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PHYSICOCHEMICAL, BIOCHEMICAL, TEXTURAL AND SENSORY PROPERTIES OF TELLI CHEESE - A TRADITIONAL TURKISH CHEESE MADE FROM COW MILK

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Abstract

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Telli (threaded) cheese is a hard cheese variety produced in the Eastern Black Sea Region of Turkey. Physicochemical, biochemical, textural and sensory properties of cow milk Telli cheese samples were investigated during 90 days of storage. Cheese samples were characterized with their high total solids (54.44%), fat (25.25%) and protein (25.14%) contents. Lactic acid was the first abundant organic acid in cheeses. The most abundant saturated fatty acids were palmitic, stearic and myristic acids while the oleic acid was found to have the highest level among the unsaturated fatty acids. Lipolysis and proteolysis of samples were increased throughout storage.

Key words: Telli cheese, proteolysis, lipolysis, organic acids, fatty acids, texture

Introduction

In addition to three major cheese types, White Pickled, Kashar and Tulum cheese, there are many traditional cheese types produced and consumed in local regions in Turkey (Turkoglu et al*.,* 2003; Sengul et al*.,* 2006; Karagozlu et al., 2009). Telli (threaded) cheese is one of the popular traditional cheese varieties in Eastern Black Sea Region of Turkey. It is generally produced from cow's milk obtained from steps of Trabzon and Artvin as well as in Sürmene and Akcaabat, which are administrative districts of Trabzon (Figure 1). The yellowish Telli cheese has quite similarities with Pasta Filata type cheeses (especially with Kashar cheese) and it's method of production resembles that of Orgu cheese made in around Diyarbakir and appearance resembles Erzurum's Civil Cheese (Kamber and Terzi, 2008). However, Telli cheese is more acidic (pH 4.8 to 5.1) and has elastic texture than Kashar cheese (pH 5.2). Kneading treatment of fresh curd in salty hot water not only gives the product a fibrous structure, but also bringing melting and stretching properties. Although the production method for Telli cheese is not standardized, small or middle scale dairies located in above-mentioned cities are trying to use modern processing methods during production. Telli cheese is consumed freshly (in general within 30 days after its production) and can be ripened by mixing with Minzi (a kind of whey cheese) in wooden barrels (Kulek) (Kamber and Terzi, 2008).

There is very limited information available about Telli cheese in the literature and no study has been car-

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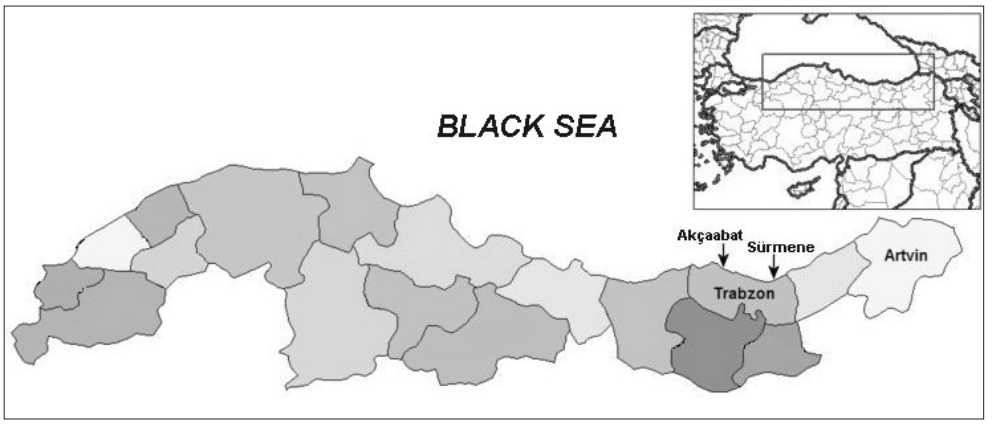

Fig. 1. The cities and towns of Eastern Black Sea Region of Turkey where Telli cheese is mainly produced

ried out to monitor the basic composition, ripening profile, texture, color and sensory properties of the cheese during storage. Therefore, the objective of this study was to determine some physicochemical, biochemical and sensory properties of Telli cheese during 90 days of storage period.

Materials and Methods

Production of cheese samples: Three different batches of Telli cheese samples were produced at August in a middle-scale dairy factory (Besikduzu Dairy Products Ltd. Sti., Besikduzu, Trabzon, Turkey). For production cheese samples, fat content of cow milk was standardized to approximately 3.5%, heated to 35°C and then rennet was added at a sufficient level in order to coagulate milk in around 35 min. Then coagulum was cut into about $1\times1\times1cm^3$ cubes, and curds were allowed to rest in whey for 2-3 min. Then, curds were transferred into moulds, covered with cheesecloth, and pressed for whey drainage for 30±5 minutes. Pressure was 150 kg weights for each 100 kg of curd. Afterwards, the curd was fermented at ambient temperature until 5.0-5.10 pH. Then, the curd was cut into slices (5 cm width, 5 mm thickness) and scalded in hot brine (72-75°C, 12-13% salt) for 2-3 min. The cheese was stretched into a string approximately 30-45 cm long and 6 cm in diameter and threaded after cooling. Finally threaded cheese was packaged under vacuum and stored at 4°C. The cheese samples were transported to the laboratory in an icebox and sampled during the 1st, 30th, 60th, and 90th days of storage period according to International Dairy Federation (IDF, 1980).

Chemical analyses: Cheese samples were analyzed for total solids, fat, salt, and, ash contents and titratable acidity (°SH) according to Oysun (2001). The pH values were measured using a Hanna 210 pH-meter. The total nitrogen (TN), water-soluble nitrogen (WSN) and soluble nitrogen in 12% tricloroacetic acid (TCA-SN) contents of samples were determined by Kjeldahl method. Sample preparation for Kjeldahl analyses was carried out according to Ardö (1999). The ripening extension index (RI_{WSN}) and ripening depth index (RI_{TCA}) were estimated as [WSN/TN] x 100 and [TCA-SN/TN] x 100 respectively. The acid degree value (ADV) was determined according to the method described by Renner (1993).

Determination of organic acids: Organic acids were determined according to modification of the method of Bevilacqua and Califano (1989). Seven gram of cheese were taken and 40 mL mobile phase (0.1% H_2PO_4) was added and mixed with a homogenizer (Ultra Turrax, T25, IKA, Labortechnik, Germany) for 1 min. The mixture was held at 40°C in a water bath for 1 h and than centrifuged at 5800 *g* for 5 min. The upper phase was filtered once through filter paper (Whatman No: 1) and than through 0.45 µm membrane filter. A Perkin Elmer Series 200 Model HPLC, equipped with an UV absorbance detector set at 214 nm was used. Chromatographic separation of 20µL samples was performed on

a Shodex RSpak KC-118 model ion exchange organic column (8x300 mm i.d.). The mobile phase was 0.1% (w/v) of phosphoric acid in distilled water (HPLC grade) with a flow rate of 0.8mL/min. 20 µL aliquots of individual standards were injected to column and their retention times were determined.

Determination of fatty acid composition: Lipids were extracted from cheese with purified kieselguhr and diethyl ether as described by Renner (1993). Fatty acid methyl esters were prepared according to AOAC (1997). The instrumentation used for determination of fatty acid composition was as follows: a Hewlett-Packard GC (model 6890) equipped with Supelco SP-2380 fused silica capillary column (60 m x 0.25 mm i.d., 0.2 µm film thickness; Supelco Inc., Bellefonte, PA, USA) and a flame ionization detector. The injection volume was 2 µL. The temperature of GC oven was programmed from 100 to 220°C at the rate of 4°C per min. The injector and detector temperatures were 300°C. Nitrogen was used as the carrier gas and the flow rate was 1 mL/min. The split ratio was set at 1:100.

Instrumental texture profile and color analyses: TA-XT plus Texture Analyzer (Vienna count, surrey GU7 1 YL, UK) was used for instrumental texture profile analysis (TPA). Cheese samples with 2 cm diameter and 2.5 cm height were used for measurements. Cheese samples were wrapped with plastic stretch to prevent dehydration and tempered to 21±1°C. A two bite penetration test was performed using P/35 probe (35 cm diameter) and operated at a crosshead speed of 1 mm/s and penetration distance of 10 mm in both upward and downward directions with 10 sec between the two cycles. Six textural parameters (hardness, adhesiveness, springiness, chewiness, gumminess and cohesiveness) were obtained from the analysis of these force-distance curves. All measurements were done in duplicate during the storage period.

The color of cheese samples was determined using a Minolta colorimeter system CR-310 (Minolta Camera Co., Osaka, Japan). The color measurements *(L, a, b)* were performed in triplicate.

Sensory evaluation: Five trained subjects, volunteer staff members, were evaluated cheese samples by the scoring test according to modification of the TSE method (TSE, 2006). Samples of about 100 g in a statistically balanced order were presented in duplicates on white dishes labeled with three-digit random numerical codes. Panelists assigned scores in partitioned booths equipped with daylight to each cheese sample for color (10 points), appearance (30 points), texture (20 points), flavor (40 points) and acceptability (100 points).

Statistical analysis: The effect of storage period was analyzed by one-way analysis of variance (ANOVA) using SPSS© 9.05 (SPSS Inc., Chicago, USA) and differences among means were compared using Duncan's Multiple Range Test.

Results and Discussion

Gross composition, physiochemical and biochemical properties of cheese samples

The average results for gross composition of Telli cheese are given in Table 1. Especially total solids value of 54.44 g/100 g and other contents considered normal in this Pasta Filata type of cheese. Changes in some physiochemical and biochemical parameters of Telli cheese throughout storage are presented in Table 2. Titratable acidity increased continually during the storage period possibility due to lactic acid and hydrogen formation. Significant differences were obtained after 30th day of storage with regard to mean values of titratable acidity ($P<0.05$). The titratable acidity values in Telli cheese were comparable to those found in other studies with different hard cheese varieties (Celik and Turkoglu, 2007; Ceylan et al., 2007; Revilla et al., 2007). A rapid increase of pH was determined in samples which reached a mean value of 5.30 at 30th day of storage ($P<0.05$). The consequent decrease occurred in pH at day 60 while a significant increase was observed at the end of storage ($P<0.05$). This fluctuation is probably sourced to the end products of proteolysis and/or

Table 1
The gross composition of Telli cheese (n=3)

Total solids (g/100 g)	54.4±0.04
Fat (g/100 g)	25.3±1.06
Fat in total solids (g/100 g)	46.4±1.98
Protein (g/100 g)	25.1±0.46
Salt (g/100 g)	3.97±0.00
Salt in total solids (g/100 g)	7.30±0.01

to the lactic acid utilization by cheese microflora (Pisano et al., 2006). The evaluation of these parameters is related to that reported by other authors for different types of hard cheeses. (Vioque et al., 2000; Pisano et al., 2006; Tarakci and Kucukoner, 2006; Celik and Turkoglu, 2007; Kilcawley et al., 2007). The acid degree value (ADV) refers to measures of the amount of free fatty acids (FFA) presents in a fat sample, which is a quantitative index of hydrolytic lipolysis in dairy products (Kesenkas et al., 2009). The general trend of lipolysis was varied and the FFA accumulation in Telli cheese samples was fluctuated during storage ($P<0.05$). Only the values through the end of storage were not significantly differed and revealed the existence of an intense lipolysis. The ADV values were much similar to that described different researchers (Severini et al., 1998; Pisano et al., 2006; Tarakci and Kucukoner, 2006; Celik and Turkoglu, 2007). Total nitrogen content increased within 60 days of storage and remained almost constant afterwards ($P<0.05$). These results were similar to those reported for goat's milk cheese, Orgu, Parmigiano Reggiano, Kashar and ewe's milk cheese (Romani et al., 2002; Tarakci and Kucukoner, 2006; Celik and Turkoglu, 2007; Ceylan et al., 2007; Bontinis et al., 2008). WSN and TCA-SN were used to determine the extent of proteolysis of Telli cheese (Table 2). Samples were showed progressive increase in the ripening index (RI) as a progress of maturation process during storage ($P<0.05$). RI_{WSN} values were increased continuously whereas the RI_{TCA} values decreased at day 60 but finally reached the highest value (9.32).

Organic acids

The main organic acids in the Telli cheese during storage were lactic, propionic, oxalic, malic, fumaric, citric, formic and acetic acids (Table 3). Lactic acid was

Table 2
Changes in some physiochemical and biochemical parameters of Telli cheese during storage[1] (n=3)

	Days of storage			
	1	30	60	90
Titratable acidity (°SH)	86.8±3.22a	89.2±8.99a	94.7±2.10ab	102.8±1.54c
pH	5.15±0.07a	5.30±0.08b	5.20±0.01a	5.38±0.04c
ADV	1.99±0.00b	1.40±0.18a	2.41±0.12c	2.22±0.10c
TN	3.96±0.22a	4.09±0.07bc	4.15±0.12c	3.98±0.02ab
RI_{WSN}	14.4±1.12a	15.7±0.61ab	16.9±1.00b	23.0±1.41c
RI_{TCA}	6.95±0.22a	8.24±0.32b	7.24±0.80a	9.32±0.54c

[1]Values with different letters within the same row are significantly different at $P<0.05$ level; ADV: acidity degree value (mg KOH / g fat); TN: Total nitrogen; RI_{WSN}: ripening index according to water soluble nitrogen as percentage of the total nitrogen; RI_{TCA}: ripening index according to trichloroacetic acid soluble nitrogen as percentage of the total nitrogen

Table 3
Organic acid concentrations in Telli cheese during storage[1] (mg/kg, n=3)

	Days of storage			
	1	30	60	90
Lactic acid	45.8±2.34a	84.3±17.41a	626.2±25.98b	673.1±51.75b
Propionic acid	2.04±0.11a	4.91±1.88b	5.84±0.34b	8.40±1.27c
Oxalic acid	1.10±0.10a	2.34±0.70b	6.54±0.26c	7.48±0.78c
Malic acid	9.91±0.58a	22.32±1.43b	28.71±9.31b	23.64±4.77b
Fumaric acid	25.5±1.09a	44.9±5.62b	46.2±9.40b	60.1±14.39b
Citric acid	8.2±1.28a	18.1±2.10b	20.9±6.65b	22.4±4.76b
Formic acid	1.30±0.15a	3.02±0.81a	23.71±2.60b	24.49±2.16b
Acetic acid	0.20±0.02a	0.54±0.20b	0.96±0.12c	1.21±0.09d

[1]Values with different letters within the same row are significantly different at $P<0.05$ level

the first abundant organic acid detected in Telli cheese and its concentration was found to be between 45.81 and 673.09 mg/kg throughout storage. The continual increase of lactic acid during storage was observed for different kind of cheeses (Zeppa et al., 2001; Akalin et al., 2002; Kesenkas et al., 2009). Propionic acid concentration increased as storage progressed, although at different rates ($P<0.05$). It remained constant between first and second months of storage and raised sharply thereafter. Oxalic acid concentration present in fresh and aged cheese was notably at higher concentrations. The initial content of oxalic acid was gradually increased ($P<0.05$) with storage and reached the maximum value of 7.48 mg/kg at the end of 90 days. Highly different results were reported for the oxalic acid content in Kashar, Cheddar and Ossalano cheeses (Lues and Botha, 1998; Zeppa et al., 2001; Kesenkas et al., 2009).

Malic acid content sharply increased after 30 days ($P<0.05$) then showed irregular changes during storage. Similarly fumaric and citric acid contents were significantly increased after 30 days and their concentration was found to be highest (60.12 and 22.41 mg/kg respectively) at the end of storage ($P<0.05$). The formic acid present in Telli cheese was initially found to be 1.30 mg/kg but sharply increased after 60 days ($P<0.05$) and remained constant thereafter. The increase in formic acid concentration at this period might be explained by the heterofermentative metabolism of lactose by means of secondary microflora (Califano and Bevilacqua, 2000). Acetic acid, which is known to be the main organic acid of brined cheeses, was found low amounts in Telli cheese naturally. It was gradually increased during storage and reached maximum level after 90 days ($P<0.05$). Many scientists have stated that the concentration of acetic acid in different cheese types such as Feta, Cheddar, Provolone, Blue, Halloumi, Ossolono, Beafort and Monterey Jack ranged from 0.13 to 7.10 mg/g cheese (Bevilacqua and Califano, 1992; Buffa et al., 2004; Kaminarides et al., 2007).

Fatty acid composition

One of the important characteristics of the quality of dairy products is the determining of the fatty acid profile (Ivanova et al., 2009). The results assembled in Table 4 indicate that the fatty acid patterns of Telli cheese was not changed during storage. The most abundant saturated fatty acids were palmitic (C16:0), stearic (C18:0) and myristic (C14:0) acids while the oleic acid (C18:1) was found to have the highest level among the unsaturated fatty acids. On the other hand, as seen from Table 4 levels of the short-chain fatty acids (SCFA, C4:0-C12:0) and medium-chain fatty acids (MCFA, C14:0-C16:1) are attracts attention because of their low perception threshold which might have a market effect on flavor development in Telli cheese. Although higher levels of long-chain fatty acids (LCFA≥C18:0) were found during storage, these fatty acids have a higher perception threshold and are thought to play a less important role in cheese flavor (Guler, 2005; Kesenkas et al., 2009). In Table 4 the results for fatty acid proportions in Telli cheese are also categorized as, polyunsaturated (PUFA), monounsaturated (MUFA)

Table 4
The fatty acid composition of Telli cheese during storage[1] (g /100 g total fatty acid, n=3)

	Days of storage			
	1	30	60	90
C4:0	2.03±0.19	2.18±0.21	1.80±0.13	1.65±0.33
C6:0	1.63±0.13	1.67±0.10	1.44±0.07	1.55±0.29
C8:0	1.10±0.04	1.12±0.05	0.96±0.03	1.10±0.19
C10:0	2.35±0.08	2.39±0.10	2.19±0.05	2.67±0.46
C12:0	2.63±0.34	2.68±0.09	2.59±0.02	3.15±0.55
C14:0	9.70±0.22	9.38±0.07	9.50±0.03	11.61±2.06
C14:1	0.69±0.04	0.74±0.05	0.74±0.01	0.89±0.16
C16:0	27.09±1.00	28.35±0.33	28.02±0.20	26.93±0.54
C16:1	1.35±0.08	1.21±0.08	1.21±0.01	1.48±0.27
C18:0	17.15±0.23	16.50±0.34	16.47±0.33	19.13±1.54
C18:1	26.78±0.56	28.00±0.26	28.09±0.17	28.55±0.58
C18:2	2.38±0.35	2.10±0.24	2.27±0.04	2.69±0.50
Others	3.72±0.00	3.76±0.33	4.61±0.06	5.62±1.11
SCFA	9.74±0.60	10.05±0.11	9.00±0.31	10.14±1.83
MCFA	40.76±0.85	41.48±0.42	41.94±0.24	43.79±2.47
LCFA	48.35±1.01	48.75±0.24	49.82±0.37	54.04±2.27
PUFA	3.65±0.70	3.21±0.07	3.38±0.13	4.10±0.88
MUFA	29.66±0.72	31.02±0.20	31.94±0.13	33.20±0.49
SFA	65.26±1.06	65.83±0.29	64.57±0.39	69.71±5.19

[1]SCFA: short-chain fatty acids; MCFA: medium-chain fatty acids; LCFA: Long-chain fatty acids; SFA: saturated fatty acids; MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids.

and saturated fatty acids (SFA). As expected PUFA/SFA ratio is very low in Telli cheese mostly like other dairy products.

Texture profile analysis

Parameters derived from texture profile analysis (TPA) are shown in Table 5. Hardness that is a measure of the amount of force required to compress the Telli cheese samples, continuously decreased as storage progressed (P<0.05) probably due to breakdown of casein especially α_{s1} fraction in to lower molecular weight peptide and hydration of the protein matrix. This decrease was also observed by other researchers in Cheddar (Fenelon and Guinee, 2000) and Kashar cheese (Sahan et al., 2007). Cohesiveness is the extent to which a cheese can be deformed before it ruptures of ratio of area on second compression to that on the first compression (Fox et al., 2000; Sahan et al., 2007).

Cohesiveness values in Telli cheese increased at the first month of storage and then significantly decreased (P<0.05), suggesting a role of softening somewhat due to proteolysis degree, protein content, ripening conditions or packaging material (Kahyaoglu et al., 2005; Romani et al., 2002). Highest gumminess value were obtained after 30 days (P<0.05) and decreased throughout the later period of storage. These results were also stated by other workers (Kahyaoglu et al., 2005; Romani et al., 2002). Springiness in Telli cheese increased with time and the highest springiness value was obtained at the end of storage. Only the initial springiness value of Telli cheese samples was significantly different from other days (P<0.05).

The differences in the springiness values could be explained by the different behavior of protein fractions and fat. The chewiness value in Telli cheese samples were significantly increased at the first month of storage and then Telli cheese samples exhibited a similar trend to the changes in the gumminess and cohesiveness during storage. The adhesiveness started to increase on the 30th day of storage and the values increased in the following days of storage (P<0.05). The difference found in adhesiveness may be linked to cheese pH, proteolysis degree, and the different polar characteristics of fat and protein fractions (Bryant et al., 1995; Romani et al., 2002). Eventually it can be said that Telli cheese shows close textural properties to most Pasta-Filata type cheeses because of its similar production method, moisture content and protein/fat matrix.

Color

Color of Telli cheese showed a gradual colorization (P<0.05) as a function of storage time as shown by an increase in *L** values (Table 6). This may be related to the composition of carotenoids level as well as riboflavin amounts, riboflavin acts as a photo-sensitizer (Rohm and Jaros, 1997; Trobetas et al., 2008). Also *L** value correlated best with panels color rating. *a** value increased after 30 days (P<0.05) while almost no change was noted throughout the rest of storage period. In contrast yellowness (*b** values) remained constant in samples stored for 30 days than sharply increased at 60th day of storage (P<0.05). It is clear that storage period of Telli cheese resulted in a tendency toward increased yellowness and variable redness values.

Table 5
Texture Profile Analysis in Telli cheese during storage[1] (n=3)

	Days of storage			
	1	30	60	90
Hardness	8.1±0.0c	5.8±1.9b	2.8±0.9a	2.9±0.4a
Cohesiveness	36.5±0.0b	50.8±3.8c	25.2±9.8b	13.1±3.4a
Gumminess	1.8±0.0a	6.4±2.4b	3.5±1.1a	3.8±0.3a
Springiness	5.4±0.0a	9.9±0.0b	9.9±0.0b	9.9±0.0b
Chewiness	9.6±0.0a	63.6±3.6c	34.5±10.6b	38.2±3.3b
Adhesiveness	0.2±0.0a	1.1±0.1b	1.3±0.0c	1.3±0.1c

[1]Values with different letters within the same row are significantly different at P<0.05 level

Table 6
Color parameters of Telli cheese during storage[1] (n=3)

	Days of storage			
	1	30	60	90
L	79.6±0.0a	81.9±1.2b	81.9±0.8b	82.8±0.8b
a	4.4±0.0a	5.0±0.3c	4.7±0.0b	4.6±0.0ab
b	48.0±0.0a	47.8±1.1a	49.9±0.5b	50.4±0.2b

[1]Values with different letters within the same row are significantly different at P<0.05 level

Sensory properties

Sensory evaluation scores of cheese samples during 90 days of storage are given in Table 7. The results showed that the first day fresh cheeses received the highest scores except texture score while the same cheeses had the lowest texture and flavor scores after 60 days. The panelists considered the appearances and color of the Telli cheese acceptable. However the appearance scores of the cheeses were significantly ($P<0.05$) declined after 60 day but the difference in color scores was not significant during storage ($P>0.05$). Moreover, overall score of Telli cheese mainly affected by the fluctuation in flavor scores. Therefore, it can be said that long-term cold (4°C) storage period appears to decrease sensorial quality of Telli cheese especially after 60th day.

Table 7
Sensory evaluation scores of Telli cheese during storage[1] (n=3)

	Days of storage			
	1	30	60	90
Color	9.8±0.7	9.7±0.6	10.0±0.0	9.2±0.5
Appearance	28.8±1.4b	28.2±0.3b	26.7±1.4a	26.3±0.3a
Texture	18.4±0.0a	19.7±0.3b	17.8±0.7a	18.1±0.4a
Flavor	37.6±2.8d	31.9±1.0c	21.2±2.6b	25.7±2.6c
Overall	94.6±3.5c	89.4±1.1b	75.6±3.4a	79.4±2.5b

[1]Values with different letters within the same row are significantly different at $P<0.05$ level

Conclusions

The main compositional characteristics of Telli cheese were its high content of total solids and fat. The high deviations were observed for total solids, fat, salt, protein and soluble protein contents throughout storage. As indicated by the ADV, lipolysis was more intense than in other ripened cheese varieties. Organic acids and free fatty acids contents were changed possibly owing to manufacturing process, milk composition and storage time. Results showed that storage period of Telli cheese resulted in a tendency toward increased yellowness. Fresh cheeses received the highest scores from sensory panel. Cheeses had the lowest texture and flavor scores after 60 days of storage.

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