



## Effects of Scalding Parameters and Ripening on the Chemical, Textural and Microstructural Properties of Urfa Cheese

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### ABSTRACT

The objectives of this study were to determine the effect of cheese scalding temperature, scalding time, and ripening time on the chemical, textural and microstructural properties of ovine milk Urfa cheese. Dry salted fresh cheeses were scalded in whey at 70 °C, 80 °C, and 90 °C for 5 and 10 minutes and ripened for 90 days, respectively. Scalding temperature significantly affected fat in dry matter and salt in dry matter ( $P<0.05$ ), total solids and nitrogen, hardness, cohesiveness, gumminess, and chewiness ( $P<0.001$ ). Scalding time significantly affected total nitrogen and gumminess ( $P<0.05$ ), total solids, and hardness ( $P<0.001$ ).

Ripening time significantly affected chemical, textural and color properties of ovine milk Urfa cheese ( $P<0.001$ ), except fat in dry matter ( $P<0.05$ ). The color properties of Urfa cheese were not significantly affected by the scalding temperature and time ( $P>0.05$ ). Besides, scalding treatments have improved the microstructure of ovine milk Urfa cheeses. Urfa cheese exhibited a more compact, coarser, and uniform structure with increasing scalding temperature and time. As a result, scalding treatments and ripening on the chemical, textural and microstructural characteristics of Urfa cheeses were substantially effective.

Keywords: Urfa cheese; Scalding; Ripening; Microstructure; Texture

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## 1. Introduction

Textural features are an expression of the rheological properties of the physical structure of food. Cheese quality and identity are largely dependent on textural properties. Cheese texture is very important on consumer acceptability and the end-use of the cheese (Hort & Le Grys 2001; Alinovi et al. 2018). Furthermore, there is a relationship between the microstructure and rheological properties of the cheese, and both are influenced by the chemical cheese composition (El Bakry & Sheehan 2014). On the other hand, numerous reactions take place during the ripening of cheese. It is known that the texture of the cheese is extensively affected by the chemical composition of cheese, cheese production, and biochemical changes during the ripening (Tomaszewska et al. 2019).

Urfa cheese is a traditional semi-hard brined Turkish cheese variety, which is manufactured mainly in the southeast Anatolia region of Turkey from raw bovine milk or mixtures of ovine and caprine milk. However, the industrial Urfa cheese has been made from cow's milk, because of the very short lactation period of ewe's and goat's milk in Turkey. Urfa cheese is consumed fresh and/or mature. The unripened Urfa cheese is only used for the production of traditional cheese dessert products, such as "cheese helva", "cheese bread", and "kadayif" (Atasoy et al. 2013). Urfa cheese is produced without milk pasteurization and starter bacteria, and cheese microflora consists of indigenous microorganisms obtained from raw milk or transmitted from the environment. The presence of natural microorganisms provides the cheese with unique characteristics and cheeses made from raw milk are preferred by consumers (Atasoy et al. 2008; Kırmacı 2016). The microbial safety of Urfa cheese is supplied by dry salting technology by the manual spreading of salt onto the cheese surface. Alternatively, scalding of fresh cheese blocks in boiling whey is an alternative practical way of reducing microbial counts in Urfa cheese. Although there is no standard scalding temperature and time in the traditional Urfa cheese production, general scalding temperature and time are applied as 65-90 °C and about 5-10 minutes, respectively. These methods have different effects on natural microflora and also chemical, textural, and microstructural properties during storage. Following scalding and/or dry salting, Urfa cheese is ripened in brine.

Although numerous studies on the microstructural and textural characteristics of many cheese varieties were conducted, studies on the microstructural and textural characteristics of Urfa cheese are limited (Özer et al. 2003). As far as we know, no study has been conducted on the color characteristics of Urfa cheese up to now. Moreover, any study investigated the effect of

scalding time on the properties of Urfa cheese was not encountered. The objective of this study was to investigate the effects of scalding temperature, scalding time, and ripening time on the color, chemical, textural and microstructural properties of Urfa cheese made from raw ewe milk.

## 2. Material and Methods

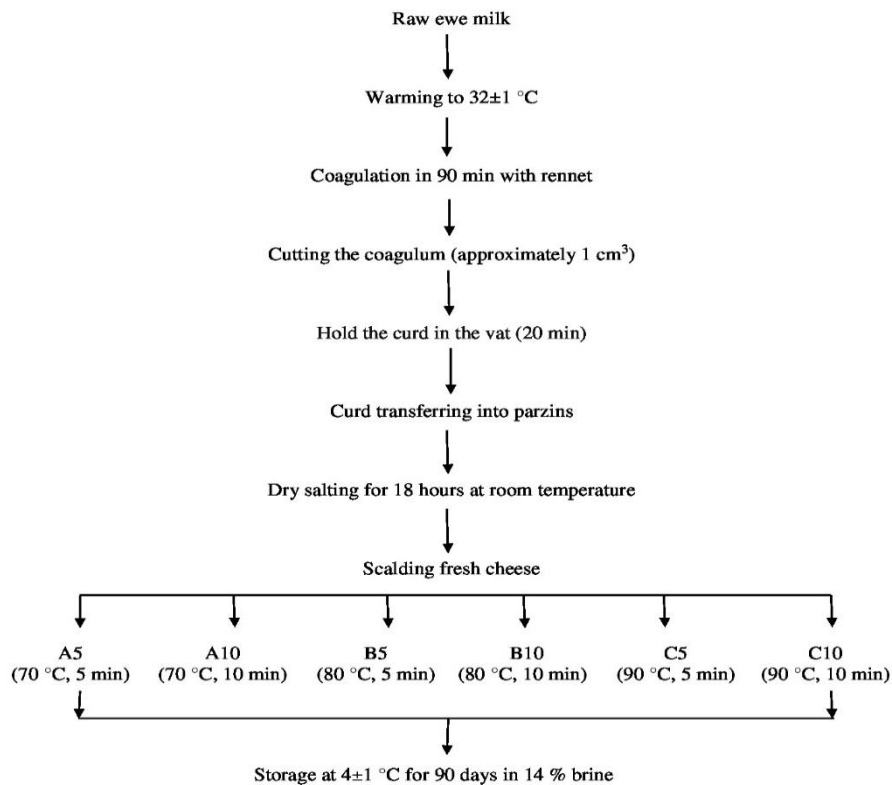
### 2.1. Materials

Ewe milk used in cheese production was obtained from Şanlıurfa province. The commercial rennet (Surer, Konya, Turkey) was used to coagulate the milk.

### 2.2. Cheesemaking and sampling

Fresh dry salted and scalded cheeses were designated as A5 (scalded at 70 °C for 5 min), A10 (scalded at 70 °C for 10 min), B5 (scalded at 80 °C for 5 min), B10 (scalded at 80 °C for 10 min), C5 (scalded at 90 °C for 5 min) and C10 (scalded at 90 °C for 10 min). Cheese production is carried out according to Atasoy et al. (2013) by the traditional method. The flow diagram of experimental Urfa cheeses is demonstrated in Figure 1. The Urfa cheese production was replicated 2 times on different days. From each batch, 1, 30, 60, and 90-day old cheese were sampled and analyzed. Each batch consisted of four cheese blocks (each block contained approximately 250 g of cheese).

**Figure 1- Flow chart of traditional Urfa cheese production**



### 2.3. Cheese analyses

The titratable acidity, total solids, and salt analyses were carried out according to Turkish Standards (1989). The IDF (1993) method for total nitrogen was used. pH was measured by pH meter (Hanna, HI 2215). The fat analysis was performed with the Gerber method according to Turkish Standards (TS 1978).

Texture profile analyses were performed using Texture Analyzer Model LF Plus (Lloyd Instruments Ltd., Hampshire, UK). Color values were determined using the Hunter Lab instrument (color Quest XE, UK). Lightness, redness, yellowness values of samples were measured according to the CIE system and the  $\Delta E$  value of samples was calculated.

Microstructures of samples were determined as described by Hayaloglu et al. (2014). Images were monitored with a scanning electron microscope (LEO, EVO 40 Model, Carl Zeiss SMT, Oberkochen, Germany) at 20 kV.

## 2.4. Statistical analyses

Results were performed by analysis of variance using the Minitab version 16 packet statistic programs. The differences between the samples were determined by Tukey's test.

## 3. Results and Discussion

### 3.1. Chemical composition

The effects of scalding parameters and ripening time on the chemical compositions of Urfa cheese are presented in Table 1 and the chemical compositions of the Urfa cheese samples during ripening are demonstrated in Table 2. Total solid contents of the samples were significantly ( $P<0.001$ ) affected by scalding temperature, scalding time, and ripening time. Also, the effects of scalding temperature ( $P<0.001$ ), scalding time ( $P<0.05$ ) on total nitrogen contents were found to be significant. Also, the total solid and total nitrogen contents of Urfa cheese were significantly increased with increasing scalding temperature and time. This is likely to be due to whey expulsion during scalding treatments. Kahyaoglu & Kaya (2003) stated that heat treatment applied to curds reduced the moisture content of Gaziantep cheese. Similar results have been reported by Tunick et al. (1993) for Mozzarella cheeses. Moreover, total solids and total nitrogen contents of Urfa cheese were significantly decreased during ripening. Changes in total solids can be attributed to the breakdown of peptide bonds and new ionic groups. These decreases may be due to the transition of the soluble nitrogen fractions into the brine during cheese storage. Further losses are referred to as hydrolysis of caseins by proteolytic enzymes to lower molecular weight compounds (Grappin & Beuvier 1997) and scattering of water-soluble nitrogen into the brine (Prasad & Alvarez 1999). Previous studies (Atasoy & Türkoğlu 2008) showed that total nitrogen and solid contents of Urfa cheese declined during storage.

While the effect of ripening time on pH and titratable acidity of Urfa cheeses were found to be significant ( $P<0.001$ ), the effects of scalding parameters were insignificant ( $P>0.05$ ). Also, titratable acidity and pH values of Urfa cheese decreased and increased ( $P<0.05$ ), respectively, until the 30<sup>th</sup> day of ripening. However, no any change was found during the rest of the storage period. These can be explained by the continued fermentation during the maturation, completed by the end of the first month. Additionally, the decrease in titratable acidity may be due to the assimilation of lactic acid and the production of ammonia (Kırmacı et al. 2014). These results are in agreement with those of Atasoy & Türkoğlu (2008) for Urfa cheese.

Fat in dry matter contents of Urfa cheese was significantly affected by scalding temperature, and ripening time ( $P<0.05$ ). In particular, the C5 sample was found to have lower fat content than others. A group of researchers (Ozer et al. 2004) have reported that scalded Urfa cheeses contained higher fat than unscalded ones. Furthermore, fat contents (as dry matter) of B10, C5, and C10 samples decreased ( $P<0.05$ ) during the first 30 days of ripening and remained almost constant after this day. Sahingil et al. (2014) reported that fat contents in dry matter of white cheeses depended on the ripening time.

**Table 1- The variance analysis results on the effect of scalding temperature, scalding time, and ripening on the chemical composition, *L*, *a*, *b*,  $\Delta E$  values, and textural properties of Urfa cheese samples (F-values of independent variables and interactions)**

	Sources of variance						
	STE	STI	R	STE x STI	STE x R	STI x R	STE x STI x R
Chemical composition							
Total solids	64.87***	54.88***	393.10***	0.06	1.17	0.11	0.57
pH	0.65	0.00	4.61***	0.07	0.19	0.11	0.22
Titratable acidity	0.66	2.22	85.59***	0.92	0.22	0.58	1.38
Total nitrogen	98.92***	7.82*	1283.12***	1.50	2.06	2.38	1.10
Fat in dry matter	5.28*	0.13	3.38*	1.01	0.94	0.59	0.36
Salt in dry matter	3.96*	0.56	785.56***	0.21	4.35**	3.53*	1.29
Texture							
Hardness	84.21***	19.29***	1219.70***	1.18	4.06***	0.43	0.31
Cohesiveness	54.58***	0.38	127.23***	1.31	8.17***	0.13	1.14
Springiness	0.71	0.55	135.67***	1.37	1.42	0.32	0.72
Gumminess	112.93***	5.43*	574.40***	1.15	25.12***	0.38	1.10
Chewiness	78.55***	4.10	548.53***	1.32	24.00***	0.45	1.09
Fracturability	0.06	0.34	29.02***	0.09	0.98	0.08	1.08
Adhesiveness	4.65*	1.34	9.78***	2.75	2.84*	3.87*	0.52
Color							
<i>L</i>	0.16	0.16	15.52***	0.53	0.26	0.12	0.42
<i>a</i>	2.75	1.99	31.09***	1.53	0.23	0.79	0.61
<i>b</i>	1.89	1.51	69.24***	1.26	1.55	0.27	1.26
$\Delta E$	0.47	0.35	6.02***	1.27	1.02	0.56	0.65

\*,  $P<0.05$  significance level; \*\*,  $P<0.01$  significance level; \*\*\*,  $P<0.001$  significance level; STE, Scalding temperature; STI, Scalding time; R, Ripening time

Salt in the dry matter contents was significantly affected by scalding temperature ( $P<0.05$ ), ripening time ( $P<0.001$ ), the interaction of the scalding temperature and ripening time ( $P<0.01$ ), and scalding time and ripening time ( $P<0.05$ ). Salt contents in the dry matter of samples increased ( $P<0.05$ ) during the ripening. In particular, the salt contents in the dry matter of the cheese samples increased until the 60<sup>th</sup> day of ripening then almost unchanged (except for the A5 sample). The changes in salt contents of Urfa cheeses were similar in previous studies (Atasoy et al. 2008). When cheese is placed in brine, salt molecules transfer from the brine into the cheese as a result of the osmotic pressure difference between the cheese and the brine. Until the osmotic balance between cheese and brine is reached, salt molecules diffusion continues. Thus, salt diffusion was faster into the cheese from brine at the beginning of the ripening.

**Table 2- The chemical composition of Urfa cheese samples during the ripening**

Cheese samples	Ripening Time (days)				
	1	30	60	90	
Total solids (g 100 g <sup>-1</sup> )	A5	58.73±0.03 <sup>Ad</sup>	56.80±0.64 <sup>ABb</sup>	54.92±0.26 <sup>Bc</sup>	52.92±0.44 <sup>Ca</sup>
	A10	59.61±0.15 <sup>Ac</sup>	58.03±0.28 <sup>ABab</sup>	55.22±0.06 <sup>Bbc</sup>	53.56±0.76 <sup>Ba</sup>
	B5	60.71±0.09 <sup>Ab</sup>	58.09±0.29 <sup>ABab</sup>	55.86±0.60 <sup>BCabc</sup>	53.88±0.77 <sup>Ca</sup>
	B10	61.49±0.19 <sup>Aab</sup>	58.63±0.28 <sup>Bab</sup>	56.74±0.01 <sup>Cabc</sup>	54.29±0.02 <sup>Da</sup>
	C5	61.57±0.26 <sup>Aab</sup>	58.68±0.31 <sup>Bab</sup>	56.43±0.03 <sup>Cab</sup>	54.61±0.31 <sup>Da</sup>
	C10	61.85±0.05 <sup>Aa</sup>	59.41±0.01 <sup>Ba</sup>	57.42±0.29 <sup>Ca</sup>	55.47±0.08 <sup>Da</sup>
pH	A5	5.25±0.00 <sup>Ba</sup>	5.42±0.03 <sup>Aa</sup>	5.43±0.22 <sup>Aa</sup>	5.47±0.01 <sup>Aa</sup>
	A10	5.26±0.10 <sup>Ba</sup>	5.32±0.07 <sup>Aba</sup>	5.46±0.12 <sup>Aa</sup>	5.49±0.09 <sup>Aa</sup>
	B5	5.21±0.11 <sup>Ba</sup>	5.44±0.01 <sup>Aa</sup>	5.42±0.14 <sup>Aa</sup>	5.52±0.04 <sup>Aa</sup>
	B10	5.23±0.07 <sup>Ba</sup>	5.34±0.15 <sup>ABa</sup>	5.40±0.01 <sup>Aa</sup>	5.58±0.16 <sup>Aa</sup>
	C5	5.15±0.12 <sup>Ba</sup>	5.31±0.09 <sup>ABa</sup>	5.42±0.16 <sup>Aa</sup>	5.40±0.18 <sup>Aa</sup>
	C10	5.24±0.00 <sup>Aa</sup>	5.42±0.20 <sup>Aa</sup>	5.35±0.18 <sup>Aa</sup>	5.38±0.18 <sup>Aa</sup>
Titratable acidity (g 100 g <sup>-1</sup> la)	A5	0.20±0.01 <sup>Aa</sup>	0.10±0.01 <sup>Ba</sup>	0.09±0.01 <sup>Ba</sup>	0.09±0.01 <sup>Ba</sup>
	A10	0.21±0.02 <sup>Aa</sup>	0.09±0.00 <sup>Ba</sup>	0.11±0.01 <sup>ABa</sup>	0.08±0.01 <sup>Ba</sup>
	B5	0.20±0.01 <sup>Aa</sup>	0.07±0.01 <sup>Ba</sup>	0.11±0.02 <sup>ABa</sup>	0.08±0.01 <sup>ABa</sup>
	B10	0.21±0.02 <sup>Aa</sup>	0.08±0.01 <sup>Ba</sup>	0.08±0.01 <sup>Ba</sup>	0.06±0.01 <sup>Ba</sup>
	C5	0.21±0.01 <sup>Aa</sup>	0.12±0.02 <sup>ABa</sup>	0.08±0.01 <sup>Ba</sup>	0.07±0.01 <sup>Ba</sup>
	C10	0.19±0.01 <sup>Aa</sup>	0.05±0.01 <sup>Ba</sup>	0.09±0.02 <sup>Ba</sup>	0.06±0.01 <sup>Ba</sup>
Total nitrogen (g 100 g <sup>-1</sup> )	A5	22.81±0.19 <sup>AcD</sup>	19.51±0.48 <sup>Bb</sup>	17.24±0.24 <sup>Cb</sup>	15.75±0.02 <sup>Cc</sup>
	A10	22.61±0.15 <sup>AcD</sup>	19.98±0.01 <sup>Ba</sup>	17.98±0.01 <sup>Cab</sup>	16.31±0.01 <sup>Dbc</sup>
	B5	23.20±0.07 <sup>Abc</sup>	20.21±0.03 <sup>Bab</sup>	18.18±0.31 <sup>Cab</sup>	16.88±0.17 <sup>Dbc</sup>
	B10	23.42±0.02 <sup>Abc</sup>	20.12±0.34 <sup>Bab</sup>	18.28±0.00 <sup>Cab</sup>	16.95±0.02 <sup>Db</sup>
	C5	24.29±0.18 <sup>Aa</sup>	20.69±0.06 <sup>Bab</sup>	18.36±0.39 <sup>Cab</sup>	17.76±0.14 <sup>Ca</sup>
	C10	23.97±0.12 <sup>Aba</sup>	20.96±0.12 <sup>Ba</sup>	18.96±0.04 <sup>Ca</sup>	18.01±0.24 <sup>Da</sup>
Fat in dry matter (g 100 g <sup>-1</sup> )	A5	45.44±0.40 <sup>Aa</sup>	45.51±0.56 <sup>Aa</sup>	46.09±0.12 <sup>Aa</sup>	45.81±0.33 <sup>Aa</sup>
	A10	45.18±0.42 <sup>Aa</sup>	45.02±0.21 <sup>Aa</sup>	45.67±0.33 <sup>Aa</sup>	45.97±0.28 <sup>Aa</sup>
	B5	45.86±0.02 <sup>Aa</sup>	45.13±0.39 <sup>Aa</sup>	45.48±0.55 <sup>Aa</sup>	45.39±0.56 <sup>Aa</sup>
	B10	45.48±0.19 <sup>Aa</sup>	44.76±0.21 <sup>Ba</sup>	45.27±0.56 <sup>Aa</sup>	45.71±0.14 <sup>Aa</sup>
	C5	44.99±0.08 <sup>Ab</sup>	44.46±0.40 <sup>Bb</sup>	45.07±0.57 <sup>Aa</sup>	44.91±0.37 <sup>Ab</sup>
	C10	45.87±0.26 <sup>Aa</sup>	44.50±0.32 <sup>Bb</sup>	45.01±0.06 <sup>Aa</sup>	45.06±0.60 <sup>Aa</sup>
Salt in dry matter (g 100 g <sup>-1</sup> )	A5	14.63±0.06 <sup>Da</sup>	18.75±0.20 <sup>Ca</sup>	21.38±0.57 <sup>Ba</sup>	23.48±0.16 <sup>Aa</sup>
	A10	15.66±0.54 <sup>Ca</sup>	19.29±0.15 <sup>Ba</sup>	20.99±0.59 <sup>ABa</sup>	22.55±0.11 <sup>Aab</sup>
	B5	14.94±0.24 <sup>Ca</sup>	19.48±0.37 <sup>Ba</sup>	21.49±0.19 <sup>Aa</sup>	22.39±0.06 <sup>Ab</sup>
	B10	14.94±0.28 <sup>Ca</sup>	20.30±0.44 <sup>Ba</sup>	21.71±0.25 <sup>ABa</sup>	22.15±0.21 <sup>Ab</sup>
	C5	14.44±0.27 <sup>Ca</sup>	19.33±0.31 <sup>Ba</sup>	21.50±0.16 <sup>Aa</sup>	21.85±0.27 <sup>Ab</sup>
	C10	14.51±0.07 <sup>Ca</sup>	19.63±0.03 <sup>Ba</sup>	21.27±0.23 <sup>Aa</sup>	21.76±0.01 <sup>Ab</sup>

<sup>A-D</sup> Means in each row with different uppercase letters were significantly affected by storage periods ( $P<0.05$ ). <sup>a-d</sup> Means with different lowercase letters were significantly different among cheese samples within the column of the similar ripening period ( $P<0.05$ ). A5 (scalded at 70 °C for 5 min), A10 (scalded at 70 °C for 10 min), B5 (scalded at 80 °C for 5 min), B10 (scalded at 80 °C for 10 min), C5 (scalded at 90 °C for 5 min) and C10 (scalded at 90 °C for 10 min).

### 3.2. Textural properties of Urfa cheeses

The effects of scalding parameters and ripening time on the textural properties of Urfa cheese are shown in Table 1. Also, textural properties of Urfa cheese samples during the ripening period are given in Table 3. The hardness values of Urfa cheese were significantly influenced ( $P<0.001$ ) by scalding temperature, scalding time, ripening time, and interaction of scalding temperature and ripening time. Also, the hardness of Urfa cheese was significantly increased with increasing scalding temperature and time. This is likely to be due to an increase in the protein concentration per unit area in the cheese matrix during scalding treatments. Tunick et al. (1993) reported that the hardness of Mozzarella cheese was influenced by curd scalding temperature. Similar results were determined in Gaziantep cheese (Kahyaoglu & Kaya 2003). Besides, the hardness of Urfa cheese samples significantly decreased ( $P<0.05$ ) during storage, and mature Urfa cheese was found less hard than fresh cheese. Reduction in hardness during storage may be due to proteolysis of the casein network. There is a positive correlation between the hardness of cheese and the quantity of intact  $\alpha_{s1}$ -casein (Lawrence et al. 1987). The products of proteolysis are generally water-soluble and cannot contribute

to the protein network (Lawrence et al. 1987). The decreases in cheese during the ripening period were also observed by some researchers (Sahan et al. 2008). Reduction in the hardness of cheeses was not surprising considering the decreased total nitrogen and total solid contents (Table 2) during the ripening.

**Table 3- The change of textural properties of Urfa cheese samples during the ripening**

Cheese samples	Ripening Time (days)				
	1	30	60	90	
Hardness	A5	28.66±0.54 <sup>AcD</sup>	20.02±0.96 <sup>Bcd</sup>	10.25±0.73 <sup>Cb</sup>	6.22±0.39 <sup>Db</sup>
	A10	31.63±1.31 <sup>Abc</sup>	22.44±0.37 <sup>Bbcd</sup>	12.77±0.04 <sup>Cab</sup>	6.81±0.50 <sup>Dab</sup>
	B5	32.71±1.26 <sup>Aabcd</sup>	24.13±0.68 <sup>Babc</sup>	14.39±0.75 <sup>Cabc</sup>	6.98±0.84 <sup>Dab</sup>
	B10	33.48±1.10 <sup>Aabc</sup>	25.63±0.85 <sup>Bab</sup>	15.70±1.13 <sup>Ca</sup>	8.09±0.55 <sup>Dab</sup>
	C5	36.97±1.03 <sup>Aab</sup>	26.16±0.82 <sup>Bab</sup>	16.01±0.78 <sup>Ca</sup>	8.91±0.49 <sup>Dab</sup>
	C10	38.48±1.00 <sup>Aa</sup>	27.08±0.16 <sup>Ba</sup>	16.81±0.61 <sup>Ca</sup>	9.62±0.57 <sup>Da</sup>
Cohesiveness	A5	0.16±0.01 <sup>Ab</sup>	0.14±0.01 <sup>Aa</sup>	0.13±0.01 <sup>ABa</sup>	0.08±0.00 <sup>Bb</sup>
	A10	0.16±0.01 <sup>Ab</sup>	0.14±0.01 <sup>ABa</sup>	0.14±0.01 <sup>ABa</sup>	0.11±0.01 <sup>Bab</sup>
	B5	0.26±0.01 <sup>Aa</sup>	0.18±0.01 <sup>Ba</sup>	0.17±0.01 <sup>BCa</sup>	0.11±0.01 <sup>Cab</sup>
	B10	0.24±0.01 <sup>Aa</sup>	0.19±0.01 <sup>ABa</sup>	0.16±0.01 <sup>BCa</sup>	0.11±0.01 <sup>Cab</sup>
	C5	0.26±0.01 <sup>Aa</sup>	0.19±0.01 <sup>Ba</sup>	0.16±0.01 <sup>Ba</sup>	0.12±0.01 <sup>Ba</sup>
	C10	0.28±0.01 <sup>Aa</sup>	0.21±0.01 <sup>ABa</sup>	0.16±0.01 <sup>BCa</sup>	0.11±0.01 <sup>Cab</sup>
Springiness	A5	0.48±0.01 <sup>Aa</sup>	0.29±0.01 <sup>Ba</sup>	0.32±0.01 <sup>BCa</sup>	0.35±0.01 <sup>Ca</sup>
	A10	0.45±0.01 <sup>Aa</sup>	0.30±0.01 <sup>Ba</sup>	0.31±0.01 <sup>Ba</sup>	0.34±0.01 <sup>Ba</sup>
	B5	0.44±0.01 <sup>Aa</sup>	0.31±0.01 <sup>Ba</sup>	0.31±0.01 <sup>Ba</sup>	0.33±0.01 <sup>Ba</sup>
	B10	0.46±0.02 <sup>Aa</sup>	0.31±0.01 <sup>Ba</sup>	0.31±0.01 <sup>Ba</sup>	0.36±0.02 <sup>Aa</sup>
	C5	0.46±0.01 <sup>Aa</sup>	0.34±0.01 <sup>Ba</sup>	0.29±0.02 <sup>Ba</sup>	0.33±0.01 <sup>Ba</sup>
	C10	0.48±0.01 <sup>Aa</sup>	0.33±0.01 <sup>Ba</sup>	0.32±0.01 <sup>Ba</sup>	0.35±0.02 <sup>Ba</sup>
Gumminess	A5	4.79±0.42 <sup>Ac</sup>	2.89±0.05 <sup>Bb</sup>	1.33±0.07 <sup>Cb</sup>	0.56±0.03 <sup>Cb</sup>
	A10	5.25±0.53 <sup>Ac</sup>	3.19±0.19 <sup>Bb</sup>	1.88±0.09 <sup>BCab</sup>	0.76±0.03 <sup>Cab</sup>
	B5	8.71±0.05 <sup>Aba</sup>	4.37±0.25 <sup>Bab</sup>	2.51±0.00 <sup>Ca</sup>	0.79±0.13 <sup>Dab</sup>
	B10	8.16±0.56 <sup>Ab</sup>	4.88±0.59 <sup>Bab</sup>	2.57±0.34 <sup>BCa</sup>	0.89±0.11 <sup>Cab</sup>
	C5	9.83±0.23 <sup>Aab</sup>	5.11±0.59 <sup>Bab</sup>	2.58±0.04 <sup>Ca</sup>	1.15±0.01 <sup>Ca</sup>
	C10	11.06±0.56 <sup>Aa</sup>	5.66±0.43 <sup>Ba</sup>	2.82±0.21 <sup>Ca</sup>	1.09±0.06 <sup>Ca</sup>
Chewiness	A5	2.33±0.15 <sup>Ac</sup>	0.85±0.01 <sup>Bb</sup>	0.42±0.01 <sup>BCb</sup>	0.19±0.02 <sup>Ca</sup>
	A10	2.41±0.25 <sup>Ac</sup>	0.97±0.08 <sup>Bb</sup>	0.58±0.01 <sup>Bab</sup>	0.26±0.02 <sup>Ba</sup>
	B5	3.87±0.07 <sup>Aabc</sup>	1.38±0.02 <sup>Bab</sup>	0.79±0.04 <sup>Cab</sup>	0.27±0.05 <sup>Da</sup>
	B10	3.76±0.47 <sup>Abc</sup>	1.50±0.08 <sup>Bab</sup>	0.80±0.14 <sup>Bab</sup>	0.32±0.05 <sup>Ba</sup>
	C5	4.55±0.03 <sup>Aab</sup>	1.76±0.23 <sup>Ba</sup>	0.75±0.07 <sup>Cab</sup>	0.38±0.01 <sup>Ca</sup>
	C10	5.33±0.37 <sup>Aa</sup>	1.90±0.19 <sup>Ba</sup>	0.91±0.01 <sup>BCa</sup>	0.38±0.01 <sup>Ca</sup>
Fracturability	A5	0.91±0.08 <sup>Aa</sup>	0.82±0.01 <sup>Aa</sup>	0.71±0.03 <sup>Aa</sup>	0.62±0.04 <sup>Aa</sup>
	A10	0.85±0.08 <sup>ABa</sup>	0.89±0.01 <sup>Aa</sup>	0.57±0.01 <sup>ACa</sup>	0.61±0.02 <sup>BCa</sup>
	B5	0.82±0.16 <sup>Aa</sup>	0.96±0.01 <sup>Aa</sup>	0.59±0.05 <sup>Aa</sup>	0.64±0.01 <sup>Aa</sup>
	B10	0.89±0.14 <sup>Aa</sup>	0.94±0.07 <sup>Aa</sup>	0.58±0.04 <sup>Aa</sup>	0.61±0.01 <sup>Aa</sup>
	C5	0.90±0.02 <sup>Aa</sup>	0.89±0.09 <sup>Aa</sup>	0.61±0.01 <sup>Aa</sup>	0.62±0.01 <sup>Aa</sup>
	C10	0.84±0.08 <sup>Aa</sup>	0.75±0.01 <sup>Aa</sup>	0.67±0.06 <sup>Aa</sup>	0.68±0.02 <sup>Aa</sup>
Adhesiveness	A5	0.09±0.01 <sup>Aa</sup>	0.04±0.01 <sup>ABa</sup>	0.01±0.01 <sup>ABa</sup>	0.03±0.02 <sup>Ba</sup>
	A10	0.08±0.01 <sup>Aab</sup>	0.09±0.01 <sup>Aa</sup>	0.06±0.01 <sup>Aa</sup>	0.04±0.03 <sup>Aa</sup>
	B5	0.10±0.01 <sup>ABa</sup>	0.07±0.01 <sup>Ba</sup>	0.04±0.01 <sup>ABa</sup>	0.02±0.01 <sup>Ba</sup>
	B10	0.06±0.01 <sup>ABabc</sup>	0.10±0.01 <sup>Aa</sup>	0.03±0.02 <sup>ABa</sup>	0.01±0.01 <sup>Ba</sup>
	C5	0.03±0.01 <sup>Abc</sup>	0.03±0.01 <sup>Aa</sup>	0.02±0.01 <sup>Aa</sup>	0.02±0.01 <sup>Aa</sup>
	C10	0.02±0.01 <sup>Ac</sup>	0.07±0.02 <sup>Aa</sup>	0.02±0.01 <sup>Aa</sup>	0.05±0.02 <sup>Aa</sup>
Stiffness	A5	87.61±1.42 <sup>Ab</sup>	29.47±0.88 <sup>Ba</sup>	28.96±0.14 <sup>Ba</sup>	26.03±2.62 <sup>Ba</sup>
	A10	96.81±4.15 <sup>Aab</sup>	30.44±1.30 <sup>Ba</sup>	30.48±0.25 <sup>Ba</sup>	26.34±2.52 <sup>Ba</sup>
	B5	93.03±5.46 <sup>Aab</sup>	30.14±0.89 <sup>Ba</sup>	28.43±1.27 <sup>Ba</sup>	27.78±1.93 <sup>Ba</sup>
	B10	108.10±8.25 <sup>Aab</sup>	34.68±2.01 <sup>Ba</sup>	32.01±2.40 <sup>Ba</sup>	26.49±2.39 <sup>Ba</sup>
	C5	119.07±9.70 <sup>Aab</sup>	33.01±2.57 <sup>Ba</sup>	35.45±1.03 <sup>Ba</sup>	25.71±0.89 <sup>Ba</sup>
	C10	121.11±5.21 <sup>Aa</sup>	33.62±0.83 <sup>Ba</sup>	34.68±1.50 <sup>Ba</sup>	26.80±0.84 <sup>Ba</sup>

<sup>A-D</sup> Means in each row with different uppercase letters were significantly affected by storage periods ( $P<0.05$ ). <sup>a-d</sup> Means with different lowercase letters were significantly different among cheese samples within the column of the similar ripening period ( $P<0.05$ ). A5 (scalded at 70 °C for 5 min), A10 (scalded at 70 °C for 10 min), B5 (scalded at 80 °C for 5 min), B10 (scalded at 80 °C for 10 min), C5 (scalded at 90 °C for 5 min) and C10 (scalded at 90 °C for 10 min).

The effects of scalding temperature, ripening time, and interaction of scalding temperature and ripening time on cohesiveness values of cheeses were found to be effective ( $P<0.001$ ). Cohesiveness values of fresh cheeses generally increased with increasing scalding temperature. It has been expressed that scalded Urfa cheeses had a higher cohesiveness value than unscalded ones (Özer et al. 2003). Moreover, cohesiveness values slightly decreased ( $P<0.05$ ) with the ripening period. These changes of cohesiveness during the ripening are in agreement with the results of some researchers (Akalin & Karaman 2010; Eroglu et al. 2016). This may be due to proteolysis. Because proteolysis breaks the structural integrity of the protein network, leading to decreased cohesiveness (Awad et al. 2005).

Even though springiness was affected ( $P < 0.001$ ) by the ripening time, it was not affected by the scalding parameters. However, some researchers (Hayaloglu et al. 2014) reported that the scalding process is required to provide elasticity in cheese. Özer et al. (2003) observed that scalding treatment increased the springiness value of Urfa cheeses. Also, springiness values of samples decreased ( $P < 0.05$ ) until the 30 days of ripening, then remained constant (except for A5 and B10 samples). The decreases in springiness during cheese storage may be due to degradation of the protein, especially the hydrolysis of para  $\kappa$ -caseinate molecules (Awad et al. 2005), and reduction of free water. Hort & Le Grys (2001) reported that the springiness of Cheddar cheese decreased during the ripening, but also somewhat remained constant in the middle period of ripening.

The effects of ripening time, scalding temperature, the interaction of scalding temperature and ripening time ( $P < 0.001$ ), and scalding time ( $P < 0.05$ ) on the gumminess values of Urfa cheese were significantly found. This textural parameter of Urfa cheese was significantly increased with increasing scalding temperature. The variation in the aforementioned textural characteristic during the scalding was due largely to the variations in the scores for hardness. Similar results were also obtained from Kahyaoglu et al. (2005) for Gaziantep cheese which is scalded and ripened in brine like Urfa cheese. Moreover, gumminess values of Urfa cheese statistically declined ( $P < 0.05$ ) during cheese ripening. Increasing the level of NaCl during cheese maturation may be decreasing in the gumminess parameter due to increased water retention in the cheese. Eroglu et al. (2016) reported that the gumminess value of Kashar cheese was influenced by ripening time. Gumminess is the product of hardness and cohesiveness (Famenin et al. 2019). For this reason, the variables affecting cohesiveness and hardness also affect values of the gumminess during the ripening.

Chewiness values of Urfa cheese were influenced by the ripening time, scalding temperature, interaction of scalding temperature, and ripening time ( $P < 0.001$ ). As the scalding temperature increased, chewiness values of Urfa cheeses were generally increased. Furthermore, a decrease in chewiness values of cheeses was observed during the first 60 days of ripening ( $P < 0.05$ ). The chewiness is one of the secondary textural parameters of the cheeses and it is calculated by the hardness, cohesiveness, and springiness of the product (Famenin et al. 2019). Thus, changes in chewiness values may be associated with the variations of the hardness, cohesiveness, and springiness values during the ripening.

Fracturability was only influenced by ripening time ( $P < 0.001$ ). Nuñez et al. (1991) reported that fracturability value of ewe's milk Manchego cheese was affected by ripening time. Only fracturability value of A10 sample showed a fluctuation during the ripening ( $P < 0.05$ ). The higher fracturability value means the lower fracturability of the product (Aminifar et al. 2010). The fracturability value of the A10 sample decreased from the 30<sup>th</sup> day of maturation, which means that the A10 sample was more fragile during the maturation. This may be related to pore formation during maturation (Aminifar & Emam-Djomeh 2014). These findings are in good agreement with previous studies for different brined cheese (Aminifar & Emam-Djomeh 2014).

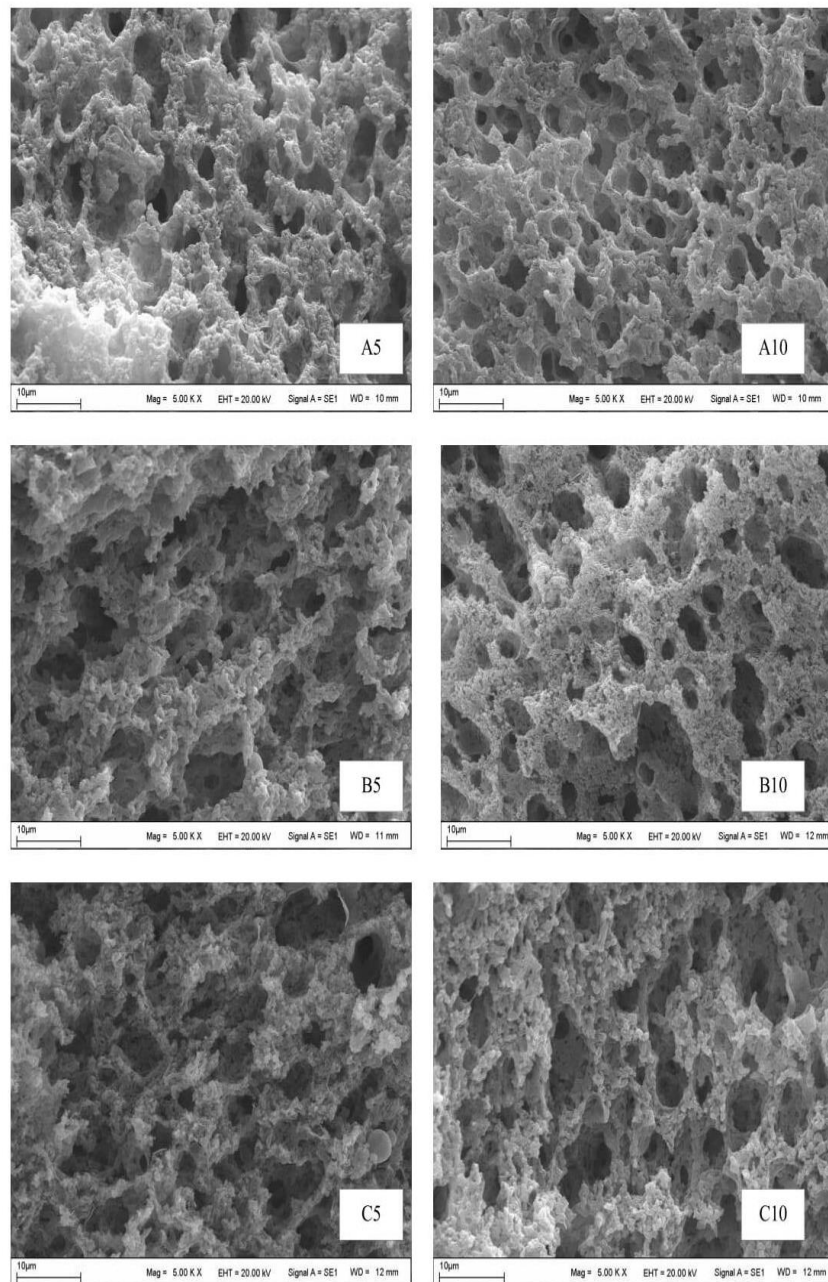
Ripening time ( $P < 0.001$ ), scalding temperature, interactions of scalding temperature and ripening time, and scalding time and ripening time ( $P < 0.05$ ) on the adhesiveness of samples were found effective. Adhesiveness value of only A5 cheese significantly reduced ( $P < 0.05$ ) during the ripening. Sahingil et al. (2014) pointed out that the adhesiveness values of white cheeses slightly decreased during maturation, but these declines were not significant. Also, the increase in scalding temperature caused a decrease in the adhesiveness values of 1-day old cheeses. It is known that the adhesiveness value is closely related to the fat and total solid content of the cheese (Motevalizadeh et al. 2018). This change in adhesiveness was following the changes in the total solid (Table 2) and fat (data not shown) during the ripening period.

Stiffness values, in other words, firmness, were influenced by the ripening time, scalding temperature, interaction of scalding temperature and ripening time ( $P < 0.001$ ), and scalding time ( $P < 0.05$ ). Although stiffness values of samples decreased ( $P < 0.05$ ) until the 30<sup>th</sup> day of ripening, they did not change during the rest of the maturation period. The decreases in springiness during the first month of storage may be due to increased moisture content and pH and breakdown of proteins (Table 2). It is known that the firmness of fresh cheeses decreases after the ripening due to biochemical and physical changes (Aminifar et al. 2010). Furthermore, there is a close relationship between the firmness of cheese and intact  $\alpha_{s1}$ -casein. This reduction of stiffness was not surprising due to proteolysis (Lawrence et al. 1987). Also, stiffness values of Urfa cheeses increased with the scalding treatment. This is likely to be due to whey removal and increasing total solid content of Urfa cheese. Additionally, the curd shrinks in size and becomes firmer during the scalding process. Especially, the stiffness value of fresh C10 samples was found higher than fresh A5 sample.

### 3.3. Microstructures of Urfa cheeses

Scanning electron micrographs of samples are presented in Figure 2. The microstructures of cheeses were evaluated before the ripening process. It was observed that scalding treatment was affected microstructures of Urfa cheeses. Scalding treatment resulted in a coarser and more uniform microstructure in Urfa cheeses. It has been stated that the scalding process gives a more compact structure in Malatya cheese (Hayaloglu et al. 2010). Özer et al. (2003) also reported that the scalding provided a more homogeneous microstructure in Urfa cheeses. Especially, it has been found that the cheeses have a more compact structure with increasing scalding time. Scalded cheeses for 10 minutes were characterized by a compact protein network, with small pores. The relationship between cheese microstructure and rheology is known (Buffa et al. 2001). These changes in the microstructure can be associated with textural changes. Thus, it has been determined that some of the textural properties of the Urfa cheeses are

changed by scalding (Table 1). Akalın & Karaman (2010) pointed out that the compactness of the protein network demonstrates the structural development of the cheese responsible for the increased hardness value.



**Figure 2- Scanning electron micrographs of Urfa cheese samples. Magnification is 5,000x**

#### 3.4. Color values of Urfa cheeses

The effects of scalding parameters and ripening time on  $L$ ,  $a$ ,  $b$ , and  $\Delta E$  values of samples are depicted in Table 1. The changes in  $L$ ,  $a$ ,  $b$  and  $\Delta E$  values of the Urfa cheeses during the maturation are shown in Table 4. The color properties of Urfa cheeses were only influenced by ripening time ( $P < 0.001$ ). It was reported that the effect of ripening time on color values of cheeses was found significant by some researchers (Buffa et al. 2001). The  $L$ ,  $b$ ,  $a$ , and  $\Delta E$  values of cheeses did not show a definite trend throughout the ripening. The change in  $L$  value of the only B10 sample was found to significant during ripening ( $P < 0.05$ ). On the other hand,  $a$  values of cheeses (except for A5 and B10) were observed fluctuating ( $P < 0.05$ ) during the maturation. 90-day old cheese generally exhibited higher  $a$  value than fresh cheeses.  $b$  values were changed ( $P < 0.05$ ) from 1<sup>st</sup> day of the ripening period and they showed a higher yellowness value than 90-day old cheese. Finally,  $\Delta E$  values of B10 and C5 samples were found to decline ( $P < 0.05$ ) at the end of maturation. Color changes may be attributed to microstructural changes of Urfa cheeses. The scattering of light is connected to its heterogeneousness at the microstructural and molecular levels. In a firm material such as cheese, light diffuses the superficial layers and penetrates largely at the interfaces of the fat globule and the edges of whey pockets (Madadlou et al. 2006).



**Table 4- The changes in *L*, *a*, *b*, and  $\Delta E$  values of Urfa cheese samples during the ripening**

Cheese samples	Ripening Time (days)				
	1	30	60	90	
<i>L</i>	A5	82.52±0.01 <sup>Aa</sup>	80.32±1.67 <sup>Aa</sup>	82.67±0.51 <sup>Aa</sup>	83.10±1.99 <sup>Aa</sup>
	A10	85.27±1.75 <sup>Aa</sup>	82.10±0.01 <sup>Aa</sup>	82.49±0.40 <sup>Aa</sup>	82.55±0.12 <sup>Aa</sup>
	B5	84.79±2.47 <sup>Aa</sup>	81.40±1.12 <sup>Aa</sup>	82.63±0.84 <sup>Aa</sup>	80.68±1.05 <sup>Aa</sup>
	B10	86.09±1.09 <sup>Aa</sup>	81.43±0.53 <sup>Ba</sup>	82.90±0.58 <sup>ABa</sup>	82.53±0.03 <sup>ABa</sup>
	C5	85.87±1.80 <sup>Aa</sup>	82.10±2.08 <sup>Aa</sup>	82.47±0.46 <sup>Aa</sup>	81.87±0.30 <sup>Aa</sup>
	C10	85.37±0.24 <sup>Aa</sup>	81.66±1.44 <sup>Aa</sup>	82.32±0.44 <sup>Aa</sup>	81.94±0.38 <sup>Aa</sup>
<i>a</i>	A5	-1.41±0.07 <sup>Aa</sup>	-1.50±0.05 <sup>Aa</sup>	-1.50±0.04 <sup>Ab</sup>	-1.33±0.13 <sup>Aa</sup>
	A10	-1.38±0.06 <sup>Aa</sup>	-1.53±0.01 <sup>Ba</sup>	-1.46±0.03 <sup>Ba</sup>	-1.11±0.02 <sup>Ba</sup>
	B5	-1.36±0.07 <sup>ABa</sup>	-1.50±0.03 <sup>Ba</sup>	-1.44±0.03 <sup>ABa</sup>	-1.22±0.02 <sup>Aa</sup>
	B10	-1.33±0.12 <sup>Aa</sup>	-1.45±0.03 <sup>Aa</sup>	-1.37±0.02 <sup>Aa</sup>	-1.16±0.05 <sup>Aa</sup>
	C5	-1.30±0.01 <sup>ABa</sup>	-1.48±0.04 <sup>Ba</sup>	-1.38±0.07 <sup>ABa</sup>	-1.17±0.03 <sup>ABa</sup>
	C10	-1.36±0.04 <sup>ABa</sup>	-1.50±0.01 <sup>Ba</sup>	-1.36±0.02 <sup>Ba</sup>	-1.19±0.02 <sup>Aa</sup>
<i>b</i>	A5	16.17±0.36 <sup>Aa</sup>	13.12±0.91 <sup>ABa</sup>	12.77±0.37 <sup>Ba</sup>	13.82±0.21 <sup>ABa</sup>
	A10	15.75±0.09 <sup>Aa</sup>	13.41±0.34 <sup>Ba</sup>	13.32±0.12 <sup>Ba</sup>	13.09±0.07 <sup>Bab</sup>
	B5	16.23±0.31 <sup>Aa</sup>	13.95±0.42 <sup>Ba</sup>	13.56±0.06 <sup>Ba</sup>	12.71±0.11 <sup>Bb</sup>
	B10	15.53±0.90 <sup>Aa</sup>	13.64±0.08 <sup>ABa</sup>	12.51±0.05 <sup>ABa</sup>	12.91±0.35 <sup>Bab</sup>
	C5	15.60±0.51 <sup>Aa</sup>	12.62±0.53 <sup>Ba</sup>	12.56±0.34 <sup>Ba</sup>	13.11±0.16 <sup>Bab</sup>
	C10	16.05±0.36 <sup>Aa</sup>	12.35±0.85 <sup>Ba</sup>	13.39±0.04 <sup>ABa</sup>	12.81±0.09 <sup>Bab</sup>
$\Delta E$	A5	88.05±0.06 <sup>Aa</sup>	81.40±1.80 <sup>Aa</sup>	83.66±0.45 <sup>Aa</sup>	84.25±2.00 <sup>Aa</sup>
	A10	86.71±1.75 <sup>Aa</sup>	69.71±13.42 <sup>Aa</sup>	83.57±0.37 <sup>Aa</sup>	83.72±0.13 <sup>Aa</sup>
	B5	86.35±2.36 <sup>Aa</sup>	82.61±1.04 <sup>Aa</sup>	83.75±0.81 <sup>Aa</sup>	81.81±0.94 <sup>Aa</sup>
	B10	87.49±0.91 <sup>Aa</sup>	82.47±0.42 <sup>Ba</sup>	83.93±0.65 <sup>Ba</sup>	83.54±0.09 <sup>Ba</sup>
	C5	87.29±1.67 <sup>Aa</sup>	80.66±0.08 <sup>Ba</sup>	83.33±0.41 <sup>ABa</sup>	82.17±1.06 <sup>ABa</sup>
	C10	86.91±0.14 <sup>Aa</sup>	82.61±1.55 <sup>Aa</sup>	83.42±0.45 <sup>Aa</sup>	82.95±0.39 <sup>Aa</sup>

<sup>A-D</sup> Means in each row with different uppercase letters were significantly affected by storage periods ( $P < 0.05$ ). <sup>a-d</sup> Means with different lowercase letters were significantly different among cheese samples within the column of the similar ripening period ( $P < 0.05$ ). A5 (scalded at 70 °C for 5 min), A10 (scalded at 70 °C for 10 min), B5 (scalded at 80 °C for 5 min), B10 (scalded at 80 °C for 10 min), C5 (scalded at 90 °C for 5 min) and C10 (scalded at 90 °C for 10 min).

#### 4. Conclusions

The results of this research showed that ripening time was effective on chemical, textural and color parameters of Urfa cheese. Scalding parameters on textural properties (except springiness and fracturability) of Urfa cheese were found to be important at the beginning of maturation. However, scalding parameters on hardness, cohesiveness, and gumminess were significant at the end of storage. Urfa cheese gained a more compact and uniform structure with the scalding parameters. Increasing scalding temperature and time positively improved the textural and microstructural properties of Urfa cheese. However, the effects of scalding temperature and time on the proteolysis, lipolysis, and volatiles compounds of Urfa cheese were not yet known. For this reason, further studies should be focused on the determination of the effect of scalding temperature and time on biochemical properties of lipolysis and proteolysis in Urfa cheese.

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