MINERAL COMPOSITION OF HERBY CHEESE PRODUCED FROM RAW AND PASTEURIZED MILK

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Abstract. In this study, the effects of sirmo *(Allium vineale* L.*)*, mendi *(Chaerophyllum macropodum* Boiss.*)* and siyabo *(Ferula rigidula* DC.) on mineral compositions of herby cheese produced from raw and pasteurized milk in brine and vacuum package during 90 days ripening were determined. Macroelements (Ca, Mg, Na, K) and micro elements (Fe, Zn, Mn) concentration of herby cheese samples were examined by Inductively Coupled Plasma-Optical Emission Spectrometer (ICP-OES). It was determined that the mineral concentration was changed from highest to lowest Na>Ca>K>Mg>Zn>Fe>Mn in the herby cheese. The highest mean concentration of Na was found in Sirmo added cheeses manufactured from raw milk in brine on the second day of ripening and the lowest mean concentration of Mn was found in Sirmo added cheeses produced from pasteurized milk in brine at the end of 90 days. Na, Ca, K, Mg, Zn, Fe and Mn content of cheeses in brine and vacuum package decreased during ripening period.
Keywords: *herbs, mineral content, ripening period, packaging type*

Introduction

Herby cheese is one of the most popular cheeses traditionally produced from raw sheep's milk in the Eastern and South eastern region of Turkey (Tarakci and Temiz, 2009) particularly around Van province. If sheep milk is not available, sheep milk can be mixed with goat and cow milk for cheese production (Tarakci et al., 2004). Herby cheese variety has a salty taste, semi hard texture and is produced in small families (Andic et al., 2010, 2015; Tuncturk et al., 2014) between May and June (Tarakci and Temiz, 2009). It has been traditionally produced more than 200 years in Van and Eastern region of Turkey (Tarakci and Akyuz, 2009). But nowadays the cheeses are also manufactured commercially using pasteurized milk, starter culture in some dairies (in Van or other parts of Turkey). Almost 12 kinds of herbs are used for the production of Herby cheese. However, the most preferred herbs are sirmo *(Allium vineale* L.*)*, mendi *(Chaerophyllum macropodum* Boiss.*)* and siyabo *(Ferula rigidula* DC.) (Kose, 2015). The herbs ensure the cheese its characteristic aroma/flavour and appearance, but also prolong the shelf-life of cheese (Hayaloglu and Fox, 2008).

There are many macro and micro minerals in milk and dairy products. These minerals are very important both in terms of nutritional physiology and physical stability of the cows and the catalytic effects of milk and dairy products (Ocak and Kose, 2015). The mineral content of cheese sample depends on various factors such as feeding, genetic, lactation period, geographical area of milk production, environmental conditions, lack of a standart technique in cheese production and possible contamination from the equipment during the cheese production (Altun and Kose, 2016).

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There are many studies related to mineral content of herby cheese. The concentration of cheese samples were found by Tarakci and Kucukoner (2008) as 313.7, 552.6, 2606, 12.70 mg/100 g for Ca, P, Na, Mg, respectively. Heavy metals (ppm) were determined as 41.79, 33.99, 6.25, 2.05 mg/kg for Fe, Zn, Cu and Mn, respectively. Tarakci et al. (2005) determined the mineral contents of herby cheese samples (mg⁄100 g) as 289.49, 499.54, 2798.61, 3.20, 31.93, 46.07, 5.95 for Ca, P, Na, Mg, Zn, Fe and Cu, respectively. The same study, Mn, Cr, Co, Cd and Ni concentrations (ppm) were determined as 2.18, 0.23, 0.29, 0.22 and 0.19, respectively. Ocak and Kose (2015) determined Ca, K, Mg, Cu, Mn, Fe and Zn content of 26 Herby cheese samples obtained from retail markets in Van. They determined the concentration ranges in the cheese samples as 268.7-678.7, 84.6-163.2, 26.3-80.8, mg/100 g, 0.38-2.23, 8.13-25.94, 0.29-2.60, 3.14-29.25 mg/kg for Ca, K, Mg, Mn, Zn, Cu and Fe, respectively. Sagun et al. (2005) determined mineral contents of herby cheeses during ripening (90 days). It was determined that Ca, Mg, Fe, Zn, Mn, Ni and Cr contents decreased ($P < 0.05$), the Na content of cheeses increased ($P < 0.05$).

Many studies were performed to determine mineral contents of herby cheese samples but there is no study focusing on the effect of packaging, ripening and different herbs on macro and micro element accumulations in herby cheese. Therefore, the purpose of this investigation was to determine the effect of packaging, ripening and different herbs on the mineral content of herby cheese produced from raw and pasteurized milk during ripening.

Materials and methods

Production of herby cheese

Two different manufacturing methods were applied for production of herby cheese samples.

In the first method, milk and herbs were not pasteurized and the starter culture was not used. The pickled forms of the most preferred three local herbs such as Sirmo *(Allium vineale* L.*)*, Mendi *(Chaerophyllum macropodum* Boiss.*)* and Siyabo *(Ferula rigidula* DC.) were separately and mixed used for cheese production. The raw milk is filtered through a cloth filter and heated to 32 °C and is then coagulated by using commercial rennet (Mayasan company, İstanbul, Turkey) for 1 h. After coagulation, the curd is cut into small cubes. The curd partly drained and divided into 5 groups (A1 control group, A2 sirmo-added groups, A3 mendi-added groups, A4 siyabo-added groups, A5 sirmo, mendi and siyabo mixture added groups). Then the pickled herbs were added at levels of 2 kg to the curd obtained from 100 kg of milk. The mixture of curd and herbs were pressed with a heavy object for 3 h and then cut into blocks (7 × 7 × 2 cm). The cheese blocks were placed in glass jars which are salted with 14% brine and held 12 h. At the end of this time, some of cheeses were continue to ripened in glass jars which were salted with 14% brine concentration, a portion of cheese were vacuum packed in plastic bags and were ripened at 4 °C for 90 days.

In the second method, the raw milk was filtered and pasteurized at 65 °C for 30 min. Then milk was cooled to 32 °C, $CaCl_2$ and starter culture (*Streptococcus thermophilus, Lactococcus lactis* subsp. *lactis* and *Lactococcus lactis* subsp. *cremoris*) were added at the ratios of 0.02 and 1.5%, respectively. Then, milk was

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coagulated with rennet enzyme. After coagulation, the curd was cut into small pieces. The curd partly drained and divided into 5 groups as in the first method (B1 control group, B2 sirmo-added groups, B3 mendi-added groups, B4 siyabo-added groups, B5 sirmo, mendi and siyabo mixture added groups). The pasteurized herbs (at 95 °C for 5 min) were added into the curd and mixed well. Then the mixture of curd and herbs were pressed for 3 h to remove the whey sufficiently and the curd was cut into the blocks (7 × 7 × 2 cm). The cheese blocks were placed in glass jars which were salted with 14% brine and held 12 h. At the end of this time, some of cheeses were continue to ripened in glass jars which were salted with 14% brine concentration, a portion of cheeses were vacuum packaged in plastic bags and were ripened at 4 °C for 90 days. Mineral compositions of samples were analyzed 2, 30, 60, 90 days of storage at 4 °C. Each assay was performed in triplicate.

Mineral analysis

The cheese samples were burned by using dry ashing method in a ash furnace at 550 °C for 16 h. Before the samples were put in the ash furnace, they were dried in the oven at 105 °C for 1 h (IDF, 1992). The ash was dissolved with 5 ml nitric acid (1 N HNO_3) on heating plate and were filtered using (Whatman no: 41) filter paper. Then the solution was diluted with 1 N HNO3 and completed in 50 ml with 1 N HNO_3. The concentrations of Ca, Mg, K, Na, Zn, Fe and Mn of the samples were measured by Inductively Coupled Plasma-Optical Emission Spectrometer (ICP-OES) (Thermo Scientific ICAP 6300 DUO, England) at 317.93, 279.55, 766.49, 588.99, 213.86, 259.94, and 257.61 respectively. Also, blank samples were prepared for use in calculations.

Statistical analysis

Concentrations of cheese samples were recorded as means± standard deviation of triplicate measurements. In the analysis of the data, SPSS (V.20) package program was used. A general linear model (GLM) analysis was used to determine the differences between the groups and the Duncan multiple comparison test was used to determine differences among the three groups. Also, for comparison of two independent groups, t test was used.

Results and discussion

The mineral content of herby cheese manufactured from raw and pasteurized milk in vacuum and brine are given *Tables 1-7*.

Calcium

The calcium concentration of vacuum and brine herby cheese samples varied from 2362.47-4820.35 mg/kg. Our results were accordance with findings of Ocak and Kose (2015), Mendil (2006) and higher than the values of determined by Ozlu et al. (2012).

As seen *Table 1*, the calcium content of cheese samples decreased from the 2th until 90 th days. The Ca loss of cheeses in brine were higher than in vacuum packaged, due to salt uptake from brine during the ripening period. Transport of Na^+ and Cl^- ions from brine into the cheese, as a consequence of the osmotic pressure

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difference between the brine and the moisture of the cheese. Depending on the amount of lactose and minerals in it, moisture of cheese has a certain osmotic pressure. The osmotic pressure of the brine is higher due to the excess of salt. For this reason, the pressure difference between the brine and cheese causes diffusion. When a moulded cheese is placed in brine, diffusions of Na^+ and Cl^- ions from brine into the cheese and diffusions of H_2O, lactose, serum protein, various mineral substances such as Ca, Mg, K, P from cheese into the brine until the osmotic pressure between both phases is equalized. The amount of water lost is about twice the amount of salt obtained. For this reason, the weight of cheese decreases during the storage period (Gider, 2006). As long as the ripening period is long, transport of Na^+ and Cl^- ions from brine into the cheese increases with very rapid salt uptake in the beginning but decreases during the storage periods (Guinee and Fox, 1986). Similarly, in our study the Ca concentrations of the herby cheeses in brine rapidly decreased from the 2nd until the 30th day of storage but the loss of Ca has decreased from the 30th until the 90th days. The reason for this explained by the some researchers as a reduction of NaCl concentration difference between brine and cheese moisture (Guinee and Fox, 1986; Gider, 2006).

Table 1. *The effects of Sirmo, Mendi and Siyabo on Ca concentrations of herby cheese produced from pasteurized and raw milk in brine and vacuum package during ripening*

Packaging type	Storage time	Treatment				
		A1	**A2**	**A3**	**A4**	**A5**
Brine	2	4650.72±161.53^{bAB}	4184.15±170.48^{cAB}	4532.91±259.5^{bAB}	4820.35±407.42^{bB}	4066.94±181.56^{cA}
	30	3556.06±83.64$^{aAB\#\alpha}$	3635.36±73.11b$^{AB\#}$	3570.58±141.42$^{aAB\#}$	3152.73±0.28$^{aA\#}$	3783.52±392.8b^{cB}
	60	3314.44±186.85$^{aA\#}$	3570.53±114.2^{abA}	3280.50±0.71^{aA}	3399.15±131.61^{aA}	3399.96±119.32^{bA}
	90	3242.70±181.08$^{aB\#}$	3209.54±189.66$^{aB\#}$	3265.66±225.17^{aB}	3204.24±91.51^{aB}	2588.47±100.07$^{aA\#}$
Vacuum	2	4650.72±161.53^{aAB}	4184.15±170.48^{bAB}	4532.91±259.5^{bAB}	4820.35±407.42^{bB}	4066.94±181.56^{aA}
	30	4525.97±179.03^{aBC}	4114.33±7.21$^{abA\alpha}$	4456.70±0.00$^{bB\alpha}$	4726.87±0.00^{bC}	3929.99±16.67$^{abA\alpha}$
	60	4384.07±97.56^{aA}	4068.84±11.31^{abB}	4216.63±141.42^{abBC}	4329.94±12.73^{abC}	3834.68±22.63$^{abA\alpha}$
	90	4226.46±166.78$^{aB\alpha}$	3886.58±35.54^{aA}	3810.42±14.14^{aA}	3968.64±2.83$^{aA\alpha}$	3788.74±0.14$^{aA\alpha}$
		B1	**B2**	**B3**	**B4**	**B5**
Brine	2	4502.60±407.15^{bA}	4365.97±564.35^{cA}	4285.91±482.4^{bA}	4384.37±296.76^{cA}	4271.32±54.28^{cA}
	30	3058.23±14.14$^{aA\#}$	3523.21±32.82$^{bcC\#}$	3188.32±64.86$^{aAB\#}$	3369.00±141.42^{bB}	3252.86±141.42^{bAB}
	60	2910.64±141.03^{aA}	3448.22±31.19$^{bC\#}$	3057.73±132.72^{aAB}	3055.33±70.71$^{abAB\#}$	3225.56±141.42^{bB}
	90	2942.95±2.83^{aB}	2362.47±282.84$^{aA\#}$	2833.74±4.24^{aB}	2876.38±18.74$^{aB\#}$	2855.01±141.42$^{aB\#}$
Vacuum	2	4502.60±407.15^{cA}	4365.97±564.35^{aA}	4285.91±482.4^{aA}	4384.37±296.76^{aA}	4271.32±54.28^{bA}
	30	4179.68±77.32^{bcA}	4256.25±0.00^{aA}	4127.20±24.37^{aA}	4224.23±349.78^{aA}	4204.50±0.28^{bA}
	60	3739.81±0.14^{abA}	4142.80±2.83^{aD}	3915.40±21.21^{aB}	3985.59±7.07^{aC}	4189.15±12.73^{bE}
	90	3200.25±238.5^{aA}	4116.04±203.92^{aB}	3895.31±2.83^{aB}	3853.78±4.24^{aB}	3963.99±40.9^{aB}

Data values are expressed as means±standard deviation. Values in the same column followed by a different letters (a-c) are significantly different ($P < 0.05$). Values in the same row followed by a different letters (A-C) are significantly different ($P < 0.05$). Values in the same column showed different letter (α) between different treatments in the same day and package ($P < 0.05$). Values in the same column showed different letter (#) between different packages in the same day and package ($P < 0.05$)

A1: control cheese manufactured from raw milk, A2: sirmo-added cheese manufactured from raw milk, A3: mendi-added cheese manufactured from raw milk, A4: siyabo-added cheese manufactured from raw milk, A5: sirmo, mendi and siyabo mixture added cheese manufactured from raw milk, B1: control cheese manufactured from pasteurized milk, B2: sirmo-added cheese manufactured from pasteurized milk B3: mendi-added cheese manufactured from pasteurized milk, B4: siyabo-added cheese manufactured from pasteurized milk, B5: sirmo, mendi and siyabo mixture added cheese manufactured from pasteurized milk

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Magnesium

It was determined that the magnesium content of samples ranged from 114.79-282.30 mg/kg. Therefore, the level of magnesium in the vacuum cheeses were higher than in brine cheeses. These results were agreement with findings obtained by Cetinkaya et al. (2016) as 111.20-214 mg/kg for Camibogazı and Ozlu et al. (2012) as 65.83-210.09 mg/kg for Kasar cheese but higher than the value determined by Kırdar et al. (2013) as 49.62 mg/kg for Akçakatik and Kirdar et al. (2015) as 72.6 to 88.9 for Kargı Tulum cheese.

The magnesium concentration of herby cheese decreased throughout the storage period similar to that Ca content. The possible reason for this situation, 70% of the Mg is in soluble form (Ocak and Kose, 2015) so transport of Mg from cheese into the brine until the osmotic pressure between brine and cheese phase is equalized during the storage period.

At the end of the ripening period, Siyabo added herby cheese (A4 and B4) in vacuum packaged had higher Mg values. This is probably due to the high Mg content of Siyabo in comparison to Sirmo and Mendi and loss of Mg in brine cheeses were higher than vacuum packaged.

Table 2. *The effects of Sirmo, Mendi and Siyabo on Mg concentrations of herby cheese produced from pasteurized and raw milk in brine and vacuum package during ripening*

Packaging type	Storage time	Treatment				
		A1	**A2**	**A3**	**A4**	**A5**
Brine	2	282.30±0.94^{cC}	250.81±8.3^{cAB}	268.49±7.54^{cBC}	280.80±21.01^{bBC}	226.08±10.71^{cA}
	30	157.84±7.21$^{bA\#}$	165.45±3.13$^{bA\#}$	166.85±2.44^{bA}	152.74±3.68^{aA}	172.62±16.38^{bA}
	60	141.58±4.84$^{aA\#}$	148.16±6.35$^{bAB\#}$	142.99±1.85$^{aAB\#}$	153.79±4.64$^{aB\#}$	149.14±3.45$^{abAB\#}$
	90	137.35±0.49$^{aAB\#}$	123.30±10.65^{aA}	139.62±7.94^{aAB}	140.02±2.97$^{aB\#}$	126.51±1.35^{aAB}
Vacuum	2	282.30±0.94^{cC}	250.81±8.3^{bAB}	268.49±7.54^{bBC}	280.80±21.01^{bBC}	226.08±10.71^{aA}
	30	216.65±8.85^{bA}	241.66±13.08^{bA}	244.16±36.23^{bA}	241.94±27^{abA}	220.96±3.15^{aA}
	60	203.93±1.07^{abB}	207.00±1.46^{aB}	186.47±2.83^{aA}	203.93±9.02^{aB}	207.90±7.52^{aB}
	90	191.35±2.79^{aA}	197.06±0.33^{aA}	178.28±0.81^{aA}	197.67±7.18^{aA}	193.57±20.6^{aA}
		B1	**B2**	**B3**	**B4**	**B5**
Brine	2	251.56±26.04^{bA}	252.58±33.79^{bA}	246.22±24.08^{bA}	238.89±6.82^{cA}	239.63±4.74^{cA}
	30	161.33±5.54$^{aC\#}$	162.02±1.54^{aC}	152.00±0.44^{aB}	163.62±0.43^{bC}	142.27±3.75$^{bA\#}$
	60	140.78±10.85^{aAB}	151.76±1.08$^{aB\#}$	137.21±3.03$^{aAB\#}$	135.41±6.88$^{aA\#}$	137.10±2.16$^{abAB\#}$
	90	135.72±0.33^{aA}	114.79±40.06^{aA}	130.97±0.98^{aA}	134.35±1.85^{aA}	128.72±2.31$^{aA\#}$
Vacuum	2	251.56±26.04^{bA}	252.58±33.79^{aA}	246.22±24.08^{cA}	238.89±6.82^{bA}	239.63±4.74^{bA}
	30	217.14±2.32^{abA}	244.17±26.86^{aA}	238.67±10.67^{bcA}	219.90±7.94^{abA}	218.36±11.14^{aA}
	60	192.20±5.33^{aA}	211.66±1.81^{aB}	203.66±7.95^{abAB}	211.87±2.64^{aB}	211.70±1.82^{aB}
	90	184.31±15.04^{aA}	188.74±21.67^{aA}	193.05±10.34^{aA}	203.33±13.92^{aA}	203.28±6.34^{aA}

Data values are expressed as means±standard deviation. Values in the same column followed by a different letters (a-c) are significantly different ($P < 0.05$). Values in the same row followed by a different letters (A-C) are significantly different ($P < 0.05$). Values in the same column showed different letter (α) between different treatments in the same day and package ($P < 0.05$). Values in the same column showed different letter (#) between different packages in the same day and package ($P < 0.05$)

A1: control cheese manufactured from raw milk, A2: sirmo-added cheese manufactured from raw milk, A3: mendi-added cheese manufactured from raw milk, A4: siyabo-added cheese manufactured from raw milk, A5: sirmo, mendi and siyabo mixture added cheese manufactured from raw milk, B1: control cheese manufactured from pasteurized milk, B2: sirmo-added cheese manufactured from pasteurized milk B3: mendi-added cheese manufactured from pasteurized milk, B4: siyabo-added cheese manufactured from pasteurized milk, B5: sirmo, mendi and siyabo mixture added cheese manufactured from pasteurized milk

Sodium

The 2005 Dietary Guidelines for Americans recommends that healthy adults limit consumption of sodium 2300 mg/d (5.84 g of NaCI or about 1 teaspoon of table salt) and hypertensive patients and the older adults should not take more than 1500 mg of sodium per day (Agarwal et al., 2011). The main source of sodium in diet is NaCl, most of salt comes from commercial food in the improved countries. Sodium is important for regulation of blood and osmotic pressure, transport of water into and out of cells and transmission of nerve cell impulses (Cruz et al., 2011). However, excess intake of Na causes high blood pressure and other chronic diseases (Felicio et al., 2013). Another symptom that may be caused by high intake of sodium is the interference in bioavailability of calcium due to the increase in the renal excretion of this mineral. According to predictive equations, it is believed that urinary excretion of calcium will increase by 30-40 mg, for each 2 g of sodium consumed. However, if the intake of sodium is below 2.4 g per day, there will be no negative effect on the bones (Cruz et al., 2011).

***Table 3.** The effects of Sirmo, Mendi and Siyabo on Na concentrations of herby cheese produced from pasteurized and raw milk in brine and vacuum package during ripening*

Packaging type	Storage time	Treatment				
		A1	**A2**	**A3**	**A4**	**A5**
Brine	2	9294.33±37.50^{aAB}	10063.22±97.13^{cB}	9760.38±801.6^{bB}	8988.52±458.28^{aAB}	8544.34±156.38^{aA}
	30	8893.50±496.39^{aA}	9191.56±276.77^{bA}	9357.64±210.07^{abA}	8174.47±1069.8^{aA}	8304.72±216.93^{aA}
	60	8459.21±257.28^{aA}	8378.36±7.91^{aA}	8277.06±128.85^{abA}	7992.04±484.57^{aA}	8091.53±13.73^{aA}
	90	7695.82±1064.04^{aA}	8177.62±50.2^{aA}	7936.84±841.97^{aA}	7438.06±62.95^{aA}	7411.54±1143.34^{aA}
Vacuum	2	9294.33±37.5b^{AB}	10063.22±97.13^{dB}	9760.38±801.6^{cB}	8988.52±458.28^{bAB}	8544.34±156.38^{bA}
	30	8312.71±688.16^{bA}	9301.38±207.3^{cA}	8323.66±1090.16^{bcA}	8111.66±478.75^{bA}	7678.90±251.44^{bA}
	60	7059.16±342.85^{aAB}	7779.52±252.12^{bB}	7151.20±653.1ab^{AB}	7464.23±639.8^{abAB}	6239.40±513.97^{aA}
	90	6182.13±415.69^{aA}	6955.23±301.85^{aA}	5954.15±188.08$^{aA\alpha}$	5800.43±1235.84^{aA}	5719.61±581.63^{aA}
		B1	**B2**	**B3**	**B4**	**B5**
Brine	2	8498.95±983.67^{aA}	8603.88±1441.57^{aA}	9474.39±277.38^{bA}	9236.33±208.12^{cA}	9028.79±612.69^{aA}
	30	8633.91±51.39$^{aB\#}$	8499.30±132.67^{aB}	7855.82±351.88^{aA}	8738.28±53.74^{bB}	8561.86±151.17$^{aB\#}$
	60	8499.70±412.14^{aB}	8352.02±276.7^{aAB}	7760.03±293.9^{aA}	7832.21±2.53^{aAB}	8114.84±12.18^{aAB}
	90	8279.66±238.89^{aA}	6533.16±1312.67^{aA}	7352.96±2.83^{aA}	7402.20±282.84^{aA}	7491.24±1378.04^{aA}
Vacuum	2	8498.95±983.67^{aA}	8603.88±1441.57^{aA}	9474.39±277.38^{bA}	9236.33±208.12^{dA}	9028.79±612.69^{bA}
	30	8104.64±30.11^{aA}	8531.79±734.49^{aA}	7866.53±315.04^{aA}	8401.65±225.07^{cA}	7631.18±93.44^{aA}
	60	8342.28±533.16^{abA}	7340.69±573.69^{aA}	7299.02±438.74^{aA}	7470.44±195.13^{bA}	7393.15±439.59^{aA}
	90	7689.56±11.77^{aC}	6902.22±202.43^{aB}	7344.09±234.14^{aBC}	6139.72±363.35^{aA}	7193.61±296.89^{aBC}

Data values are expressed as means±standard deviation. Values in the same column followed by adifferent letters (a-c) are significantly different ($P < 0.05$). Values in the same row followed by adifferent letters (A-C) are significantly different ($P < 0.05$). Values in the same column showed different letter (α) between different treatments in the same day and package ($P < 0.05$). Values in the same column showed different letter (#) between different packages in the same day and package ($P < 0.05$)

A1: control cheese manufactured from raw milk, A2: sirmo-added cheese manufactured from raw milk, A3: mendi-added cheese manufactured from raw milk, A4: siyabo-added cheese manufactured from raw milk, A5: sirmo, mendi and siyabo mixture added cheese manufactured from raw milk, B1: control cheese manufactured from pasteurized milk, B2: sirmo-added cheese manufactured from pasteurized milk B3: mendi-added cheese manufactured from pasteurized milk, B4: siyabo-added cheese manufactured from pasteurized milk, B5: sirmo, mendi and siyabo mixture added cheese manufactured from pasteurized milk

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The sodium content of cheese samples ranged from 5719.61 to 10063.22 mg/kg. It has been exhibited that the sodium levels suggested for a healthy person can be met by consuming about 250 g of Herby cheese. Sodium in herby cheese is due to milk naturally contain some sodium as well as due to added salt and pickled herbs. Our results were similar with findings obtained by Cetinkaya et al. (2016) as 4852.5-10520 mg/kg for Camiboğazı, by Holland et al. (1995) as 700 mg/100 g for Brie cheese, lower than the value determined by Tarakci and Kucukoner (2008) as 2606 mg/100 g for herby cheese and higher than the value determined by Holland et al. (1995) as 380 mg/100 g for Cottage cheese, by Felicio et al. (2013) as 574.5, 473.4, 588.8 mg/100 g for Mozzarella, Minas and Prato cheeses, respectively.

Potassium

The metabolism of water is affected and myoneural activities are stimulated by Na as well as K, in the human body. According to nutritional recommendations, the sufficient Na and K proportion in diet must be of 0.6 for adults and 0.5 for children (Cruz et al., 2011).

Table 4. *The effects of Sirmo, Mendi and Siyabo on K concentrations of herby cheese produced from pasteurized and raw milk in brine and vacuum package during ripening*

Packaging type	Storage time	Treatment				
		A1	**A2**	**A3**	**A4**	**A5**
Brine	2	1124.98±152.2^{bB}	890.48±30.02^{bAB}	1059.20±271.59^{bB}	992.24±31.94^{cAB}	642.36±44.39^{cA}
	30	474.88±58.23^{aA}	475.31±107.91^{aA}	410.84±3.1$^{aA\alpha}$	450.57±0.71$^{bA\#\alpha}$	483.70±64.63^{bA}
	60	422.42±21.23^{aA}	384.14±5.66^{aA}	390.02±7.79$^{aA\alpha}$	447.76±18.59$^{abA\#}$	444.56±64.2^{abA}
	90	384.69±5.66$^{aA\#}$	367.78±94.54^{aA}	309.00±107.08^{aA}	396.60±4.24$^{aA\#}$	321.25±51.88^{aA}
Vacuum	2	1124.98±152.2^{bB}	890.48±30.02^{cAB}	1059.20±271.59^{bB}	992.24±31.94^{cAB}	642.36±44.39^{aA}
	30	570.76±48.91^{aA}	626.63±2.88^{bA}	587.25±116.72^{aA}	642.82±4.03^{bA}	628.33±11.53^{aA}
	60	555.95±40.22^{aA}	622.50±36.34^{bA}	497.59±98.92^{aA}	625.46±0.32^{abA}	611.76±7.07^{aA}
	90	499.50±4.84^{aAB}	418.10±87.89^{aA}	504.98±40.13^{aAB}	581.95±11.4^{aB}	605.94±1.41$^{aB\alpha}$
		B1	**B2**	**B3**	**B4**	**B5**
Brine	2	758.55±85.55^{bA}	914.23±159.64^{bA}	791.87±90.63^{bA}	650.45±87.45^{bA}	799.25±14.14^{aA}
	30	466.96±16.55$^{aAB\#}$	435.83±75.24^{aA}	486.75±4.95^{aAB}	510.83±4.17^{aAB}	535.39±21.09^{bB}
	60	373.15±123.6^{aA}	390.57±44.53^{aA}	445.62±7.07^{aA}	478.45±42.56^{aA}	508.18±32.36^{bA}
	90	351.61±1.41^{aA}	323.87±104.81^{aA}	416.09±29.32^{aA}	387.75±7.71^{aA}	364.35±8.61$^{aA\#}$
Vacuum	2	758.55±85.55^{bA}	914.23±159.64^{bA}	791.87±90.63^{cA}	650.45±87.45^{bA}	799.25±14.14^{bA}
	30	579.43±6.72^{aA}	594.53±86.59^{aA}	716.41±54.22^{bcA}	612.98±36.8^{abA}	591.21±66.76^{aA}
	60	554.07±27.89^{aA}	555.28±1.9^{aA}	547.57±53.44^{abA}	563.62±39.39^{abA}	553.08±35.54^{aA}
	90	515.10±70.92^{aA}	419.22±67.96^{aA}	525.52±46.95^{aA}	476.80±53.76^{aA}	507.70±3.54^{aA}

Data values are expressed as means±standard deviation. Values in the same column followed by a different letters (a-c) are significantly different ($P < 0.05$). Values in the same row followed by a different letters (A-C) are significantly different ($P < 0.05$). Values in the same column showed different letter (α) between different treatments in the same day and package ($P < 0.05$). Values in the same column showed different letter (#) between different packages in the same day and package ($P < 0.05$)

A1: control cheese manufactured from raw milk, A2: sirmo-added cheese manufactured from raw milk, A3: mendi-added cheese manufactured from raw milk, A4: siyabo-added cheese manufactured from raw milk, A5: sirmo, mendi and siyabo mixture added cheese manufactured from raw milk, B1: control cheese manufactured from pasteurized milk, B2: sirmo-added cheese manufactured from pasteurized milk B3: mendi-added cheese manufactured from pasteurized milk, B4: siyabo-added cheese manufactured from pasteurized milk, B5: sirmo, mendi and siyabo mixture added cheese manufactured from pasteurized milk

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As seen in *Table 4*, the K values of herby cheese samples were significantly decreased during the ripening period. The K values of brine cheeses were determined lower than vacuum packaged cheeses at the end of the storage periods. The possible reason for this situation, the cheese that was ripened in a brine had a higher salt content than the cheese ripened in vacuum packaging. In general, as the salt content increases, the acidity decreases and the pH value increases in the cheese (Kose, 2015; Almenara et al., 2007). The final average values were lower than those described by Ocak and Kose (2015) and similar with findings obtained by Mendil (2006) for herby cheeses and by Murtaza et al. (2014) for cheddar cheese.

Iron

Iron is an essential trace element is incorporated as a catalyst in various metabolic reactions. It is a component of hemoglobin, myoglobin, cytochrome and other proteins and plays an important role in the transport, storage and use of oxygen. Milk and dairy products are insufficient source in terms of Fe for human nutrition (Zamberlin et al., 2012). Its deficiency causes anaemia, decrease in immunity and alteration in mental development (Gaucheron, 2000).

Table 5. *The effects of Sirmo, Mendi and Siyabo on Fe concentrations of herby cheese produced from pasteurized and raw milk in brine and vacuum package during ripening*

Packaging type	Storage time	Treatment				
		A1	**A2**	**A3**	**A4**	**A5**
Brine	2	6.59±0.13b$^{C\alpha}$	5.00±0.20^{aB}	4.08±0.1$^{aA\alpha}$	4.19±0.43^{aA}	6.04±0.06$^{bC\alpha}$
	30	5.33±1^{abA}	4.89±0.31^{aA}	3.76±0.29^{aA}	4.11±0.02^{aA}	4.89±1.05^{abA}
	60	4.26±1.44^{abA}	4.10±1.05^{aA}	3.70±0.71^{aA}	3.66±0.66^{aA}	4.29±0.73^{abA}
	90	3.28±0.5^{aA}	3.52±0.54^{aA}	3.42±0.74^{aA}	3.28±0.06^{aA}	3.06±0.25^{aA}
Vacuum	2	6.59±0.13^{dC}	5.00±0.2^{bB}	4.08±0.1^{bA}	4.19±0.43^{bA}	6.04±0.06^{cC}
	30	4.75±0.07$^{cD\alpha}$	4.44±0.33^{aCD}	3.78±0.04^{abA}	3.84±0.13^{abAB}	4.26±0.08^{bBC}
	60	3.79±0.12^{bB}	4.37±0.07^{aC}	3.61±0.07^{abAB}	3.49±0.19^{abAB}	3.42±0.06^{aA}
	90	3.19±0.29^{aA}	4.27±0.1^{aB}	3.44±0.33^{aAB}	3.30±0.35^{aA}	3.06±0.49^{aA}
		B1	**B2**	**B3**	**B4**	**B5**
Brine	2	4.39±0.34^{cA}	4.89±0.06^{bAB}	5.54±0.08^{dAB}	5.63±0.95^{bB}	5.26±0.13^{bAB}
	30	4.11±0.08$^{bcA\#}$	4.70±0.28^{bBC}	4.51±0.01^{cABC}	4.47±0.28^{abAB}	5.05±0.19^{bC}
	60	3.83±0.09^{bB}	4.13±0.14^{aC}	3.80±0.1^{bB}	3.48±0.11^{aA}	3.72±0.03^{aAB}
	90	3.16±0.02^{aA}	3.84±0.07^{aA}	3.03±0.43^{aA}	3.46±0.19^{aA}	3.61±0.49^{aA}
Vacuum	2	4.39±0.34^{cA}	4.89±0.06^{aAB}	5.54±0.08^{cAB}	5.63±0.95^{bB}	5.26±0.13^{bAB}
	30	3.51±0.06^{abA}	3.99±0.75^{aA}	4.45±0.13^{bA}	4.02±0.45^{aA}	4.50±0.35^{abA}
	60	3.79±0.04^{bcA}	3.78±1.32^{aA}	3.40±0.06^{aA}	3.43±0.29^{aA}	3.67±0.37^{aA}
	90	3.06±0.27^{aA}	3.65±0.4^{aA}	2.97±0.27^{aA}	3.29±0.07^{aA}	3.51±0.54^{aA}

Data values are expressed as means±standard deviation. Values in the same column followed by a different letters (a-c) are significantly different ($P < 0.05$). Values in the same row followed by a different letters (A-C) are significantly different ($P < 0.05$). Values in the same column showed different letter (α) between different treatments in the same day and package ($P < 0.05$). Values in the same column showed different letter (#) between different packages in the same day and package ($P < 0.05$)

A1: control cheese manufactured from raw milk, A2: sirmo-added cheese manufactured from raw milk, A3: mendi-added cheese manufactured from raw milk, A4: siyabo-added cheese manufactured from raw milk, A5: sirmo, mendi and siyabo mixture added cheese manufactured from raw milk, B1: control cheese manufactured from pasteurized milk, B2: sirmo-added cheese manufactured from pasteurized milk B3: mendi-added cheese manufactured from pasteurized milk, B4: siyabo-added cheese manufactured from pasteurized milk, B5: sirmo, mendi and siyabo mixture added cheese manufactured from pasteurized milk

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Zinc

Zinc is an essential mineral that is very nutritionally for human and deficiency creates significant implications for human health. The deficiency of Zn results in a wide spectrum. Its clinical effects depending on age, stage of development and deficiencies of related metals (Bakircioglu et al., 2011). The maximum tolerable daily intake of Zn is 60 mg (FAO/WHO, 1999, 1999). In this study, the content of Zn for herby cheeses in brine and vacuum packages were lower than the WHO's values.

Table 6. *The effects of Sirmo, Mendi and Siyabo on Zn concentrations of herby cheese produced from pasteurized and raw milk in brine and vacuum package during ripening*

Packaging type	Storage time	Treatment				
		A1	**A2**	**A3**	**A4**	**A5**
Brine	2	16.65±0.86^{aB}	14.63±0.13^{bAB}	14.87±0.08^{bAB}	16.67±1.34^{cB}	14.12±1.32^{bA}
	30	16.03±0.87^{aB}	14.50±0.24^{bAB}	14.76±0.27^{bAB}	15.67±0.95^{bcB}	13.91±0.17^{bA}
	60	14.95±0.23^{aB}	14.16±0.52^{abAB}	14.25±0.66^{abAB}	13.48±0.42$^{abA\#}$	13.24±0.01^{abA}
	90	13.71±2.58^{aA}	13.63±0.16^{aA}	13.49±0.13^{aA}	11.36±0.08$^{aA\#}$	11.28±0.88^{aA}
Vacuum	2	16.65±0.86^{aB}	14.63±0.13^{aAB}	14.87±0.08^{aAB}	16.67±1.34^{aB}	14.12±1.32^{aA}
	30	16.36±0.5^{aB}	14.45±0.19^{aA}	14.42±0.62^{aA}	16.02±0.84^{aB}	13.94±0.07^{aA}
	60	16.05±0.31^{aC}	14.16±0.13^{aB}	13.87±0.19^{aAB}	15.89±0.28^{aC}	13.42±0.33^{aA}
	90	15.79±0.34$^{aC\alpha}$	13.93±0.65^{aAB}	13.69±0.59^{aAB}	14.59±0.16^{aB}	13.04±0.05^{aA}
		B1	**B2**	**B3**	**B4**	**B5**
Brine	2	15.61±1.84^{aA}	14.75±2.09^{aA}	15.65±1.69^{bA}	16.59±1.99^{aA}	16.58±0.19^{bA}
	30	14.22±3.1^{aA}	15.00±0.53^{aA}	14.68±0.95^{abA}	15.11±4.08^{aA}	15.32±1.94^{abA}
	60	13.54±1.61^{aA}	14.92±0.86^{aA}	14.47±0.86^{abA}	14.93±0.04^{aA}	13.87±1.02^{abA}
	90	12.36±0.96^{aAB}	13.99±0.28^{aB}	12.20±0.28$^{aA\#}$	13.31±0.41$^{aAB\#}$	12.22±0.96^{aAB}
Vacuum	2	15.61±1.84^{aA}	14.75±2.09^{aA}	15.65±1.69^{aA}	16.59±1.99^{aA}	16.58±0.19^{aA}
	30	15.53±1.38^{aA}	14.54±0.07^{aA}	15.50±0.31^{aA}	16.41±0.49^{aA}	16.16±0.80^{aA}
	60	15.25±0.19^{aA}	14.34±0.15^{aA}	15.35±0.76^{aA}	15.80±0.84^{aA}	15.25±1.10^{aA}
	90	12.96±0.34^{aA}	14.13±0.37^{aB}	15.36±0.05^{aC}	15.09±0.34^{aC}	14.93±0.31^{aC}

Data values are expressed as means±standard deviation. Values in the same column followed by a different letters (a-c) are significantly different ($P < 0.05$). Values in the same row followed by a different letters (A-C) are significantly different ($P < 0.05$). Values in the same column showed different letter (α) between different treatments in the same day and package ($P < 0.05$). Values in the same column showed different letter (#) between different packages in the same day and package ($P < 0.05$)

A1: control cheese manufactured from raw milk, A2: sirmo-added cheese manufactured from raw milk, A3: mendi-added cheese manufactured from raw milk, A4: siyabo-added cheese manufactured from raw milk, A5: sirmo, mendi and siyabo mixture added cheese manufactured from raw milk, B1: control cheese manufactured from pasteurized milk, B2: sirmo-added cheese manufactured from pasteurized milk B3: mendi-added cheese manufactured from pasteurized milk, B4: siyabo-added cheese manufactured from pasteurized milk, B5: sirmo, mendi and siyabo mixture added cheese manufactured from pasteurized milk

The Zn concentration of herby cheeses produced from raw and pasteurized milk changed from 11.28 to 16.67, 12.96 to 16.59 mg/kg, respectively. It has been found that the Zn concentration of cheese produced from both pasteurized and raw milk decreased during the storage period. But, at the end of the storage periods, the Zn content of brine cheeses were found lower than vacuum packaged cheeses. When the findings are compared with the literature, our results were lower than the value determined by Oksuztepe et al. (2013) as 20.50 mg/kg for white cheese, by Isleten et al. (2007) as 2.12-8.19 mg/100 g for Ezine cheese, by Cichoscki et al. (2002) as 29.21-36.60 mg/kg

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for Prato cheese, by Altun and Kose (2016) as 22.70 to 65.37 for Kelle cheese, by Bilandzic et al. (2015) as 46 mg/kg for semi hard fat cheese consumed in Croatia.

Manganese

The Institute of Medicine suggests that intake of Mn should not exceed the tolerable daily maximum limit of 11 mg/day (National Research Council, 1989). In this study, Mn concentrations of cheese samples changed from 0.70 to 0.26 mg/kg. The content of Mn for Herby cheese samples in brine and vacuum packages were lower than the National Research Council.

Table 7. *The effects of Sirmo, Mendi and Siyabo on Mn concentrations of herby cheese produced from pasteurized and raw milk in brine and vacuum package during ripening*

Packaging time	Storage type	Treatment				
		A1	**A2**	**A3**	**A4**	**A5**
Brine	2	0.52 ± 0.11^{bA}	0.70 ± 0.08^{bB}	0.46 ± 0.06^{aA}	0.59 ± 0.04^{cAB}	0.43 ± 0.01^{aA}
	30	0.50 ± 0.03^{abA}	0.46 ± 0.01^{aA}	0.39 ± 0.16^{aA}	0.38 ± 0.01^{bA}	0.39 ± 0.01^{aA}
	60	0.37 ± 0.04^{abA}	0.37 ± 0.01^{aA}	$0.35\pm0.01^{aA\alpha}$	0.34 ± 0.01^{abA}	0.38 ± 0.02^{aA}
	90	0.34 ± 0.04^{aA}	0.33 ± 0.03^{aA}	0.33 ± 0.00^{aA}	0.31 ± 0.00^{aA}	0.33 ± 0.13^{aA}
Vacuum	2	0.52 ± 0.11^{bA}	0.70 ± 0.08^{bB}	0.46 ± 0.06^{bA}	0.59 ± 0.04^{bAB}	0.43 ± 0.01^{bA}
	30	0.37 ± 0.01^{abA}	0.46 ± 0.04^{aAB}	0.44 ± 0.05^{bAB}	0.51 ± 0.06^{bB}	0.40 ± 0.02^{bAB}
	60	0.36 ± 0.04^{abA}	0.40 ± 0.07^{aA}	0.30 ± 0.01^{aA}	0.39 ± 0.01^{aA}	0.36 ± 0.03^{abA}
	90	0.34 ± 0.01^{aAB}	$0.38\pm0.01^{aB\alpha}$	0.31 ± 0.01^{aA}	0.37 ± 0.01^{aB}	0.30 ± 0.03^{aA}
		B1	**B2**	**B3**	**B4**	**B5**
Brine	2	0.42 ± 0.05^{aA}	0.42 ± 0.06^{bA}	0.51 ± 0.11^{bA}	0.55 ± 0.02^{bA}	0.46 ± 0.08^{aA}
	30	0.39 ± 0.00^{aA}	0.36 ± 0.04^{abA}	0.31 ± 0.01^{aA}	0.35 ± 0.11^{abA}	0.42 ± 0.13^{aA}
	60	0.35 ± 0.02^{aAB}	0.36 ± 0.01^{abB}	0.31 ± 0.01^{aA}	0.33 ± 0.01^{abAB}	0.34 ± 0.02^{aAB}
	90	0.33 ± 0.05^{aA}	0.26 ± 0.00^{aA}	0.30 ± 0.06^{aA}	0.28 ± 0.10^{aA}	0.35 ± 0.01^{aA}
Vacuum	2	0.42 ± 0.05^{aA}	0.42 ± 0.06^{aA}	0.51 ± 0.11^{aA}	0.55 ± 0.02^{bA}	0.46 ± 0.08^{aA}
	30	0.39 ± 0.01^{aAB}	0.38 ± 0.01^{abA}	0.40 ± 0.02^{aAB}	0.40 ± 0.03^{aAB}	0.44 ± 0.02^{aB}
	60	0.34 ± 0.01^{aA}	0.36 ± 0.02^{abA}	0.37 ± 0.03^{aA}	0.38 ± 0.01^{aA}	0.39 ± 0.05^{aA}
	90	0.32 ± 0.05^{aA}	0.30 ± 0.01^{aA}	0.34 ± 0.06^{aA}	0.38 ± 0.04^{aA}	0.38 ± 0.01^{aA}

Data values are expressed as means±standard deviation. Values in the same column followed by a different letters (a-c) are significantly different ($P < 0.05$). Values in the same row followed by a different letters (A-C) are significantly different ($P < 0.05$). Values in the same column showed different letter (α) between different treatments in the same day and package ($P < 0.05$). Values in the same column showed different letter (#) between different packages in the same day and package ($P < 0.05$)

A1: control cheese manufactured from raw milk, A2: sirmo-added cheese manufactured from raw milk, A3: mendi-added cheese manufactured from raw milk, A4: siyabo-added cheese manufactured from raw milk, A5: sirmo, mendi and siyabo mixture added cheese manufactured from raw milk, B1: control cheese manufactured from pasteurized milk, B2: sirmo-added cheese manufactured from pasteurized milk B3: mendi-added cheese manufactured from pasteurized milk, B4: siyabo-added cheese manufactured from pasteurized milk, B5: sirmo, mendi and siyabo mixture added cheese manufactured from pasteurized milk

Decrease in the Mn concentrations of pasteurized and raw milk herby cheeses were determined during the ripening period. The possible decrease in pH can induce this situation. In general, Mn are linked to the insoluble fraction of casein micelle of milk in a ratio of 95% (Cichoscki et al., 2002). However, as the pH in cheese decreases during ripening, migration of Mn towards the soluble fraction is monitored (Macedo and Malcata, 1997). As a result, the loss of Mn content occurs in brine or vacuum packaged

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samples. Our results showed similar behaviour with findings obtained by Cichoscki et al. (2002) as 0.36 to 0.26 mg/kg for Prato cheese, were higher than the value determined by Kirdar et al. (2015) as 0.11 to 0.19 µg/g for Kargi Tulum Cheese and were lower than the value determined by Macedo and Malcata (1997) as 1.17 to 1.40 mg/kg for Serra cheese.

Conclusions

As a result, Na, Ca, K, Mg, Zn, Fe and Mn content of cheese samples were influenced by herbs, packaging, ripening and heat treatment. It was observed that ripening has the most pronounced effect on studied variables. The concentrations of minerals in cheese samples decreased and the changes of ratios of mineral compounds were different during storage period. The vacuum packaged cheeses were found to have a higher mineral content than the cheeses stored in brine at the end of 90 days. Because of the mineral loss of cheeses in brine were higher than in vacuum packaged due to diffusions of mineral substances from cheese into the brine during maturation. This investigation is first study comparing herbs species, packaging type and ripening period on the mineral content of herby cheeses produced from pasteurized and raw milk. Therefore, further investigations are needed to determine the influence of various factors on the mineral compositions of herby cheeses.

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