ added samples. While fat content of cheeses were higher in homogenized cheese samples; dry matter, pH and Ca were lower in whey belonging to homogenized milk cheese samples. Consequently, it can be said that pasteurization, homogenization and $CaCl_2$ addition processes had positive effects on yield and composition of White cheeses.

Keywords: Homogenization, Pasteurization, $CaCl_2$, White cheese, Whey

Beyaz Peynir ve Peyniraltı Suyu Bileşimine Homojenizasyonun, $CaCl_2$ İlavesinin ve Pastörizasyonun Etkisi

Özet: Bu çalışmada, Beyaz Peynir ve peyniraltı suyu bileşimine farklı homojenizasyon basıncının, pastörizasyon işleminin ve $CaCl_2$ ilavesinin etkisi incelenmeye çalışılmıştır. Pastörizasyon işlemi, peynirlerin kül ve kalsiyum içeriğini artırmış, bunların aksine peyniraltı suyunun kuru madde, kül, kuru madde de kül ve kalsiyum içeriği pastörizasyona bağlı olarak azalmıştır. Çiğ sütten yapılan peynirlerde suyun ayrılması sırasında pH değeri daha düşük olduğundan bu örneklerde peynir pıhtısından çok fazla kalsiyum ayrılmasına sebep olmuştur. Peynirlerin düzeltilmiş randımanı homojenize edilmiş, pastörize edilmiş ve $CaCl_2$ eklenmiş örneklerde artmıştır. Homojenize edilmiş peynir örneklerinde yağ içeriği daha yüksek iken, bu örneklere ait peyniraltı sularında kurumadde, pH ve kalsiyum daha düşük bulunmuştur. Sonuç olarak, pastörizasyon ve homojenizasyon işlemi ile $CaCl_2$ ilavesinin Beyaz peynirlerin verimi ve kompozisyonu üzerine olumlu etkileri olduğu söylenebilir.

Anahtar kelimeler: Homejenizasyon, Pastörizasyon, $CaCl_2$, Beyaz peynir, Peyniraltı suyu

Introduction

Homogenization and pasteurization of cheese-milk and $CaCl_2$ addition cause major physical and chemical changes in cheese. Homogenization of milk creates smaller globules with a greater total fat-water interfacial surface area. The surface active proteins, especially caseins, either as semi-intact micelles or as micellar fragments, cover the newly formed surface of the fat globules, and this protects the fat from coalescing (Everett and Auty 2008, Sharma and Dalgleish 1993). As the pressure of the homogenization increased, the size of the fat globules in the milk decreased, and the caseins micelles required to spread even more widely over the surface of the fat (Dalgleish et al. 1996). In the absence of heating, the serum proteins seem to play a relatively minor role in this process (Dalgleish and Sharma 1993). But it has been shown that β-lactoglobulin and α-lactalbumin both interact with the κ-casein associated with the fat globules when whole milk is heated (Dalgleish and Blanks 1991; Houlihan et al. 1992). Experimentally, it is demonstrable that heating causes the incorporation of large amounts of serum protein into the fat globule fraction and occurrence is form as it were a second membrane layer around the fat globule (Dalgleish and Sharma 1993). Summarizing, heat treatment of milk results in a complex mixture of native whey proteins, whey protein aggregates and casein micelles covered with whey protein. Both heating and homogenization of milk leaded to physical and chemical changes in the milk and milk products, especially cheese, for example, the rennet coagulation of milk is considerably changed (Sharma and Dalgleish 1993), they are a lower drainage of whey from the rennet curd, increase the coagulum strength (Ghosh et al. 1994), increase the whiteness, moisture retention (Everett and Auty 2008; Tunick et al. 1993), they provide higher cheese yield because of lower fat losses in whey, lower free oil in cheese due to the increased degree of fat emulsification and increased rate of lipid hydrolysis for certain types of cheese, e.g., Blue cheese (Madadlou et al. 2007; Solorza and Bell 1998a; McMahon et al. 1997).

Heating of homogenized milk changed both physical and chemical properties in the milk fat globule membrane and serum proteins due to their interaction (Sharma and Dalgleish 1993, 1994; Dalgleish and Sharma 1993, Van Boekel and Walstra 1989). Both fore-warming and homogenization also affect the renneting and heat stability properties of milk (Sharma and Dalgleish 1994).

The effects of calcium addition to milk and pH are not independent events. Ca^{2+} also reduces pH due to chelation of HPO_3^{2-} and $H_2PO_3^-$ ions, thus the increase in milk gel firmness and the reduced time for clotting to occur may be due to a decrease in pH rather than an increase in soluble calcium. A reduction of 0.01 units of pH per mM of Ca^{2+} addition, up to 5 mM, has been reported by Ramet et al. (1981). Increasing the amount of total (ionic plus insoluble) calcium in cheese enhances casein-casein interactions, thereby reducing meltability and increasing cheese firmness (Everett and Auty 2008; Solorza and Bell 1998b).

White cheese is produced using raw milk, traditionally. However, in last two decades, pasteurization and $CaCl_2$ addition are becoming standard processes in White cheese making, but, homogenization is a rarely used application. The aim of this study was to evaluate the effect of homogenization and homogenization of cheese milk and $CaCl_2$ addition on cheese compositional parameters.

Material and Methods

Raw milk supplied from a Dairy Plant of Agriculture Faculty of Yüzüncü Yıl University. Lyophilised culture of *Lactococcus lactis* subsp. *lactis* and *Lactococcus lactis* subsp. *cremoris* were purchased from Peyma (Chr. Hansen's Co., İstanbul, Turkey). All chemicals were analytical grade (Sigma Chemical Co. St. Louis, MO, USA; Merck, Darmstadt, Germany).

Cheese production was carried out in Dairy Pilot Plant of Food Engineering Department of Yuzuncu Yil University.

White Cheese and Whey

For White cheese making, bovine milk was heated to 50 °C and then divided into three batches. The first batch was kept in unhomogenized form, the second batch was homogenized at 7.5 MPa (Giusti Corp., Wellingborough, Northants, UK) and the third batch was homogenized at 15 MPa. Then each batch was divided into two parts. The first part of milk was pasteurized (65 °C for 30 min) and the second part was not. After that each milk part was divided into two equal parts and $CaCl_2$ was added into a part. Thus 12 cheese milk batches were obtained totally (Table 1).

Pasteurized cheeses were prepared according to industrial method. After cooling (35 °C), $CaCl_2$ (150 ppm) was added into the pasteurized milk. Lyophilized cultures sub-cultured twice in sterilized reconstituted skim milk individually and a mixture (1/1, v/v) of these bacteria were inoculated to each treatment (20 g/L) (only for pasteurized samples). After 30 min, rennet extract (70 ppm, 1/10 000 strenght, Pınar Inc., Istanbul-Turkey) was added to treatment, which was incubated at 30 °C to develop the curd. After coagulation time (approximately 90 min) the curd was cut into 1 cm^3 with a curd knife, transferred to cheese cloth and allowed to stand for 3 h under pressure (10 kg weight) for draining the whey. After the removal of the whey, cheese mass was divided into blocks of about 7x7x7 cm with a knife.

Table 1. Definition of cheese-milk types used in the experiment

Cheese-milk	Homogenization pressure (MPa)	Pasteurization	Addition of $CaCl_2$
1	0	+	+
2	7.5	+	+
3	15	+	+
4	0	+	-
5	7.5	+	-
6	15	+	-
7	0	-	+
8	7.5	-	+
9	15	-	+
10	0	-	-
11	7.5	-	-
12	15	-	-

Chemical Analyses

Total solids, fat, total nitrogen, titratable acidity and pH of the cheeses were determined according to AOAC methods (1995). Protein content of cheeses was calculated multiplying the total nitrogen content by 6.38. Moisture, non-fat dry matter (NFDM), moisture in NFDM, fat in DM, protein in DM and ash in DM used for Principal Component Analysis (PCA) were obtained by calculation. Cheese yields were converted to adjusted yield basing on their average dry matter content (Metzger and Mistry 1994), Ca was determined by atomic absorption spectrometry at 422.7 nm (Thermo Solaar AAS Spectrometry, Type M6 MK2, UK). P was determined by UV-Vis spectrophotometer at 400 nm (PGeneral T80 double beam UV-VIS Spectrophotometer, China) (AOAC 1995). For quantification these elements, samples were obtained by dry ashing at 550°C in a furnace and then solubilized in nitric acid (IDF 1992).

Statistical analysis

Experiment was performed on three replicates for White cheese and whey samples. Each analysis was done in duplicate following analytical procedure as defined above. All data were subjected to an analysis of variance (ANOVA) and separated by Tukey's Multiple Range Test perform using the SAS statistical software (SAS 2005). To gain insight into the structure of the data set, Principal Components Analysis (PCA) was performed. PCA is a well-known mathematical transformation of the raw data; it is an exploratory technique that indicates relationships among variables (Piggot and Sharman 1986).

Results and Discussion

White Cheese

The effect of different homogenization pressure, heat treatment and $CaCl_2$ addition into cheese-milk on composition and yield of White cheese were given in Table 2

Table 2. The effect of different homogenization pressure, heat treatment and $CaCl_2$ addition into cheese- milk on composition and yield of White cheese

$CaCl_2$	Pressure (MPa)	Heat treatment	Dry Matter (%)	Ash (%)	pH	Acidity (%)	Fat (%)	Protein (%)	Ca (mg/kg)	P (mg/kg)	Adjusted Yield
0	0	R	37.55 ± 0.16^{b}	1.58 ± 0.02^{ab}	5.41 ± 0.01^{abc}	0.28 ± 0.01^{cde}	18.75 ± 0.35^{c}	16.74 ± 0.12^{ab}	3363.41 ± 40.41^{ab}	2371.53 ± 6.16^{a}	16.42 ± 0.18^{d}
		P	38.27 ± 0.12^{ab}	1.40 ± 0.07^{def}	5.30 ± 0.01^{cd}	0.35 ± 0.01^{abc}	19.00 ± 0.00^{c}	17.10 ± 0.43^{a}	2900.67 ± 49.94^{bc}	2218.53 ± 1.33^{a}	16.36 ± 0.40^{d}
	7.5	R	38.84 ± 0.55^{ab}	1.52 ± 0.01^{bc}	5.41 ± 0.01^{abc}	0.28 ± 0.01^{de}	20.50 ± 0.71^{abc}	15.97 ± 0.58^{ab}	3392.17 ± 59.04^{ab}	2391.34 ± 2.81^{a}	16.99 ± 0.25^{cd}
		P	37.80 ± 0.61^{b}	1.24 ± 0.01^{g}	5.15 ± 0.04^{e}	0.40 ± 0.01^{a}	21.25 ± 0.35^{ab}	15.15 ± 0.26^{b}	2206.52 ± 3.85^{d}	2142.09 ± 2.86^{a}	18.47 ± 0.29^{ab}
	15	R	37.53 ± 0.05^{b}	1.49 ± 0.01^{bcd}	5.47 ± 0.01^{a}	0.25 ± 0.01^{e}	19.75 ± 0.35^{bc}	15.90 ± 0.52^{ab}	3247.59 ± 47.80^{ab}	2341.16 ± 1.93^{a}	16.96 ± 0.19^{cd}
		P	37.42 ± 0.62^{b}	1.31 ± 0.01^{fg}	5.30 ± 0.02^{cd}	0.35 ± 0.02^{abcd}	20.25 ± 0.35^{bc}	15.33 ± 0.14^{b}	2472.16 ± 1.67^{cd}	1958.76 ± 1.48^{a}	18.19 ± 0.54^{abc}
150	0	R	38.24 ± 0.49^{ab}	1.63 ± 0.01^{a}	5.43 ± 0.02^{ab}	0.28 ± 0.02^{cde}	18.75 ± 0.35^{c}	17.11 ± 0.20^{a}	3609.40 ± 93.74^{bc}	2468.65 ± 8.85^{a}	16.45 ± 0.34^{d}
		P	37.86 ± 0.05^{b}	1.39 ± 0.02^{ef}	5.30 ± 0.07^{cd}	0.32 ± 0.01^{bcde}	19.25 ± 0.35^{c}	16.51 ± 0.57^{ab}	2976.02 ± 69.88^{a}	2164.55 ± 1.87^{a}	18.17 ± 0.14^{abc}
	7.5	R	38.32 ± 0.25^{ab}	1.48 ± 0.01^{cde}	5.41 ± 0.01^{abc}	0.29 ± 0.00^{bcde}	19.75 ± 0.35^{bc}	16.22 ± 0.78^{ab}	3327.36 ± 46.60^{ab}	2269.07 ± 7.15^{a}	17.11 ± 0.39^{bcd}
		P	38.28 ± 0.72^{ab}	1.26 ± 0.01^{g}	5.23 ± 0.02^{de}	0.36 ± 0.04^{ab}	21.25 ± 0.35^{ab}	15.29 ± 0.12^{b}	2294.83 ± 1.25^{d}	2038.42 ± 1.59^{a}	18.82 ± 0.62^{a}
	15	R	38.06 ± 0.16^{b}	1.49 ± 0.01^{bcd}	5.49 ± 0.01^{a}	0.25 ± 0.01^{e}	20.25 ± 1.06^{bc}	15.61 ± 0.60^{ab}	3387.67 ± 1.85^{ab}	2308.67 ± 7.14^{a}	17.43 ± 0.28^{bcd}
		P	39.71 ± 0.26^{a}	1.45 ± 0.01^{cde}	5.31 ± 0.01^{bcd}	0.36 ± 0.01^{ab}	22.25 ± 0.35^{a}	15.67 ± 0.35^{ab}	2741.62 ± 3.55^{bc}	2088.79 ± 2.75^{a}	18.81 ± 0.07^{a}

[a, b, c] Means in each column with different superscripts were significantly different (*P*<0.05); P = pasteurized milk, R= raw milk

Compositional properties as ash, pH, acidity, Ca, adjusted yield (*P*<0.001), fat (*P*<0.01) and protein (*P*<0.05) of the White cheeses were found to be affected significantly by heating of cheese-milk. While ash, protein, pH, Ca and P were higher in the cheese made from raw milk; acidity, fat and adjusted yield of the pasteurized cheese were higher (Table 2). In pasteurized cheese, reduction in the numbers of naturally present bacteria in milk, addition starter lactic acid bacteria and their high acidifying activity possibly led to a faster development of acidity. The pH of pasteurized and pressure-treated milk cheeses was found lower than in cheeses made from raw milk (Buffa et al. 2005). Calcium ions released as dissociated form at low pH values and passed to whey, thus Ca, P and ash ratio decreased depending on pH decrease.

The heating of milk may be used to increase cheese yield, by binding the whey protein to the micelles (Dalgleish and Sharma 1993). Similar results were obtained in homogenized samples and $CaCl_2$ added samples. While fat content and yield of white cheese were higher (*P*<0.001) in homogenized samples. Homogenization of milk affects the casein network, thereby altering its basic structure and leads to lower curd firmness during rennet coagulation, curd shattering during cutting and increased fine losses to whey (Nair et al. 2000). Depending on the homogenization pressure, fat contents of the cheeses increased, conversely fat contents of whey decreased. As known, homogenization causes better fat recovery in cheese curd (Metzger and Mistry 1994; Walstra et al. 1999).

Addition of $CaCl_2$ to the milk was also observed to affect the adjusted yield (*P*<0.01), ash and Ca (*P*<0.05) (Table 2). Depending on the cheese manufacturing protocol (firmness of gel at cutting, cut programme), the addition of $CaCl_2$ may also increase the level of milk fat recovered to cheese, cheese moisture and cheese yield. The increase is likely to be due to the more rapid curd-firming rate, which would increase rigidity of the gel/curd during the early stages of syneresis, thereby limiting the ability of the matrix to rearrange and express whey (O'Callaghan and Guinee 2010).

Principal component analysis (PCA) was applied to compositional variables that were affected by pasteurization, homogenization pressure and addition of $CaCl_2$. Results from the PCA belonging to White cheese showed that principal components (PC) 1 and 2 described about 72.39 % of the total variation of sample: 49.33 % PC1 and 23.06 % PC2 (Fig. 1). While PC1 was heavily loaded on homogenization, pasteurization, NFDM, moisture in NFDM, fat, fat in DM, protein, ash, pH, titratable acidity, Ca, P and adjusted yield, the second factor (PC2) was loaded on DM, moisture and $CaCl_2$. There were positive significant correlations between homogenization and moisture in NFDM, fat, fat in DM, adjusted yield and negative significant correlations between homogenization and NFDM, protein and protein in DM. On the other hand, correlations between pasteurization and moisture in NFDM, fat, fat in DM, titratable acidity and adjusted yield were found significantly positive; and correlations between pasteurization and ash, ash in DM, NFDM, pH, P and Ca were determined significantly negative. $CaCl_2$ addition only correlated with DM of cheese, significantly.

Compositional variables such as dry matter, pH, Ca, P, nonfat dry matter, ash dry matter and protein, showed positive loadings with PC1, whereas moisture, titratable acidity, fat, pasteurization and protein dry matter showed negative loading with this factor (Fig. 1). The second factor (PC2) was high positive loadings with pH, Ca, ash, protein, P and non-fat dry matter and it showed negative loading with homogenization, pasteurization, $CaCl_2$ fat, dry matter, adjusted yield and titratable acidity. Results also showed that there is negative significant relationship among homogenization, heat treatment, moisture, pH, Ca, P, ash and protein (Fig. 1)

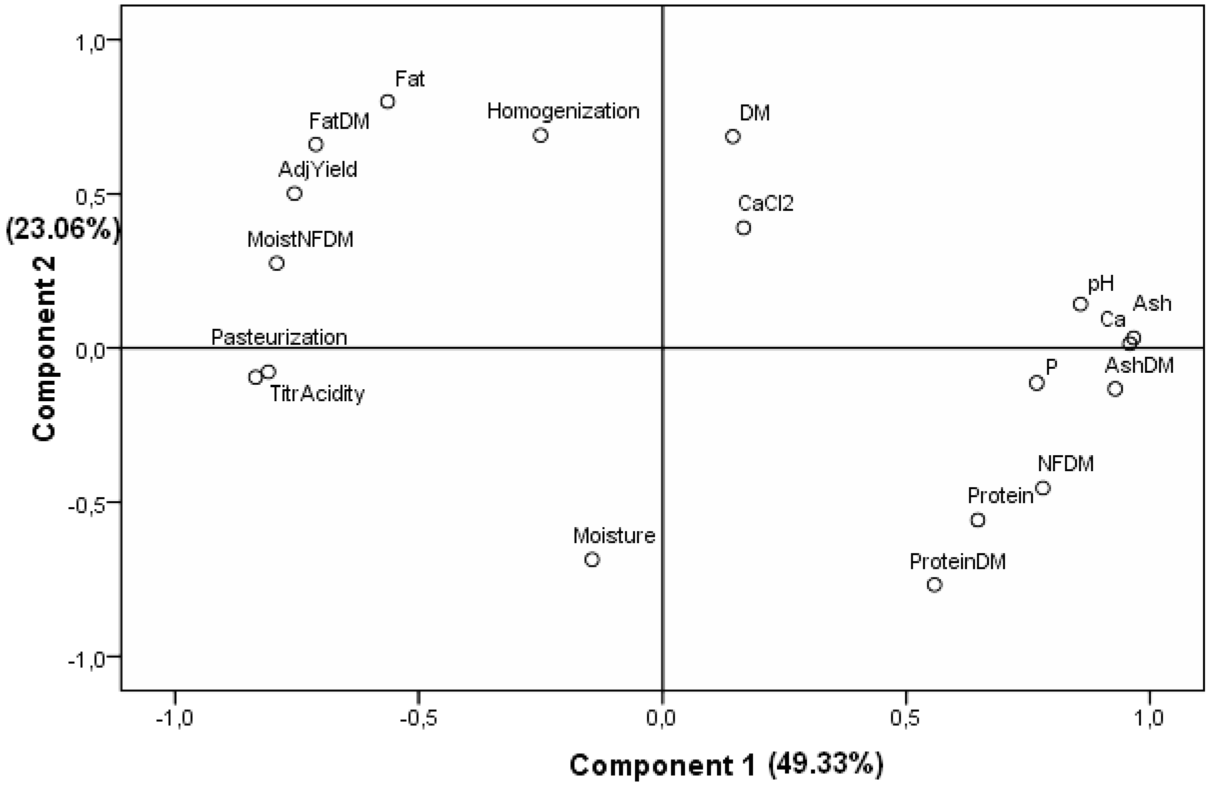

Fig.1. Principal component analysis of the effect compositional variables that were affected By pasteurization, homogenization pressure and addition of $CaCl_2$ in White cheese.

Whey

The composition of whey was given in Table 3. Generally, the dry matter, fat, pH (P<0.001) and protein (P<0.05) contents of whey obtained from pasteurized cheese were significantly lower. Positive relationship was determined between titratable acidity and Ca, P and ash. The observed increases in the levels of ionic calcium in the whey were probably due to the conversion of the colloidal calcium phosphate to ionic form.

Dry matter, pH and fat contents of whey decreased with homogenization pressure of milk compared with that of the control (P<0.001), possibly because of the loss of fat clumps in nonhomogenized sample during draining. In other studies, homogenization was reported to reduce the fat content of whey (Metzger and Mistry 1994, Nair et al. 2000). The protein in cheese whey was also lower for homogenized samples compared to control sample. The lower fat and protein losses with homogenization could be attributed to the reduction in fat globule size and the modified fat globule membrane by adsorption of proteins onto fat globule surface.

Lower fat and protein content of homogenized whey samples reflected on the total solids content as well. Whey from control had higher total solids compared to that from homogenized treatments.

Table 3. The effect of different homogenization pressure, heat treatment and $CaCl_2$ to cheese-milk on composition of whey

$CaCl_2$ (ppm)	Preussre (MPa)	Heat treatmnet	Dry Matter (%)	Ash (%)	pH	Acidity (%)	Fat(%)	Protein (%)	Ca (mg/kg)	P (mg/kg)
0	0	R	6.47 ± 0.03^{a}	0.54 ± 0.00^{d}	5.93 ± 0.05^{a}	0.24 ± 0.01^{d}	0.40 ± 0.00^{a}	0.95 ± 0.02^{a}	411.03 ± 3.43^{a}	408.91 ± 0.67^{a}
		P	6.36 ± 0.02^{ab}	0.61 ± 0.01^{a}	5.60 ± 0.03^{cd}	0.27 ± 0.01^{bcd}	0.30 ± 0.00^{b}	0.89 ± 0.01^{a}	451.35 ± 35.99^{a}	407.99 ± 26.88^{a}
	7.5	R	6.36 ± 0.14^{ab}	0.56 ± 0.04^{bcd}	5.88 ± 0.03^{ab}	0.24 ± 0.01^{d}	0.10 ± 0.00^{c}	0.95 ± 0.14^{a}	376.75 ± 31.00^{a}	408.76 ± 18.51^{a}
		P	6.03 ± 0.14^{cde}	0.56 ± 0.01^{a}	5.49 ± 0.04^{de}	0.31 ± 0.01^{a}	0.10 ± 0.00^{c}	0.84 ± 0.04^{a}	408.71 ± 75.09^{a}	536.25 ± 22.34^{a}
	15	R	6.33 ± 0.06^{abc}	0.56 ± 0.00^{cd}	5.83 ± 0.04^{ab}	0.25 ± 0.01^{cd}	0.10 ± 0.00^{c}	0.95 ± 0.03^{a}	400.81 ± 27.27^{a}	429.48 ± 5.32^{a}
		P	5.89 ± 0.06^{e}	0.58 ± 0.01^{abc}	5.53 ± 0.04^{de}	0.29 ± 0.01^{abc}	0.10 ± 0.00^{c}	0.79 ± 0.02^{a}	407.22 ± 44.51^{a}	545.71 ± 134.46^{a}
150	0	R	6.46 ± 0.13^{a}	0.57 ± 0.02^{abcd}	5.90 ± 0.03^{a}	0.24 ± 0.01^{d}	0.35 ± 0.01^{ab}	0.87 ± 0.03^{a}	422.40 ± 2.81^{a}	414.70 ± 4.50^{a}
		P	6.26 ± 0.05^{abc}	$0. 58 \pm 0.01^{abcd}$	5.75 ± 0.02^{bc}	0.25 ± 0.01^{d}	0.30 ± 0.00^{b}	0.95 ± 0.07^{a}	436.20 ± 29.49^{a}	429.29 ± 5.87^{a}
	7.5	R	6.31 ± 0.07^{abc}	0.58 ± 0.00^{abc}	5.86 ± 0.06^{ab}	0.25 ± 0.01^{cd}	0.10 ± 0.00^{c}	0.89 ± 0.08^{a}	413.46 ± 2.31^{a}	424.38 ± 24.72^{a}
		P	6.06 ± 0.02^{bcde}	0.59 ± 0.01^{abc}	5.52 ± 0.03^{de}	0.29 ± 0.00^{ab}	0.10 ± 0.00^{c}	0.87 ± 0.08^{a}	494.68 ± 9.89^{a}	456.90 ± 12.01^{a}
	15	R	6.24 ± 0.03^{abcd}	0.56 ± 0.02^{cd}	5.83 ± 0.05^{ab}	0.25 ± 0.01^{d}	0.10 ± 0.00^{c}	0.85 ± 0.10^{a}	384.14 ± 1.06^{a}	416.94 ± 15.89^{a}
		P	5.93 ± 0.03^{de}	0.60 ± 0.00^{ab}	5.45 ± 0.01^{e}	0.32 ± 0.01^{a}	0.10 ± 0.00^{c}	0.85 ± 0.00^{a}	455.73 ± 58.02^{a}	548.20 ± 152.49^{a}

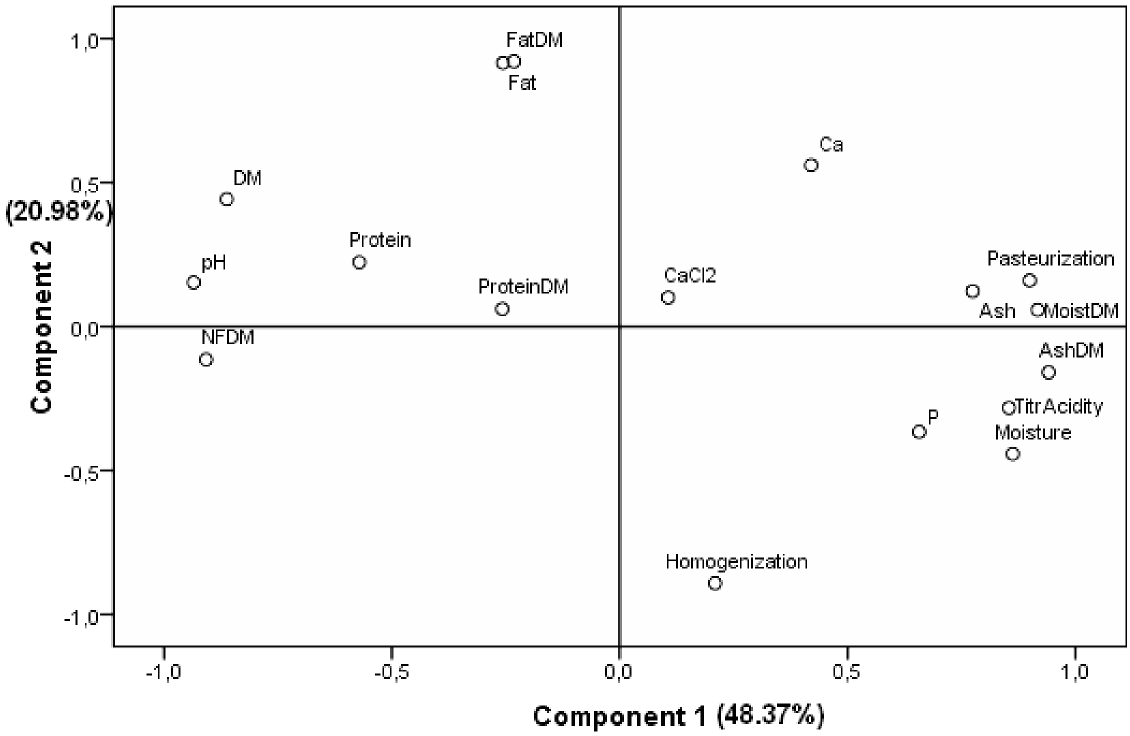

Fig. 2. Principal component analysis of the effect compositional variables that were affected by pasteurization, homogenization pressure and addition of $CaCl_2$ in whey

According to the PCA analysis results showed that principal components 1 and 2 described about 69.35 % of the total variation of sample: 48.37 % for PC1 and 20.98 % for PC2. There was negative significant relationship among homogenization and some other compositional variables such as protein, fat, dry matter, Ca etc. (Fig. 3). As expected, parameters of whey were oppositely placed in the figure when compared White cheese parameters.

Conclusion

Homogenization, pasteurization and added $CaCl_2$ are common processes in dairy industry that can alter product characteristics.

Pasteurization process decreased pH, ash, calcium and phosphorus content of cheeses, on the contrary, these parameters of whey increased depending on pasteurization. Because of the addition of starter cultures into pasteurized milk could speed up acidification, decreased through soluble form of calcium and as a result, ash is reduced.

Homogenization of the cheese milk had a positive effect on fat retention and cheese yield. The addition of calcium into the milk enhanced the retention of this mineral in the cheeses. Therefore, in the industrial production method use of homogenization, pasteurization and $CaCl_2$ addition should be preferred for obtaining White cheeses at a standard quality.

References

Buffa M, Guamis B, Trujillo A J (2005). Specific effect of high-pressure treatment of milk on cheese proteolysis. J. Dairy Res. 72:385-392.

Dalgleish DG, Blanks JM (1991). Formation of complexes between serum proteins and fat globules during the heating of whole milk. Milchwissenschaft 49:75-78.

Dalgleish DG, Sharma SK (1993). Interactions between milk fat and milk proteins – the effect of heat on the nature of the complexes formed. IDF Special Issue 9303. Protein & Fat Globule Modifications p. 7-17.

Dalgleish DG, Tosh SM, West S (1996). Beyond homogenization: the formation of very small emulsion droplets during the processing of milk by a microfluidizer. Neth. Milk & Dairy Journal 50:135-148.
Everett DW, Auty MAE (2008). Cheese structure and current methods of analysis. Int. Dairy Journal 18:759-773.
Ghosh BC, Steffl A, Hinrichs J, Kessler HG (1994). Rennetability of whole milk homogenized before or after pasteurization. Milchwissenschaft 49:363-366
Houlihan AV, Goddard PA, Nottingham SM, Kitchen BJ, Masters CJ (1992). Interaction between the bovine milk fat globule membrane and skim milk components on heating whole milk. J.Dairy Res. 59:187-195.
IDF (1992). Trace elements in milk and milk products. Brussels, Belgium: Int. Dairy Federation..
Madadlou A, Khosroshahi A, Mousavi ME (2007). Rheology, Microstructure, and Functionality of Low-Fat Iranian White Cheese Made with Different Concentrations of Rennet. J.Dairy Sci. 88:3052-3062.
McMahon DJ, Orme BJ, Ernstrom CA (1997). Improving fermentation and fat retention when making cheeses from ultrafiltered milk. Aust. J. Dairy Tech. 52:53-57.
Metzger LE, Mistry VV (1994). A new approach using homogenization of cream in the manufacture of reduced fat Cheddar cheese. 1. Manufacture, composition, and yield. J. Dairy Sci. 77:3506-3515.
Nair MG, Mistry VV, Oommen BS (2000). Yield and functionality of Cheddar cheese as influenced by homogenization of cream. Int. Dairy J. 10:647-657.
O'Callaghan DJ, Guinee TP (2010). Control and Prediction of Quality Characteristics in the Manufacture and Ripening of Cheese, pp. 260-314, In: Technology of Cheesemaking, Law BA and Tamime AY (eds), a John Wiley & Sons, Ltd., Publication.
Official Methods of Analysis, AOAC (1995). Calcium, magnesium and phosphorus in cheese. AOAC Official Method 991 25.
Piggot JR, Sharman K (1986). Methods to aid inter pretation of multidimensional data. In statistical procedures in food research. In Piggott JR (ed). Elsevier Applied Science, London, UK..
Ramet JP, El Mayda E, Webber F (1981). Correction par apport de chlorure de calcium de l'aptitude a la coagulation enzymatique d'un lait reconstitute refrigere. Milchwissenschaft 36:143-146.
SAS (2005). SAS/STAT Software:Hangen and Enhanced,Version 9.1.3., SAS Inst. Inc.,Cary, N.C. USA.
Sharma SK, Dalgleish DG (1993). Interactions between milk serum proteins and synthetic fat globule membrane during heating of homogenized whole milk. J. Ag. Food Che., 41:1407-1412.
Sharma SK, Dalgleish DG (1994). Effect of heat on the incorporation of milk serum proteins into the fat globule membrane of homogenized milk. J Dairy Res.61:375-384.
Solorza FJ, Bell AE (1998a). The effect of calcium addition on the rheological properties of a soft cheese at various stages of manufacture. Int. J. of Dairy Tech. 51:23-29.
Solorza FJ, Bell AE (1998b). Effect of calcium on the minerals retention and cheesemaking parameters of milk. Int. J. Dairy Tech. 51:37-43.
Tunick MH, Mackey KL, Shieh JJ, Smith PW, Cooke P, Malin EL (1993). Rheology and microstructure of low-fat mozeralla cheese. Int. Dairy J. 3:649-662.
Van Boekel MAJS, Walstra P (1989). Physical changes in the fat globules in unhomogenized and homogenized milk. IDF Bulletin No. 238:13-16.
Walstra P, Geurts TJ, Noomen A, Jellema A, Van Boekel MAJS (1999). Dairy Technology: Principles of milk, properties and processes, Parcel Deccer, Inc. New York-Basel, pp. 726.