Evaluation of Some Physical, Chemical and Sensory Properties of Kasar Cheese and Its Processed and Analogue Types

Musa YALMAN[a], Onur GÜNEŞER[b], Yonca KARAGÜL YÜCEER[c]

[a]*Çanakkale Onsekiz Mart University, Graduate School of Natural and Applied Sciences, Department of Food Engineering, 17020, Çanakkale, TURKEY*

[b]*Uşak University, Faculty of Engineering, Department of Food Engineering, 64200, Uşak, TURKEY*

[c]*Çanakkale Onsekiz Mart University, Faculty of Engineering, Department of Food Engineering, 17020, Çanakkale, TURKEY*

ABSTRACT

The objective of this study was to evaluate the changes in physical, chemical and sensory properties of the kasar cheese and its processed and analogue types during 90-day storage. Aroma-active compounds in the cheeses were identified by gas chromatography-olfactometry. Sensory properties of the cheeses were determined by descriptive sensory analysis. Differences in basic composition of the cheeses were found. There were also significant differences among the cheeses in terms of meltability, oil separation index, $L*$ and $a*$ values. Whey, cooked, creamy and fermented were the most intense sensory descriptors in the cheeses analyzed on days 1 and 30. However, waxy and animal intensities were much higher in analogue cheese than others. 18 aroma-active compounds were determined in the cheeses during 90 day storage. Diacetyl, acetic acid, butyric acid, 2-/3-methyl butyric acid, 2-acetyl-2-thiazoline, β-ionene, 2-phenylethyl alcohol, maltol, *p*-cresol, sotolon, δ-decalactone and γ-dodecalactone were some of the characteristic aroma-active compounds. Kasar cheese was the most liked cheese while analogue cheese was the least liked cheese by consumers.

Keywords: Analogue; Kasar and processed cheeses; Flavor

Kaşar Peyniri, Eritme ve Taklit Tiplerinin Bazı Fiziksel, Kimyasal ve Duyusal Özelliklerinin Değerlendirilmesi

ÖZET

Bu çalışmanın amacı, kaşar, eritme kaşar ve taklit kaşar peynirlerinin, 90 günlük depolama süresince fiziksel, kimyasal ve duyusal özelliklerinde meydana gelen değişiklikleri değerlendirmektir. Peynirlerin aroma-aktif bileşenleri gaz kromatografi-olfaktometri ile saptanmıştır. Peynirlerin duyusal özellikleri tanımlayıcı duyusal analiz ile belirlenmiştir. Peynirlerin temel bileşenlerinde farklılıklar bulunmuştur. Peynirler arasında eriyebilirlik, yağ ayrılma indeksi, $L*$ ve

a^* değerleri açısından önemli farklılıklar gözlenmiştir. Peynirlerde 1. ve 30. günde peynir altı suyu, pişmiş, kremamsı ve fermente en yoğun tanımlayıcı terimlerdir. Ancak taklit peynirde, mumsu ve hayvanımsı aroma yoğunlukları diğer peynirlerden daha fazladır. Peynirlerde 90 günlük depolama süresince 18 aroma-aktif bileşen belirlenmiştir. Karakteristik aroma-aktif bileşenlerin bazıları; diasetil, asetik asit, bütirik asit, 2-/3-metil bütirik asit, 2-asetil-2-tiazolin, β-iyonen, 2-feniletil alkol, maltol, p-kresol, sotolon, δ-dekalakton ve γ-dodekalakton'dur. Kaşar tüketiciler tarafından en çok sevilen peynir olurken, taklit Kaşar ise en az beğenilen peynir olmuştur.

Anahtar Kelimeler: Taklit; Kaşar ve eritme peynirler; Lezzet

1. Introduction

Many types of processed and analogue cheeses have entered to the market due to increase in the usage of cheese as a major ingredient in various foods (pizza, hamburger etc.) and food service (salad bar etc.) over the past few decades (Awad et al 2004; Kapoor & Metzger 2008). It was emphasized that processed cheese was the leader (243 million kg) in the total super market in the USA (Kapoor & Metzger 2008). Processed cheese is made by mixing of cheese curd and other ingredients such as emulsifying salts, water, salts etc., while analogue cheese is produced by the mixtures of dairy and/or non-dairy proteins (rennet casein, soy protein) and dairy fat or vegetable oils (corn, sunflower oils). During the production of both cheeses, heating and mixing processes are applied to obtain a homogeneous cheese structure with an extended shelf life. Functional properties of both cheeses (meltability, microstructure, viscosity, stretching ability etc.) are the most important factors for the performance of the cheese which contribute to the taste and the aesthetic appeal of the food during preparation and consumption. Functional properties of both cheeses were influenced by the ingredients used in the cheese formulation and processing conditions (Bachmann 2001; Guinee 2002; Kapoor & Metzger 2008).

Kasar cheese is a pasta filata-type cheese and consumed in a large scale after the White cheese in Turkey. It is estimated that 80,000 tons of Kasar cheese is produced in Turkey annually. Kasar cheese is commonly made from pasteurized cow milk in industrial scale. However, traditionally it can be made from the mixture of sheep's and cow's milk (Atasoy 2008; Hayaloglu 2009; Yasar & Guzeler

2011). Scalding and kneading are the most important stages to form characteristic properties of the cheese. Kasar cheese has smooth, dry and yellowish rind, homogenous structure without gas holes, its flavor is piquant and slightly salty (Ucuncu 2004). Nowadays, processed cheese technology has been used in the production of Kasar cheese. Two approaches have been commonly used for this purpose, the first one is the addition of melting salts instead of scalding of the curd after coagulation of milk by rennet enzyme. The other one is using rennet casein and other additives (melting salts, cream, vegetable oil, water etc.) instead of pasteurized milk (Koca & Metin 2004; Balkir & Metin 2011). Both types of cheeses are commonly used in pizzas, prepared foods, salad, sandwich, pasta, sauces and toast.

The effects of processing parameters, storage conditions and packaging types on physical and chemical properties of Kasar cheese had been extensively studied (Sert 2004; Tarakci & Kucukoner 2006; Var et al 2006; Urkek 2008; Yasar & Guzeler 2011). However, its processed and analogue types have not been discussed in terms of chemical, physical and sensory properties and characteristic aroma-active compounds in details. The objectives of this study were to evaluate and compare the changes in physical, chemical and sensory properties of the kasar cheese and its processed and analogue types during storage.

2. Material and Methods

2.1. Materials

Three types of cheese formulation were evaluated in the present study. They were kasar cheese,

processed cheese and cheese analogue. All cheeses were produced in a dairy plant located in Biga Vocational School, Department of Dairy Technology, (Canakkale Onsekiz Mart University, Canakkale, Turkey). In production of the cheeses, cow milk was obtained from milk producers in Biga region. Rennet casein (DSE 7943, 90 mesh) and melting salts (Kasomel™ 2185, Kasomel™ 3112) were obtained from Fonterra (Rellingen, Germany) and Ozgocerler Dairy Company (Adana, Turkey), respectively. All chemicals used in this study were analytical and chromatographic grades (Merck, Darmstadt, Germany).

2.2. Cheese making procedure and composition of cheeses

Kasar cheese was produced by following the traditional production steps. Processed and analogue cheeses were produced by in-house production procedures. The production steps of the cheeses were given in Figure 1.

Titratable acidity (% lactic acid), pH, dry matter (%) and ash (%) contents of the cheeses were determined by Bradley et al (1992). Nitrogen (%) content of the cheeses was determined by AOAC (2000). Fat (%) content was determined by Gerber method (NEN 1969). Mohr method was used for determination of salt (%) (Metin 2006).
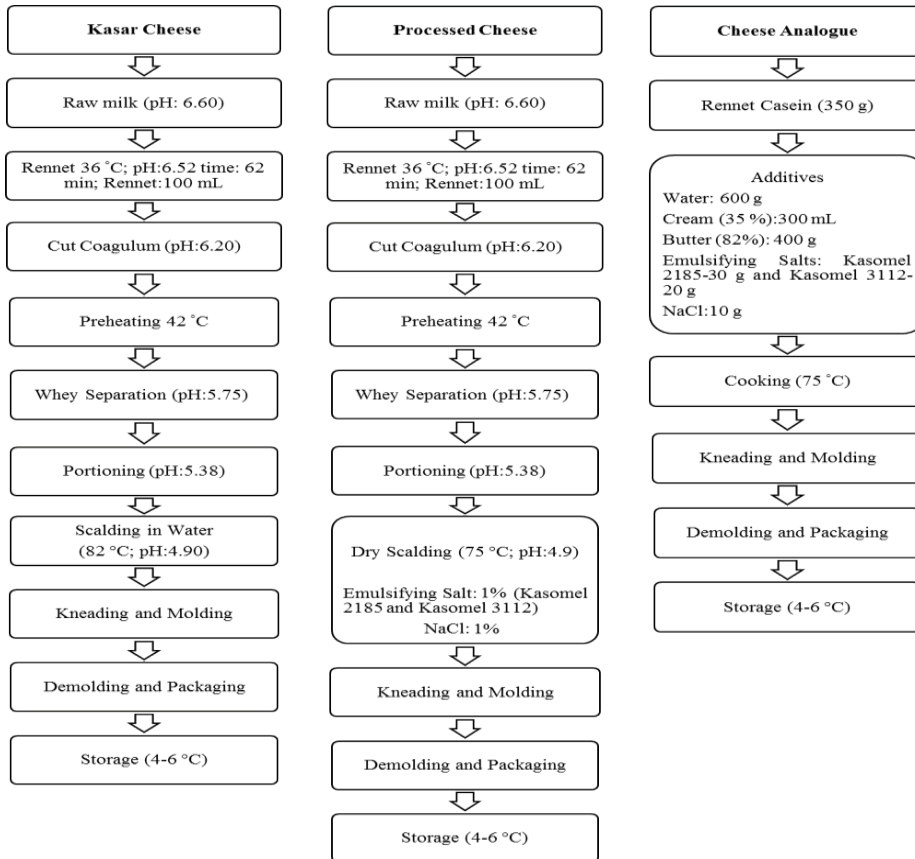
Figure 1- Cheese production steps

Şekil 1- Peynir üretim aşamaları

2.3. Physical analysis

Hardness and melting properties of cheeses were evaluated. Hardness of cheeses was determined by TA.XTPlus texture analyzer (Stable Micro Systems Ltd, Surrey, UK) with 2 mm diameter cylinder P2 probe (stainless steel). The hardness test was carried out on 15×15×15 mm of cheese sample at 20 °C. Test parameters were; pre-test speed of 1.0 mm s^{-1}, test speed of 2.0 mm s^{-1}, post-test speed of 1.0 mm s^{-1}. Hardness value of cheese, which was expressed a maximum force required to compress the cheese, was calculated from TPA curve using Texture Exponent software (Okpala et al 2010). Melting test was determined by two methods (Schreiber test and tube test) (Koca & Metin 2004). Oil separation index of cheeses was also determined (Awad et al 2004). Minolta Cr-400 (Minolta Co. Ltd, Tokyo, Japan) was used to measure L^*, a^*, and b^* color parameters of cheese samples. Color measurements were taken from three different locations of each sample (ISO 2008).

2.4. Analysis of aroma-active compounds

Solid phase microextraction (SPME) procedure was used for extraction of aroma compounds (Pawliszyn 2012). Five grams of grated cheese samples were placed in 40 mL amber colored and screw top vial with hole cap PTFE/silicon septa (Supelco, Bellafonte, US) and then 1 g of NaCl was added. Samples were kept at 40 °C in water bath for 30 min to improve mass transfer between cheese matrix and headspace. 2 cm-50/30 µm DVB/Carboxen/PDMS stable flex SPME fiber (Supelco, Bellafonte) was inserted at a depth of 2 cm for extraction of volatile compounds from headspace for 15 min.

Aroma-active compounds of cheese samples were determined by using gas chromatography-olfactometry (GCO) (Agilent Technologies, HP 6890 GC, Wilmington, De, USA). Sniffing was achieved on a polar capillary column (HP-INNOWAX (30m length x 0.25 mm id x 0.25 µm film thickness (d$_f$)); J & W Scientific, Folsom, CA, USA). The GC oven temperature was programmed from 40 °C to 200 °C at a rate of 10 °C min^{-1}, with initial hold of 3 min and final hold time of 20 min. The FID and sniffing port were maintained at the temperatures of 250 °C and 200 °C, respectively. Post peak intensity method was used for determination of aroma intensities by using 10-point scale anchored on the left with 'not' and on the right with 'very' (Van Ruth 2001). Aroma-active compounds were identified by comparing retention indices (RI) and odor quality of unknowns with those of authentic standards analyzed at the same experimental conditions by sniffer during GCO procedure. Retention indices of aroma-active compounds were calculated by using n-alkane series (Van den Dool & Kratz 1963).

2.5. Sensory analysis

Sensory descriptors of the cheese samples were developed by using Spectrum™ method. Four female and two male panelists (26-42 years of age) were selected from Department of Food Engineering at Canakkale Onsekiz Mart University to identify flavor attributes of cheese samples. 60 hours of training sessions were performed to familiarize descriptive terms. The terms used to define taste and flavor were shown in Table 1. Panelists quantified the intensities of the attributes using 15-point scale anchored on the left with 'not' and on the right with 'very'. Panelists used water to rinse their mouth (Meilgaard et al 1999). Consumer test was conducted by using seven point hedonic scale to determine liking of cheese samples by 48 panelists (Meilgaard et al 1999).

2.6. Statistical analysis

Analysis of variance (two way ANOVA) was conducted to determine the differences among the cheeses with respect to chemical, physical and sensory properties (Sheskin 2000). The ANOVA model is shown in Equation 1.

$$Y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + e_{ijk} \tag{1}$$

Where; Y_{ijk}, observed or measured value of kth the cheese in cheese type i and storage time j; µ, general population mean; α_i, effect of cheese type (i= 1, 2, 3); βj, effect of storage time (j= 1, 2, 3); $(\alpha\beta)_{ij}$, effect of cheese type by storage time interaction; e_{ijk}, random error term.

Table 1- Descriptive terms used for sensory evaluation of cheeses

Çizelge 1- Peynirlerin duyusal değerlendirmesinde kullanılan tanımlayıcı terimler

Descriptors	Definitions	References*
Cooked	Cooked milk related aromatics	Heated milk (85 ºC 10 min)
Whey	Whey related aromatics	Fresh whey
Creamy/milk fat	Milk fat related aromatics	Cream
Waxy	Wax related aromatics	Wax
Animal	Sheep, cow etc. related aromatics	Na-caseinate
Fermented	Fermented milk related aromatics	Yogurt
Nutty	Hazelnut or peanut related aromatics	Roasted hazelnut
Sour	Taste sensation elicited by acids	0.05% w v^{-1} citric acid solution
Salty	Taste sensation elicited by salts	0.02% w v^{-1} NaCl solution
Sweet	Taste sensation elicited by sugars	2% w v^{-1} sugar solution
Umami	Chemical feeling factor elicited by certain peptides and nucleotides	0.5% w v^{-1} monosodium glutamate solution

*, reference adapted from Meilgaard et al (1999)

The Tukey honestly significant difference (HSD) test was used for separating means Cheese samples were also evaluated by Multidimensional scaling method (MDS) in terms of sensory differences of cheese samples. Results of consumer test were evaluated by non-parametric Kruskal-Wallis and Friedman tests. Dunn test was used for determination of significant differences in non-parametric tests. The results of differences from control test which evaluated by Welch because of the results did not meet the prerequisites (homogeneity of variance and equality of variance) for ANOVA (Sheskin 2000) Minitab for Windows (version 13.0), SPSS 2006 (SPSS 2006) for Windows (version 17.0), NCSS 2007 and MSTAT-C statistical packages were used for all statistical analyses.

3. Results and Discussion

3.1. Basic composition

Basic composition of cheeses was determined on the first day of storage. Chemical composition of the cheeses was shown in Table 2. While significant differences were observed among the cheeses in terms of protein (%), fat (%) and ash content (%) (P<0.05), there were no significant differences in total dry matter (%) and salt content (%) of the cheese samples. The highest protein content was observed in kasar cheese, whereas the lowest value was observed in analogue cheese (P<0.01). Moreover, the highest fat and ash contents were determined in analogue cheese, but both values were the lowest in kasar cheese. Our findings were supported by

Table 2- Composition (mean±SE) of cheese samples

Çizelge 2- Peynir örneklerinin kompozisyonu (ortalama±standart hata)

Composition (%)	Kasar cheese	Processed cheese	Cheese analogue	P value
Dry matter	50.68±0.97	48.75±3.20	50.74±0.61	0.74
Protein	26.86±0.61^{A*}	21.49±1.15^{B}	17.98±0.01^{B}	0.01
Fat	21.50±0.25^{B}	24.00±1.00^{B}	29.75±1.00^{A}	0.01
Salt	1.16±0.13	0.89±0.14	0.87±0.01	0.26
Ash	3.24±0.69^{B}	3.55±0.16^{AB}	4.15±0.02^{A}	0.04

*, means in the same attribute followed by different superscripts (A-B) letter represent significant differences among cheeses (P<0.05); SE, standard error

other researchers (Piska & Stetina 2004; Sert 2004; Dimitreli et al 2005; Curuk 2006; Yasar 2007; Balkır & Metin 2011). While Karademir-Sanlı (2006) indicated that dry matter of kasar cheese changed between 46.03-49.66%, Koca (2002) showed dry matter content of low fat kasar cheese in between 45.13-52.0%. In a study conducted by Balkır & Metin (2011), imitatiton fresh kasar cheese was prepared from casein, caseinates and soy protein. The cheese had 46.34-52.22% of dry matter, 22.99-27.49% of fat, 20.05-24.32% of total protein, 1.19-2.15% of salt and 3.18-3.77% of ash.

Changes in pH and titratable acidity were shown in Table 3. Significant interaction was determined between storage time and cheese type in terms of pH and titratable acidity. pH values of kasar cheese was lower than other cheese samples during the storage (P<0.05). Specifically anoluge cheese had higher pH values than other two cheeses. For titratable acidity, processed cheese samples had higher values than other cheeses until 30 day storage. Similar

pH results were reported by Bunka et al (2009) and Urkek (2008) for kasar cheese and processed cheese. However, higher titratable acidities were reported for kasar and analogue cheese by other researchers (Gursoy 2000; Oztekin 2003; Oksuztepe et al 2009). Oksuztepe et al (2009) showed that titratable acidity of kasar cheese was average 0.42% (lactic acid), whereas, Oztekin (2003) reported that titratable acidity of kasar cheese changed between 0.80-0.87% (lactic acid).

3.2. Color measurements

Color measurements of cheese samples were shown in Table 4. Specifically, L^* and b^* values are important color parameters for cheeses. No significant interaction between cheese type and storage time was determined for color values (P>0.05). Cheese type had significant effect on L^* (P= 0.02) and a^* (P= 0.01) values. L^* values of processed and analogue cheeses were higher than kasar cheese. The highest a^* value was determined in processed cheese. Cheese analogue had the lowest a^* value (Table 4).

Table 3- pH and titratable acidity (% lactic acid) (mean±SE) of cheeses during storage

Çizelge 3- Depolama boyunca peynirlerin pH ve titrasyon asitliği (% laktik asit) (ortalama±standart hata)

Day	Kasar cheese		Processed cheese		Cheese analogue	
	pH	Titratable acidity	pH	Titratable acidity	pH	Titratable acidity
1	5.52±0.06[Ac]*	0.43±0.33[Bb]	5.97±0.06[ABb]	0.73±0.04[Ba]	7.39±0.02[Aa]	0.41±0.10[Bb]
30	5.07±0.05[Bc]	0.52±0.18[Ab]	5.80±0.02[Bb]	1.33±0.13[Aa]	6.93±0.09[Ba]	0.51±0.11[Ab]
90	5.63±0.07[Ac]	0.35±0.21[Ca]	6.03±0.01[Ab]	0.43±0.01[Ca]	6.37±0.01[Ca]	0.44±0.04[Ba]
P value	0.01		0.01		0.01	

*, means in the same attribute during storage followed by different superscripts (A-C) letter represent significant differences (P≤0.05) and means in the same attribute of different cheeses in the same day followed by different lowercase letters (a-c) represent significant differences (P≤0.05); SE, standard error

Table 4- Color values (mean± SE) of cheese samples during storage

Çizelge 4- Depolama boyunca peynir örneklerinin renk değerleri (ortalama±standart hata)

Day	Kasar cheese			Processed cheese			Cheese analogue		
	L^* value	a^* value	b^* value	L^* value	a^* value	b^* value	L^* value	a^* value	b^* value
1	83.38±0.05	-3.31±0.17	15.78±1.37	83.33±2.95	-4.11±0.03	16.75±0.40	83.09±0.96	-2.67±0.15	18.07±4.26
30	81.28±0.53	-2.79±0.34	13.37±1.18	82.17±0.98	-3.36±0.02	15.00±0.38	84.15±0.22	-2.09±0.09	15.97±2.84
90	80.95±0.49	-4.48±0.09	17.32±0.20	86.68±1.22	-3.98±0.44	17.03±0.11	88.14±0.00	-3.42±0.29	20.68±3.44
Overall	81.86±0.35[C]*	-3.52 ± 0.20[B]	15.49 ± 0.91	84.06±1.71[B]	-3.81 ± 0.16[A]	16.26 ± 0.29	85.12 ± 0.39[A]	-2.72 ± 0.17[C]	18.24 ± 3.51

*, means in the same color attribute in different cheeses followed by different superscripts (A-C) represent significant differences (P≤0.05); SE, standard error

L^*, a^* and b^* values determined in natural, process and analogue cheeses in the present study are consistent with the findings of other studies (Gursoy 2000; Awad et al 2004; Firat 2006; Dervisoglu & Gul 2011). Awad et al (2004) found that L^*, a^* and b^* values of processed Ras cheese changed between 82.9-85.8, 3.9-4.1 and 20.1-21.4, respectively. In a study by Gursoy (2000), it was found that analogue cheeses prepared with 10% soya milk had -3.22, -3.03, -2.24 of a^* values in 1st, 30th and 45th days of storage.

3.3. Textural properties of cheeses

Table 5 shows the changes of textural properties of cheese samples during storage. Meltabilities determined by tube (P= 0.01) and by Schreiber test (P= 0.01), oil separation indexes (P= 0.02) and hardness of the cheeses (P= 0.01) were significantly affected by cheese type. The lowest hardness was determined in kasar cheese while processed cheese had the highest hardness. The lowest meltability scores were determined in cheese analogue Moreover, the lowest oil separation index was found in processed cheese. Kasar cheese and analogue cheese samples have similar oil separation indexes (P>0.05, Table 5). Similar results were reported by Koca (2002), Koca & Metin (2004) and Altan et al (2005).

3.4. Aroma-active compounds of cheeses

Total 18 aroma compounds were defined in cheese samples (Table 6). Diacetyl, acetic acid, butyric acid, 2-acetyl-2-thiazoline, 2-phenylethyl alcohol, maltol, sotolon, δ-decalactone and γ-dodecalactone had higher intensities than other aroma compounds in the cheeses. While acetic acid was determined at high intensities in processed cheese samples on days 1 and 90, it was determined at very low intensity (0.5) in analogue cheese in the first day of storage. β-Ionene was only found in analogue cheese. Maltol intensity was higher in kasar cheese than processed cheese on day 30. γ-dodecalactone was only found at higher intensity in processed cheese on day 90. δ-Decalactone was determined in all cheese samples. However, the intensity of δ-decalactone was higher in analogue cheese than the other cheeses on days 30 and 90. These might be results of some ingredients (cream and butter) used to produce analogue cheese.

Table 5- Textural properties (mean±SE) of cheese samples during storage

Çizelge 5- Depolama boyunca peynir örneklerinin tekstürel özellikleri (ortalama±standart hata)

Day	Hardness (gram force)	Schreiber test (mm)	Tube test (cm)	Oil separation index
		Kasar cheese		
1	4.83±0.27	17.88±1.50	13.82±2.13	152.9±76.5
30	4.79±0.20	21.13±2.00	12.25±0.70	133.8±16.2
90	4.56±0.06	18.50±1.62	12.72±0.47	197.1±14.7
Overall	4.72±0.18^{C*}	19.17±1.70^A	12.93±1.1^A	161.26±35.80^A
		Processed cheese		
1	78.85±3.85	17.00±0.25	9.65±4.10	38.24±2.94
30	64.4±2.09	18.81±1.94	12.90±1.15	58.82±5.88
90	50.82±2.38	15.63±3.13	7.90±3.20	82.4±41.2
Overall	64.69±2.77^A	17.14±1.77^A	10.15±2.81^A	59.82±16.67^B
		Cheese analogue		
1	38.16±3.17	0.65±0.219	0.43±0.22	70.59±5.88
30	22.50±9.83	0.44±0.437	0.70±0.15	60.29±4.41
90	21.08±0.75	4.63±4.25	2.18±0.92	179.4±14.7
Overall	27.24±4.66^B	1.91±1.63^B	1.10±0.43^B	103.42±8.33^{AB}

*, means in the same texture attribute in different cheeses followed by different superscripts (A-C) letter represent significant differences (P≤0.05); SE, standard error

Increases in intensities of butyric acid, 2-/3-methyl buytric acid and 2-acetyl-2-thiazole were higher in Kasar and analogue cheeses than processed cheese during storage. The intenisty of unknown 3 with spicy flavor decreased in all cheese samples during storage. Aroma-active compounds determined in the cheese samples were reported by several other studies (Karagul-Yuceer et al 2001; Qian & Reineccius 2002; Carunchia-Whetstine et al 2003; Avsar et al 2004; Awad et al 2004; Mahajan et al 2004; Karagul-Yuceer et al 2009; Vitova et al 2012). They have a great contribution on flavor of many dairy products. Ethly pentanoate, *p*-cresol, maltol, sotolon, 2-acetly-2-thiazoline and δ-decalactone were found as aroma-active compounds in Cheddar cheese (Avsar et al 2004). Hayaloglu (2009) investigated volatile composition of kasar cheese at different stages of ripening. Acetic acid, butyric acid, pentanoic acid, 2-phenylethyl alcohol and *p*-cresol were also determined in Kasar cheese similar to our findings. Guneser & Karagul-Yuceer (2011) determined similar aroma-active compounds in Circassian cheese by GCO analysis. However, the intensities of γ-dodecalactone, *p*-cresol, 2-phenylethyl alcohol and 2-/3-methyl buytric acid were found to be higher in Circassian cheese than our cheese samples. Also, acetic acid was observed at higher intensity in processed cheese compared to Circassian cheese.

3.5. Descriptive sensory analysis of cheeses

Eleven descriptive terms were developed by panelists (Table 1). Among the cheese samples, analogoue cheese became inedible due to deterioration at 90 days storage. Sensory evaluation of cheese samples was conducted at 1st and 30th days

Table 6- Aroma active compounds of cheese samples during storage

Çizelge 6- Depolama boyunca peynir örneklerinin aroma aktif bileşenleri

Aroma	RI[a]	Aroma quality[b]	Aroma intensity[c]								
			Kasar cheese			Processed cheese			Cheese analogue		
			D1	D30	D90	D1	D30	D90	D1	D30	D90
Diacetyl	<1100	Creamy/fat	0.6	1.1	0.3	0.8	1	1	-	1.2	1.3
Ethyl pentanoate	1171	Fruity	0.3	-	0.4	-	-	-	-	-	-
Unknown 1	1278	Sour	2	1.3	2.3	1.3	0.7	1.8	-	0.4	1.5
Methional	1392	Potato/metallic	0.5	-	-	0.9	-	1	0.6	-	-
Acetic acid	1435	Sour	5	0.4	-	6	-	6	0.5	-	-
Unknown 2	1480	Mushroom/metallic	-	1.3	0.8	-	0.9	-	-	0.5	-
Butyric acid	1538	Acid	0.3	1.3	6	-	3	-	0.3	1	6
2-/3-methyl butyric acid	1603	Sour/vinegar	0.9	-	2.3	-	1	0.9	1.5	0.9	4.3
2-acetyl-2-thiazoline	1717	Popcorn	0.4	-	3.5	1.5	-	5.8	-	-	3.5
Pentanoic acid	1733	Sour	-	-	-	-	3.3	-	-	0.8	-
b-ionene	1866	Herbaceous	-	-	-	-	-	-	0.8	0.8	1
2-phenylethanol	1927	Rose/Sour	-	0.8	0.9	-	0.8	0.8	0.4	-	-
Maltol	1988	Burnt sugar	1.3	4.5	0.5	0.7	-	0.8	2.5	2.3	1.2
p-cresol	2012	Animal	-	-	-	-	-	1.8	-	0.4	-
Unknown 3	2087	Spicy	1.8	-	-	1.8	-	-	1.8	0.7	-
Sotolon	2139	Burnt sugar	-	2	0.8	-	1.8	1.5	1	1.5	1.3
d-decalactone	2244	Flower/lactone	1.8	3	2	0.9	1.5	3	1.8	2.5	2.3
g-dodecalactone	2380	Sweet/lactone	-	1.5	1.5	-	1	2.3	-	0.8	1.4

[a], retention indices is on INNOWAX column (J &W Scientific, Folsom, CA, USA); [b], aroma quality determined on olfactory port; [c], mean aroma intensities (post-peak intensity, 10-point scale) on INNOWAX column; odour intensities represent the mean of each sample evaluated in duplicate by sniffer; D1, day1; D30, day 30; D90, day 90

of storage. Significant interaction was determined between storage time and cheese type in terms of whey and animal like terms (P≤0.05). At the first day of storage, it was found that whey flavor intensity was lower in kasar cheese anologue than other cheese samples while animal like flavor intensity was higher than other cheese samples (Table 7). Karagül-Yüceer et al (2003) found that rennet casein had an animal like/wet dog flavor which was associated its volatile copmounds such as hexanoic acid, indole and guaiacol and *p*-cresol. For this reason, higher animal like flavor in Kasar cheese analogues prepared by rennet casein could be ascribed to characteristics of rennet casein.

Table 8 shows the effects of cheese type on nutty, waxy, cooked, creamy, salty, sour and umami intensities percieved by panelists. Nutty intensities of natural kasar and proced cheeses were higher than analogue cheese (P≤0.05). Nutty intensities of kasar cheese and proced cheese were higher than analogue cheese. Cheese type affacted waxy aroma note (P≤0.05). It was found that intensity

of waxy flavor was higher in cheese analogue than other cheese samples. This might be related to the composition of cheese analogue. It was emphasized that waxy flavor in cheese associated medium chain fatty acid such as 4-methyl octanoic and 4-ethyl octanoic acid by Delahunty & Drake (2004). Intensities of umami taste were lower in all cheese samples. In practice, kasar cheese had higher intensity of umami taste than other cheese samples. The intensities of cooked and creamy in cheese samples were found to be between 2.40-3.21 and 2.90-3.79, respectively. Similar results were reported by other researchers (Karagul-Yuceer et al 2007; Adhikari et al 2009). Adhikari et al (2009) determined that intensities of cooked and creamy flavors in processed cheese ranged between 2.20-2.54 and 3.54-4.33 respectively. Karagul-Yuceer et al (2007) determined that sour, sweet and umami tastes in Ezine cheese ranged between 2.31-4.28, 0.53-1.25 and 0.53-1.40, respectively.

Significant effects of storage were determined on the intensities of fermented flavor and sweet taste of the

Table 7- Intensities (mean±SE) of whey and animal like aroma in cheese samples during storage

Çizelge 7- Peynirlerde depolama boyunca peyniraltı suyu ve hayvansı aroma yoğunlukları (ortalama±standart hata)

Day	Kasar cheese		Processed cheese		Cheese analogue	
	Whey	Animal	Whey	Animal	Whey	Animal
1	3.31±0.15[Aa*]	0.04±0.04[Ab]	2.77±0.19[Aa]	0.00[Bb]	0.41±0.13[Bb]	6.87±0.39[Aa]
30	2.75±0.09[Aa]	0.04±0.04[Ab]	1.94±0.25[Bb]	0.40±0.14[Ab]	1.58±0.39[Ab]	2.65±0.64[Ba]
P value	0.01		0.01		0.01	

*, means in the same attribute during storage followed by different superscripts (A-B) represent significant differences (P≤0.05); means in the same attributes of different cheeses followed by different lowercase (a-b) letters represent significant differences (P≤0.05); SE, standard error; mean expresses aroma intensity after testing, 10-point scale

Table 8- Intensities (mean±SE) of sensory descriptors in cheese samples

Çizelge 8- Peynir örneklerinde duyusal tanımlayıcıların yoğunlukları (ortalama±standart hata)

Samples	Nutty	Waxy	Cooked	Creamy	Salty	Sour	Umami
Kasar cheese	0.64±0.11[A*]	0.02±0.02[B]	3.21±0.14	2.90±0.14	1.56±0.23	1.43±0.20	0.80±0.39
Processed cheese	0.52±0.17[A]	0.54±0.32[B]	2.83±0.32	3.79±0.42	1.28±0.16	1.12±0.18	0.29±0.11
Cheese analogue	0.02±0.02[B]	3.67±0.38[A]	2.40±0.30	3.12±0.48	1.42±0.19	0.93±0.13	0.37±0.12
P value	0.01	0.01	0.63	0.16	0.63	0.16	0.30

*, means in the same attribute of different cheeses followed by different superscripts (A-B) represent significant differences (P≤0.05); SE, standard error; mean expresses aroma intensity after testing, 10-point scale

cheese samples (P= 0.03). On the 30th day of storage, intensities of fermented flavor (1.41±0.28) and sweet taste (1.45±0.17) were higher than the first day of storage. When the examined all sensory descriptors of cheese samples by multidimensional scaling methods, it can be said that kasar cheese and processed cheese had similar sensory characteristics (Figure 2).
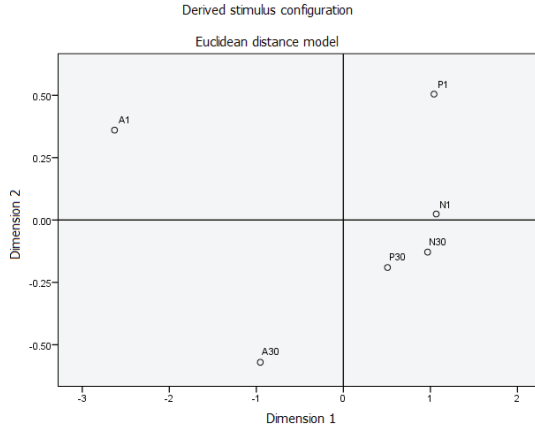
Figure 2- Multidimensional scaling map of cheese samples in terms of descriptive sensory properties during storage (A, analogue cheese; P, processed cheese; N, kasar cheese (1:1st day of storage 30:30th day of storage)), dimension 1 and 2 were established for cheese samples based on all sensory properties by MDS analysis

Şekil 2- Depolama boyunca tanımlayıcı duyusal özellikler bakımından peynir örneklerine ait çok boyutlu ölçeklendirme haritası (A, taklit peynir; P, eritme peynir; N, kaşar peyniri (1:1. gün, 30:30. gün)) boyut 1 ve 2 tüm duyusal özellikler dikkate alınarak peynir örnekleri için MDS analizi ile oluşturulmuştur

3.6. Consumer acceptance test

The panelists evaluated color/appearance, texture, flavor and overall liking of the cheese samples (Table 9). Based on consumer test, significant differences were observed among the cheeses in terms of flavor attribute (P= 0.01). However no significant differences were determined among the cheeses in terms of appearance (P= 0.50) and texture acceptance (P= 0.08). Kasar cheese had the highest flavor acceptance score while the analogue cheese had the lowest flavor score. Color/appearance and texture scores of the cheese samples varied between 4.81-5.14 and 4.37-4.95, respectively. Moreover, kasar cheese had the highest preference than the other samples. However, the lowest preference score was determined in analogue cheese. These results confirmed that consumers prefer kasar cheese to processed cheese and analogue cheese. Similar results were also indicated by other studies (Gursoy 2000; Koca 2002; Karademir-Sanli 2006). Gursoy (2000) showed that process cheese prepared with 10% soya milk had lower score than kasar cheese in terms of appearance/color, texture and flavor characteristics.

4. Conclusions

Differences in some chemical, physical, sensory properties and aroma characterization of kasar, processed and analogue cheeses were determined. There were significant differences among the cheeses in terms of protein, ash and fat contents, and variations were determined among the cheeses based on pH and titratable acidities during storage.

Table 9- Consumer acceptance and ranking test scores (mean±SE) of cheeses

Çizelge 9- Peynirlerin tüketici kabul ve sıralama test puanları (ortalama±standart hata)

Samples	Color/Appearance	Texture	Flavor	Ranking test
Kasar cheese	5.14±0.13	4.95±0.16	5.14±0.15[A*]	1.62±0.11[C]
Processed cheese	4.89±0.14	4.62±0.14	4.43±0.17[B]	2.00±0.11[B]
Cheese analogue	4.81±0.17	4.37±0.20	3.66±0.20[C]	2.35±0.10[A]
P value	0.50	0.08	0.01	0.01

*, means in the same sensory attribute of different cheese samples followed by different superscript letters (A-C) represents significant differences (P≤0.05); SE, standard error; mean expresses ranking scores, 7-point scale

No significant changes were determined in L^*, a^* and b^* values, hardness, oil separation and melting properties in cheeses during 30 days of storage. 18 aroma-active compounds were determined in the cheeses during 90 day storage. Diacetyl (butter), unknown 1, acetic acid (vinegar), butyric acid (cheesy), 2-/3-methyl butyric acid (sour, dirty), 2-acetyl-2-thiazoline (popcorn), β-ionene (herbal), 2-phenylethyl alcohol (rose), maltol (burnt sugar), p-cresol (animal like), sotolon (burnt sugar), δ-decalactone (flower, peach) and γ-dodecalactone (sweet) were some of the characteristic aroma-active compounds in the cheeses. 'Whey', 'cooked', 'creamy', 'salty' and 'sour' were determined as the most intense sensory descriptors of the cheeses. 'Animal like' and 'waxy' aroma intensities were higher in analogue cheese than the other cheeses. Kasar cheese was the most liked cheese while analogue cheese was the least liked one.

Acknowledgements

References

Adhikari K, Cole A, Grun I, Heyman H, Hsieh F H & Huff H (2009). Physical and sensory characteristics of process cheeses manufactured by extrusion technology. *Journal of the Science of Food and Agriculture* **89**(8): 1428-1433

Altan A, Turhan M & Gunasekaran S (2005). Short communication: Comparison of covered and uncovered Schreiber test for cheese meltability evaluation. *Journal of Dairy Science* **88**(3): 857-861

AOAC (2000). Official Methods of Analysis of AOAC 17th ed. International. Gaithersburg, USA

Atasoy A F (2008). Evaluation of pH change kinetics during different stages of kashar cheese production from bovine, ovine and caprine milk. *Journal of Food Processing and Preservation* **32**: 416-428

Avsar Y K, Karagul-Yuceer Y, Drake M A, Singh T K, Yoon Y & Cadwallader K R (2004). Characterization of nutty flavor in cheddar cheese. *Journal of Dairy Science* **87**(7): 1999-2010

Awad R A, Abdel-Hamid L B, El-Shabrawy S A & Singh R K (2004). Physical and sensory properties of block processed cheese with formulated emulsifying salt mixtures. *International Journal of Food Properties* **7**(7): 429-448

Bachmann H P (2001). Cheese analogues: A review. *International Dairy Journal* **11**: 505-515

Balkir P & Metin M (2011). Physicochemical and textural properties of imitation fresh kasar cheeses prepared from casein, caseinates and soy protein. *Gıda* **36**(1): 17-24

Bradley J R L, Arnold J E, Barbano D M, Semerad R G, Smith D E & Vines B K (1992). Chemical and physical methods. In: Standard methods for the examination of dairy products, ed: Marshall, RT. *American Journal of Public Health*, Washington DC, pp. 433-531

Bunka F, Kriz O, Velickova A, Bunkova L & Kracmar S (2009). Effect of acid hydrolysis time on amino acid determination in casein and processed cheese with different fat content. *Journal of Food Composition and Analysis* **22**(3): 224-232

Carunchia-Whetstine M E, Karagul-Yuceer Y, Avsar Y K & Drake M A (2003). Identification and quantification of aroma components in fresh chevre-style goat cheese. *Journal of Food Science* **68**: 2441-2447

Curuk M (2006). Influence of the melting salts used on the some characteristics and ripening properties of kashar like cheese. PhD Thesis, Cukurova University (Unpublished), Adana

Delahunty & Drake (2004). Sensory character of cheese and its evaluation. *Cheese Chemistry, Physics and Microbiology* **1**: 455-457

Dervisoglu M & Gul O (2011). Microbiological and chemical properties of vacuum packaged Kashar cheese produced in black sea region, Turkey. In: *Proceedings of the 11th International Congresson Engineering and Food*, 22-26 May, Athens, Greece, pp. 1295-1297

Dimitreli G, Thomareis A S & Smith P G (2005). Effect of emulsifying salts on casein peptization and apparent viscosity of processed cheese. *International Journal of Food Engineering* **1**(4): 1-15

Guinee T P (2002). The functionality of cheese as an ingredient-a review. *Australian Journal of Dairy Technology* **57**: 79-91

Guneser O & Karagul-Yuceer Y (2011). Characterisation of aroma-active compounds, chemical and sensory properties of acid-coagulated cheese: Circassian cheese. *International Journal of Dairy Technology* **64**(4): 517-525

Gursoy O (2000). Possible use of soy milk in kasar cheese production (Soya sütünün kaşar peyniri üretiminde kullanım olanakları). MSc Thesis, Pamukkale University (Unpublished), Denizli

Hayaloglu A A (2009). Volatile composition and proteolysis in traditionally produced mature kasar cheese. *International Journal of Food Science and Technology* **44**(7): 1338-1394

ISO (2008). ISO-CIE Standard, 11664-4. Colorimetry, Part 4: CIE 1976 *L* a* b** colour space

Kapoor R & Metzger L E (2008). Process cheese: Scientific and technological aspects-A review. *Comprehensive Reviews in Food Science and Food Safety* **7**(2): 194-214

Karademir-Sanli E (2006). Effect of pasteurization temperatures and of using exopolysaccharide-producing culture on some properties of low-fat kasar cheese. PhD Thesis, Ankara University Graduate School of Natural and Applied Sciences (Unpublished), Ankara

Karagul-Yuceer Y, Drake M A & Cadwallader K R (2001). Aroma-active components of nonfat dry milk. *Journal of Agricultural Food Chemistry* **49**: 2948-2953

Karagül-Yüceer Y, Vlahovich K N, Drake M A & Cadwallader K R (2003). Characteristic aroma components of rennet casein. *Journal of Agricultural and Food Chemistry* **51**(23): 6797-6801

Karagul-Yuceer Y, Isleten M & Uysal-Pala C (2007). Sensory characteristics of Ezine cheese. *Journal of Sensory Studies* **22**(1): 49-65

Karagul-Yuceer Y, Tuncel B, Guneser O, Engin B, Isleten M, Yasar K & Mendes M (2009). Characterization of aroma-active compounds, sensory properties and proteolysis in Ezine cheese. *Journal of Dairy Science* **92**(9): 4146-4157

Koca N (2002). Bazı yağ ikame maddelerinin yağı azaltılmış taze kaşar peynirinin nitelikleri üzerine etkileri. Doktora tezi, Ege Üniversitesi, Fen Bilimleri Enstitüsü (Basılmamış), İzmir

Koca N & Metin M (2004). Textural, melting and sensory properties of low-fat fresh kasar cheeses produced by using fat replacers. *International Dairy Journal* **14**(4): 365-373

Mahajan S S, Goddik L & Qian M C (2004). Aroma compounds in sweet whey powder. *Journal of Dairy Science* **87**: 4057-4063

Meilgaard M, Civille G V & Carr B T (1999). Descriptive analysis techniques. In: M Meilgaard, G V Civille & B T Carr (Eds), *Sensory Evaluation Techniques*, 3rd ed, Boca Raton, FL: CRC, pp. 161-170

Metin M (2006). Milk Technology. Ege University Press, Izmir, Turkey, pp. 802

NEN (1969). Netherlands Standard 3059 (The Netherlands Standardization Institute), butyrometric determination of the fat content of cheese (Gerber-Van Gulik method). Netherland Milk Dairy Journal **23**: 214-220

Okpala C O R, Piggott J R & Schaschke C J (2010). Influence of high-pressure processing (HPP) on physico-chemical properties of fresh cheese. *Innovative Food Science and Emerging Technologies* **11**(1): 61-67

Oksuztepe G, Patir B, Dikici A & Ilhak O I (2009). Microbiological and chemical quality of vacuum packaged kasar cheese marketed in Elazıg. *Fırat University Health Science Veterinary Journal* **23**(2): 89-94

Oztekin F S (2003). An investigation on general properties of processed cheese from white cheese of different fat content. PhD Thesis, Ankara University Graduate School of Natural and Applied Sciences (Unpublished), Ankara

Pawliszyn J (2012). Solid-phase microexraction in perspective. In: J Pawliszyn (Ed), *Handbook of Solid Phase Microextraction*, Elsevier Inc., Waltham, MA, USA. pp. 1-12

Piska I & Stetina J (2004). Influence of cheese ripening and rate of cooling of the processed cheese mixture on rheological properties of processed cheese. *Journal of Food Engineering* **61**(4): 551-555

Qian M & Reineccius G (2002). Identification of aroma compounds in parmigiano-reggiano cheese by gas chromatography/olfactometry. *Journal of Dairy Science* **85**(6): 1362-1369

Sert D (2004). Determination of some properties of kashar cheese, produced from pasteurize and raw milk

during ripening. Master Thesis, Selcuk University (Unpublished), Konya

Sheskin D J (2000). Parametric and Nonparametric Statistical Procedures. Chapman & Hall/CRC, 669-684 pp. New York, USA

SPSS (2006). SPSS 15 for Windows. Release 15.0 ver., SPSS Inc. Chicago, IL, USA

Tarakci Z & Kucukoner E (2006). Changes during ripening on Van herby cheeses produced with milk different fat contents. *Yuzuncu Yil University Journal of Agriculture Science* **16**(1): 19-24

Ucuncu M (2004). From A to Z Cheese Technology, Ege University Press, Izmir, Turkey, pp. 948-969

Urkek B (2008). Effect of homogenization and packaging on some chemical, biochemical, electrophoretic, sensorial and microbiological properties of kashar cheese. Master Thesis, Yuzuncu Yil University (Unpublished), Van

Van Del Dool H & Kratz P D (1963). A generalization of the retention index system including linear temperature programmed gas-liquid partition chromatography. *Journal of Chromatography A* **11**: 463-471

Van Ruth S M (2001). Methods for gas chromatography-olfactometry: A review. *Biomolecular Engineering* **17**: 121-128

Var I, Erginkaya Z, Guven M & Kabak B (2006). Effect of antifungal agent and packaging material on microflora of kasar cheese during storage period. *Food Control* **17**(2): 132-136

Vitova E, Loupancova B, Sklenarova K, Divisova R & Bunka F (2012). Identification of volatile aroma compounds in processed cheese analogues based on different of fat. *Chemical Pap* **66**(10): 907-913

Yasar K (2007). Effects of different coagulants used and ripening period on properties of kasar cheese. PhD Thesis, Cukurova University (Unpublished), Adana

Yasar K & Guzeler N (2011). Effect of coagulant type on the physicochemical and organoleptic properties of kasar cheese. *International Journal of Dairy Technology* **64**(3): 372-379