The effects of packaging materials on the fatty acid composition, organic acid content, and texture profiles of Tulum cheese

Oktay Tomar, Gökhan Akarca, Veli GÖK, and M. Yusuf Çağlar

Abstract: In this research, Erzincan Tulum cheese was packaged in its original packaging material, the skin bag, small intestine, and appendix to observe the changes in its physical, chemical, and textural properties during storage day. Lactic acid% values increased in all Tulum cheeses throughout storage stage. At the end of the storage period, the highest value was determined in the sample filled in the small intestine (20.10%). All fatty acid values were increased, and the highest increase was identified in oleic acid (C 18:1) (skin bag 2.18%), linoleic acid (18:2) (appendix 0.41%), and palmitic acid (C 16:0) (small intestine 0.34%), respectively. All organic acids increased in stored sample. The highest increase among organic acids was determined to be 4.47% in lactic acid. As a result of the Texture Profile Analyses (TPA), the hardness, and adhesiveness of Tulum cheeses increased during storage periods, whereas the springiness, cohesiveness, and chewiness values decreased. Gumminess value declined in the sample filled into the appendix (with a value of 36.01), whereas it increased in the other two samples. The highest increase in hardness values was 2,520.27 N at given storage time was in the samples filled into appendix while the highest adhesive values of −49.82 were determined in the sample filled into small intestine.

Keywords: fatty acids, packaging, skin bag, texture, Tulum cheese

Practical Application: Tulum cheese is usually produced by filling sheep or goat skin bag. Goat or sheep skin bag are not always available, and the amount of cheese produced in them is excessive. Therefore, cheeses were also filled to small intestine and appendix. At the end of the study, there were no negative effects on cheeses filled with intestine and appendix. The use of small intestine and appendix has helped to develop a product that will be appreciated by the consumers with no adverse effects in the physicochemical and textural properties of cheese.

1. INTRODUCTION

Currently, over 100 types of cheese are produced in Turkey (Tomar, Akarca, Beykaya, & Çağlar, 2018). The most-produced three cheeses are white cheese, Kasar cheese, and Tulum cheese. Tulum cheese is one of the traditional cheeses, usually made from raw sheep milk in Turkey (Tekin & Guler, 2019). Also made from goat's milk, combination of sheep's and goat's milk, or cow's milk (Gürsoy, Küçükçetin, Gökçe, Ergin, & Kocatürk, 2018). Ripening is mostly done in a plastic barrel or goat skin bag (Tekin & Guler, 2019). Tulum cheeses are produced in every region in Turkey, it exhibits regional variations depending on the raw material, production method, structure, and ripening conditions (Kirdar, Kose, Gun, Ocak, & Kursun, 2015). Erzincan, Afyon, İzmir and Konya tulum cheeses are the most popular and most consumed tulum cheese types (Çetinkaya, 2008; Yerlikaya & Akbulut, 2019).

Tulum cheese has a granular or open texture; is semihard and white or cream in color; and has a buttery taste and tangy flavor (Çakmaçı, 2011). The color of Erzincan Tulum cheese is white-cream, high fat content with a hard structure, and in buttery taste (Çakmakçı, 2011). Tulum cheese types has a longer ripening period (over 3 months). It is produced by the local people living in the highlands from raw ewe milk with no heat treatment, particularly, during May and September and ripened in particular caves. However, in recent years, the increasing demand of this cheese type has resulted in its production at the industrial level (Hayaloglu, Cakmakci, Brenchany, Deegan, & McSweeney, 2007).

In the ripening process of cheese, microorganisms, particularly yeasts in the milk and at the ripening environment contribute to the ripening production. Mostly no additional starter culture is used in cheese production, thereby, its microbial content consists of the natural or wild microbiota of raw milk (Bergamaschi & Bittane, 2018; Kazancıgil, Demirci, Öztrük-Negiş, & Akın, 2019; Öztürk & Akın, 2018). In the process starting from the filter of whey to the end of the ripening stage, the natural flora found in the cheese form the taste and aroma components that impart unique characteristics to this cheese through glycolysis (Niro et al., 2017; Ozturkoglu-Budak et al., 2016; Öztürk & Akın, 2018). Tulum cheese is traditionally filled into skin bags produced from sheepskin is now filled into various packaging materials including plastic barrels, pitchers, intestine, and artificial bags (Tomar et al., 2018).

Skin bags mostly obtained from the skins of goats or sheeps (Hayaloglu, Fox, Guven, & Cakmakci, 2007; Şengül, Türkoğlu, Çakmakçı, & Çon, 2001). The small intestine is an organ in the gastrointestinal tract of mammals (Yen & Wright, 2006). Appendix

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doi: 10.1111/1750-3841.15404

Journal of Food Science
A Publication of the Institute of Food Technologists

is a thin tube located at the junction of the small intestine and large intestine in all mammals (Malla, 2003).

This research objected to determine the changes in physical, chemical, and textural characters of the Tulum samples, filled into various packaging materials (skin bag, intestine, and appendix) during the storage period.

2. MATERIALS AND METHODS

2.1 Materials

Akkaraman ewe milks were supplied from the sheep breeders at the highlands of Erzincan. Production of cheese was produced according to Sert, Akın, and Aktümsek (2014) and Cakir and Cakmakci (2018) (Figure 1).

2.2 Fatty acid composition

The fat extraction of Tulum cheese and for the fatty-acids methyl esters (FAME) AOAC (1990) methods were used. HP 7890A (Agilent, Santa Clara, CA, USA) equipped with flame-ionization detector (FID) on a split injector was used to identify fatty acid composition of tulum samples. The capillary column (100 m × 0.25 mm, 0.2 μm) (HP88, Folsom, CA, USA) was used to separate fatty acids. The beginning of analysis oven temperature was 100 °C (5 min) and then the temperature was increased to 10 °C/min to 240 °C (10 min). The temperature of the injector and detector was 250 °C. The carrier gas (helium) flowed at rate of 30 mL/min (Pinho, Ferreira, & Ferreira, 2002).

The atherogenicity (AI) and thrombogenicity (TI) indices were calculated according to the equation used by Senso et al. (2007).

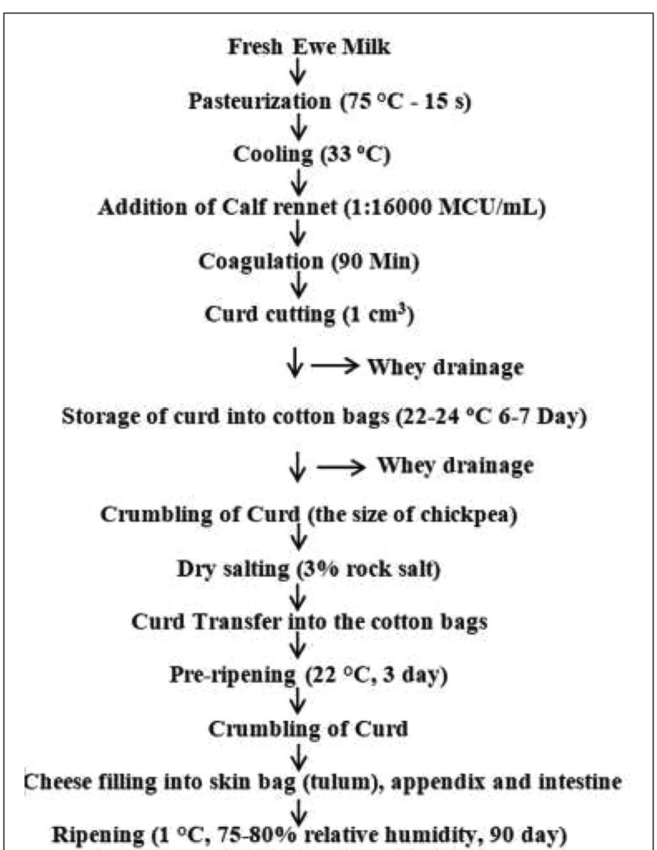

FIGURE 1–Flow diagram of Tulum cheeses production.

2.3 Organic acids

The organic acids quantification of samples were analyzed by HPLC system (Agilent 1100) according to the modified methods described by Tomar (2019). For the organic acids in the samples, 5 g of cheese sample was dissolved in 25 mL of 0.001 H_2SO_4 and centrifuged at 5,000 rpm for 10 min. The wavelength of detector was optimized at 210 nm for quantification of acetic, lactic acid, propionic acid, formic, and citric organic acids. Separation of organic acids was carried out using a column (Aminex HPX-87H; 300 × 7.8 mm; Bio-Rad Laboratories Inc., Hercules, CA, USA) at 30 °C.

The mobile phase was 0.1 N of phosphoric acid in pure deionize water (HPLC grade) with a flow rate of 0.9 mL/min. Triplicate injections (about 40 μL) were performed for all Tulum cheeses. The standard solutions of acetic, lactic acid, propionic acid, formic and citric acids (Sigma-Aldrich, St. Louis, MO, USA) were prepared in pure deionized water to determine the retention times and calibration peaks.

2.4 Titratable acidity

Titratable acidity values of the samples were measured according to the method of AOAC 947.05 (AOAC, 2012).

2.5 Texture profile analysis (TPA)

Texture analyzer was performed to determine texture profile of cheese samples. The whole study was carried out at room temperature and the load cell of the analyzer (TA-XT 2*i*, Stable Microsystems Ltd., Surrey, UK) was determined as 50 kg. All samples were cut into cubic particles of 2.5 cm. A 50 mm stainless compression probe was used to determine the texture profiles of the samples. The speed of the probe pretest and test was 1.0 and 5.0 mm/s, respectively. Samples were compressed for about 40% of their height and stand for 5 s between two compressions. Hardness (N), adhesiveness (g.s), cohesiveness, springiness, chewiness (N), and gumminess (N) of the samples were calculated according to the software of analyzer (Dantas et al., 2016).

2.6 Statistical analysis

Present research was designed according to randomized complete block design by 4 (storage times) × 3 (packaging type) factorial experiments. Two-way variance procedures were used to determine the differences ($P < 0.05$) of data throughout storage period. All statistical analyzes were performed using SPSS program (SPSS, 17.0.1). Differences between means were compared by Duncan's multiple range tests. Design was completely randomized with three replications.

3. RESULTS AND DISCUSSION

3.1 Fatty acids composition

Probability amounts of fatty acid composition for all main effects and interactions are presented in Table 1. Storage time ($P < 0.0001$) was statistically significant on the fatty acid amount of Tulum cheeses stored in different packages ($P < 0.05$) (Table 1). Butyric acid and linoleic acid were affected by packaging types ($P < 0.05$).

The highest fatty acid determined in cheeses palmitic acid (C 16:0) followed by oleic acid and myristic acid is similar to those reported by Akarca (2020) and Yilmaz, Ayar, and Akin (2005). Butyric acid amount in samples filled in skin bag was found to be 1.89% (Table 1). In other two Tulum cheeses, it was found to be 1.84% ($P > 0.05$). The highest fatty acids increasing throughout storage time was in the samples filled in the appendix with 0.03% ($P < 0.05$). Addis, Piredda, Pes M Di Salvo, Scintu, and Pirisi (2005) stated that the tangy taste and butyric acid formation depending on the storage were also affected by the type of rennet used in the production. The highest caprylic acid amount was in the sample filled in skin bag and small intestine with 2.50% throughout the storage time ($P > 0.05$). This amount was followed by those from samples filled into the appendix ($P > 0.05$). Regarding Tulum cheeses stored for 120 days, similarly the researchers (Sert et al., 2014) found that caprylic acid amounts increased during storage ($P < 0.05$).

It has been reported that butyric, caproic, caprylic, and capric acids, known as short-chain fatty acids increase, particularly during ripening periods due to their lipolytic activity, and contribute to the taste and aroma formation of cheeses (Rahmat & Richter, 1996). In this study these fatty acids increased until storage day of 60 and then decreased.

At the beginning of the study, lauric acid was determined to be 5.16%, whereas it decreased by 4.26% at storage day of 90 ($P < 0.05$). Contrary to this research, Yilmaz et al. (2005) and Sert et al. (2014) reported that lauric acid amount increased during storage. The differences were associated with the raw material, pasteurization treatment applied to the milk, production method, storage, and ripening conditions. Moreover, the soapy taste developed in the cheeses at the stage of ripening was associated with the increase in lauric acid (Georgala et al., 2005).

Oleic acid ratios inclined in all samples during storage ($P < 0.05$). Oleic acid (C18:1) was determined to be 23.11% at the beginning of storage, reached 25.21% with an increase of 2.1% at the storage day of 60 ($P < 0.05$) (Table 1). The obtained results were lower than those reported by Yilmaz et al. (2005), and higher than those reported by Sert et al. (2014). The differences were reported to be associated with intracellular esterase and lipase autolysis, while that microflora on the surface of the samples and the NaCl concentration affected the free oleic acid amounts (Madkor, Tong, & El-Soda, 1999).

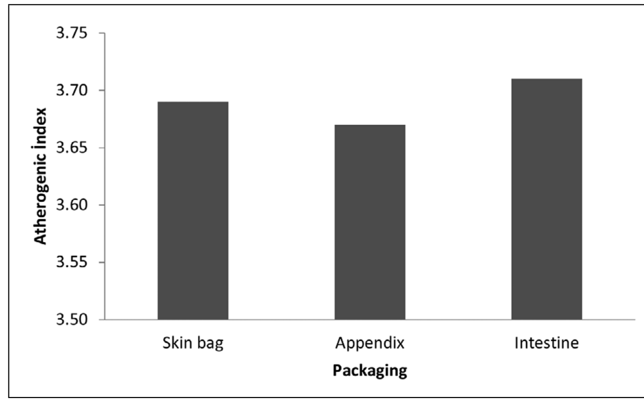

FIGURE 2–The atherogenicity (AI) indices of Tulum cheese.

Atherogenic index (AI) values of Tulum samples varied between 3.67 and 3.71 (Figure 2) and index of thrombogenicity (IT) values ranged between 4.21 and 4.24 (Figure 3). It was determined that the difference between the AI and IT values of the samples was insignificant ($P > 0.05$).

3.2 Organic acids content

Organic acids are main sensory attributes, because they have desired or undesired affect the flavor of the dairy products. These compounds are formed due to the activities of different microorganisms (Akalın, Gönç, & Akbaş, 2002). The amount of organic acids depends on the microbial activity during the ripening periods (Matera et al., 2018).

TABLE 1–Probability values and the effects of storage time, packaging and storage time × packaging interaction on fatty acid profile (%).

Source of variation	Butyric (C4.0)	Caproic (C6.0)	Caprylic (C8.0)	Capric (C10.0)	Lauric (C12.0)	Myristic (C14.0)	Palmitic (C16.0)	Stearic (C18.0)	Oleic (C18.1)	Linoleic (C18.2)
Storage time										
2	1.56^{ab}	2.11^{b}	2.57^{b}	8.44^{b}	5.16^{a}	13.18^{a}	25.17^{d}	9.96^{b}	23.11^{c}	1.96^{b}
30	1.58^{c}	1.71^{c}	2.03^{d}	6.88^{d}	4.25^{b}	12.33^{b}	26.67^{b}	10.70^{a}	23.68^{b}	2.11^{ab}
60	2.45^{a}	2.76^{a}	3.26^{a}	8.85^{a}	4.30^{b}	10.93^{d}	26.87^{a}	10.74^{a}	19.79^{d}	2.10^{ab}
90	1.82^{b}	1.80^{c}	2.12^{c}	7.43^{c}	4.26^{b}	11.99^{c}	25.50^{c}	9.87^{b}	25.21^{a}	2.23^{a}
P value	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Packaging										
Skin bag	1.84^{b}	2.07	2.50	7.89	4.45	12.08	25.97	10.34	22.91	2.16^{a}
Appendix	1.84^{b}	2.09	2.49	7.90	4.51	12.10	26.03	10.32	22.99	2.08^{b}
Intestine	1.89^{a}	2.13	2.50	7.92	4.52	12.15	26.17	10.31	22.95	2.07^{b}
P value	0.046	0.131	0.901	0.839	0.193	0.164	0.228	0.950	0.198	0.043
Storage time x Packaging										
SB × 2	1.66	2.13	2.55	8.41	5.08	13.11	25.05	10.10	22.97	2.11
AP × 2	1.51	2.10	2.58	8.59	5.20	13.27	25.30	9.83	23.20	1.90
SI × 2	1.51	2.09	2.58	8.53	5.21	13.15	25.17	9.96	23.16	1.88
SB × 30	1.53	1.65	2.00	6.87	4.22	12.36	26.29	10.65	23.72	2.15
AP × 30	1.58	1.68	2.04	6.83	4.30	12.33	26.67	10.57	23.68	2.04
SI × 30	1.63	1.80	2.04	6.95	4.22	12.31	27.04	10.88	23.65	2.14
SB × 60	2.36	2.75	3.25	8.80	4.23	10.88	26.99	10.79	19.79	2.15
AP × 60	2.49	2.79	3.24	8.81	4.28	10.85	26.82	10.79	19.86	2.09
SI × 60	2.49	2.73	3.29	8.94	4.38	11.06	26.81	10.64	19.73	2.06
SB × 90	1.86	1.73	2.19	7.48	4.27	11.95	25.55	9.80	25.15	2.22
AP × 90	1.80	1.79	2.09	7.41	4.23	12.08	25.44	9.95	25.25	2.31
SI × 90	1.81	1.88	2.08	7.40	4.28	11.95	25.51	9.87	25.22	2.16
P value	0.427	0.198	0.530	0.464	0.521	0.062	0.195	0.455	0.235	0.088

AP, appendix; SB, Skin bag SI, small intestine.
a–d Means within column for each source of variation significantly different ($P < 0.05$).

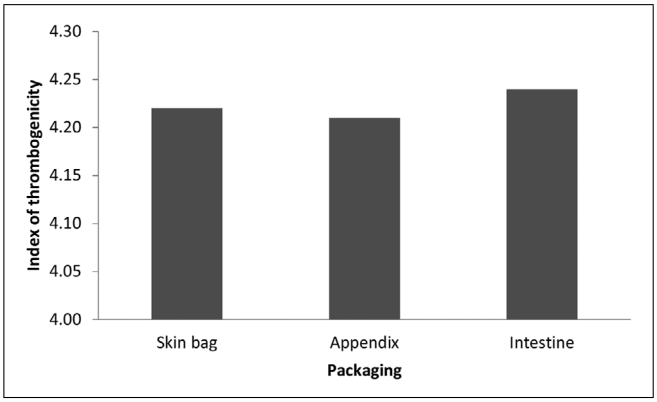

FIGURE 3–The thrombogenicity (TI)) indices of Tulum cheese.

Storage period effected the organic acid values of Tulum cheeses significantly ($P < 0.0001$). Packaging types, storage period × packaging type's interaction did not affect the organic acid values samples (Table 2). Formic acid amount increased in all cheese samples by an average amount of 1% during storage ($P < 0.05$) (Table 2). Formic acid is produced by *Lactobacillus delbrueckii* spp. *bulgaricus* by the fermentation during storage in many ripened cheese types (Courtin & Rul, 2003).

The acetic acid content increased throughout storage periods ($P < 0.05$) (Table 2) in Tulum cheeses. Acetic acid amount, which had an average amount of 2.86% at the beginning of the storage reached 5.41% at storage day of 90 ($P < 0.05$) (Table 2). The highest increase was determined in cheese samples filled into small intestine with 2.59% whereas the lowest increase was determined in the samples filled into the appendix with 2.51%. Propionic acid was produced by the lactic acid and propionic acid bacteria in cheese during storage from pyruvic acid. These bacteria, albeit low, have proteolytic activity and decompose proteins and amino acids in long-term ripening periods and contribute to the formation of desired aroma in cheeses (Langsrud & Reinbold, 1973). Propionic acid amounts of cheese samples increased by 0.77%, 0.84%, and 1.14% to be filled into small intestine, appendix, and skin bag, respectively ($P < 0.05$) (Table 2).

Lactic acid bacteria use citrate as a fermentation substrate and derived to pyruvic acid, carbon dioxide, and acetic acid (Bouzas, Kantt, Bodyfelt, & Torres, 1993). Citric acid values increased in all samples throughout storage periods ($P < 0.05$) (Table 2). The lowest citric acid content at the storage day of 2 was measured in the Tulum cheese filled into the small intestine with 1.41%, whereas the highest citric acid amount at the storage day of 90 was measured in Tulum cheese filled into a skin bag with 2.56%. Lactic acid is a final product of the bacterial fermentation and obtained through the metabolizing of lactose.

Lactic acid, including product development and preservation, is necessary for the formation of taste and flavor. During storage, the amount of lactic acid was the highest increase by 4.47% ($P < 0.05$) (Table 2). The highest incline was measured in the samples filled in to appendix with 4.07%, which was followed by the samples filled into the skin bag with 4.55%, and the samples filled into small intestine with 4.78%.

3.3 Titratable acidity

In the ripened cheeses, lactic acid increased over time depending on the activity of the fermentative bacteria (Sert et al., 2014). The titratable acidity in terms of lactic acid % increased in all cheese samples throughout storage ($P < 0.05$). It was determined that, at the end of the storage, titratable acidity in terms of lactic acid varied between 1.12 and 1.20% and the highest values were obtained in the sample filled into appendix (Table 2). Çakır and Çakmakçı (2018) and Tekin and Güler (2019) similar to our study, determined that the titratable acid content increased during storage.

TABLE 2–Probability values and the effects of storage time, packaging, and storage time × packaging interaction on titratable acidity (%) and organic acid content (%).

Source of variation	Acidity	Formic	Acetic	Propionic	Citric	Lactic
Storage time						
2	0.85^{c}	0.37^{a}	2.86^{c}	2.31^{c}	1.41^{c}	15.31^{b}
30	0.91^{bc}	0.69^{a}	4.23^{b}	2.57^{b}	1.82^{b}	16.29^{c}
60	0.97^{b}	1.69^{b}	5.22^{c}	3.34^{a}	2.27^{a}	19.16^{a}
90	1.15^{a}	1.38^{c}	5.41^{c}	3.13^{a}	2.51^{a}	19.78^{a}
P value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Packaging						
Skin bag	0.96^{a}	1.03^{a}	4.40^{a}	2.82^{a}	2.01^{a}	17.68^{a}
Appendix	0.98^{a}	1.04^{a}	4.43^{a}	2.85^{a}	2.00^{a}	17.45^{a}
Intestine	0.97^{a}	1.03^{a}	4.45^{a}	2.84^{a}	1.99^{a}	17.77^{a}
P value	0.869	0.859	0.270	0.807	0.797	0.069
Storage time × Packaging						
SB × 2	0.85	0.37^{d}	2.84^{e}	2.24	1.44^{d}	15.31^{d}
AP × 2	0.84	0.37^{d}	2.88^{e}	2.32	1.41^{d}	15.30^{d}
SI × 2	0.85	0.36^{d}	2.86^{e}	2.36	1.37^{d}	15.32^{d}
SB × 30	0.90	0.69^{d}	4.18^{d}	2.57	1.78^{c}	16.22^{c}
AP × 30	0.91	0.74^{c}	4.28^{d}	2.58	1.85^{c}	16.32^{c}
SI × 30	0.91	0.65^{c}	4.22^{d}	2.57	1.82^{c}	16.33^{c}
SB × 60	0.97	1.65^{a}	5.21^{c}	3.09	2.27^{b}	19.33^{bc}
AP × 60	0.98	1.68^{a}	5.18^{c}	3.34	2.27^{b}	18.81^{c}
SI × 60	0.97	1.74^{a}	5.27^{bc}	3.30	2.26^{b}	19.33^{bc}
SB × 90	1.12	1.40^{b}	5.38^{ab}	3.38	2.56^{a}	19.86^{bc}
AP × 90	1.20	1.38^{b}	5.39^{ab}	3.16	2.47^{a}	19.37^{ab}
SI × 90	1.13	1.37^{b}	5.45^{a}	3.13	2.51^{a}	20.10^{a}
P value	0.968	<.0001	0.005	0.079	0.002	0.017

AP, appendix; SB, skin Bag, SI, small intestine.
a–e Means within column for each source of variation significantly different ($P < 0.05$).

TABLE 3–Probability values and the effects of storage time, packaging and storage time × packaging interaction on texture profile analysis (TPA).

Source of variation	Hardness (N)	Adhesiveness (g.s)	Springiness	Cohesiveness	Gumminess (N)	Chewiness (N)
Storage time						
2	1,456.35^{d}	127.86^{c}	0.56^{a}	0.23^{a}	334.25^{b}	186.77^{a}
30	1,907.92^{c}	117.30^{b}	0.48^{a}	0.16^{b}	311.47^{c}	150.44^{b}
60	2,369.90^{b}	110.10^{b}	0.38^{b}	0.13^{bc}	314.40^{c}	119.18^{c}
90	3,301.64^{a}	67.62^{a}	0.25^{b}	0.11^{c}	349.62^{a}	87.06^{d}
P value	<0.0001	<0.0001	<0.0001	0.002	<0.0001	<0.0001
Packaging						
Skin bag	2,273.28^{a}	107.66^{b}	0.40^{a}	0.16^{a}	334.69^{a}	130.91^{b}
Appendix	2,211.94^{b}	94.71^{a}	0.48^{a}	0.17^{a}	340.00^{a}	159.45^{a}
Intestine	2,291.64^{a}	114.80^{c}	0.38^{a}	0.15^{a}	307.61^{b}	117.23^{c}
P value	0.029	<.0001	0.080	0.749	<0.0001	<0.0001
Storage time × Packaging						
SB × 2	1,518.24^{ef}	131.09	0.59	0.21	318.83^{c}	188.11^{a}
AP × 2	1,439.48^{f}	123.08	0.57	0.23	331.08^{b}	188.72^{a}
SI × 2	1,411.33^{f}	129.42	0.52	0.25	352.83^{ab}	183.47^{a}
SB X 30	2,164.15^{d}	121.10	0.43	0.16	346.26^{ab}	148.90^{b}
AP × 30	1,806.59^{d}	105.19	0.55	0.18	325.19^{bc}	178.85^{a}
SI × 30	1,753.03^{e}	125.61	0.47	0.15	262.95^{e}	123.59^{c}
SB × 60	2,439.15^{c}	111.58	0.33	0.13	317.09^{c}	104.64^{d}
AP × 60	2,188.62^{d}	100.75	0.48	0.15	328.29^{b}	157.58^{b}
SI × 60	2,481.93^{c}	117.98	0.32	0.12	297.83^{d}	95.30^{e}
SB × 90	2,971.57^{b}	66.85	0.23	0.12	356.59^{ab}	82.02^{e}
AP × 90	3,413.08^{a}	49.82	0.30	0.11	375.44^{a}	112.63^{cd}
SI × 90	3,520.27^{a}	86.19	0.21	0.09	316.82^{c}	66.53^{f}
P value	<.0001	0.125	0.775	0.882	<0.0001	0.001

AP, appendix; SB, skin bag, SI, small intestine.
a–e Means within column for each source of variation significantly different ($P < 0.05$).

3.4 Texture profile analysis

Storage period ($P < 0.0001$) and packaging types ($P < 0.05$) (except Springiness and Cohesiveness) had a significant effect of Texture profile analysis (TPA) of cheeses (Table 3). The storage time × packaging ($P < 0.05$) interactions also effected TPA properties of cheeses (Table 3).

Hardness in Tulum cheeses incline ($P < 0.05$) throughout storage periods (Table 3). The highest hardness (with 3520.27 N) was determined in the samples filled into appendix with 3,520.27 N whereas the lowest was determined in the samples filled into skin bag ($P < 0.05$) (Table 3) at the storage day of 90. It was determined that hardness values were related to the moisture level of cheese samples and the salt ratio in the moisture. Although hardness values decreased as the moisture ratio of the cheeses increased, the hardness increased as the salt ratio increase in moisture (Kaya, 2002). The interactions between proteins and polysaccharides in the cheese are very important in terms of improving the structure and stability of the product and the polysaccharide types and the charge carried by these is responsible for managing these interactions (Hosseini et al., 2013). Therefore, high protein values affected the hardness values of the cheeses (Sahan, Yasar, Hayaloglu, Karaca, & Kaya, 2008).

Adhesiveness values of the samples increased by an average of 60.24 g.s in all cheeses throughout storage periods ($P < 0.05$) (Table 3). The highest increase of 131.09 g.s was in the samples filled into the skin bag at the storage day of 2, whereas the lowest was determined 49.82 g.s in the samples filled into appendix at the storage day of 90 ($P < 0.05$) (Table 3). Adhesiveness values of the samples decreased during storage ($P < 0.05$). Similarly, Tomar (2019) and Aday and Karagul Yuceer (2014) found a decrease in adhesiveness values in cheese samples during storage. However, Carvalho et al. (2015) stated that adhesiveness values increased depending on the storage period.

Springiness is defined as the ratio of the cheese recovering its initial form after the first compression force. The springiness values decreased throughout storage time in all samples, similar to those reported by Kumar, Kanawjia, and Kumar (2014) ($P < 0.05$) (Table 3). The highest decrease (0.36) was determined in samples filled in the skin bag, followed by samples filled into the small intestine with 0.31 and the samples filled into appendix small intestine with 0.27 ($P < 0.05$) (Table 3). Oluk, Güven, and Hayaloglu (2014) reported that springiness values in cheese samples were affected by the fat and moisture content of cheese. There is a relationship between the amount of moisture and hardness in cheese, their effects on protein microstructure existed springiness. These are responsible for the loss in the ability of the cheese to recover to its original structure (Zisu & Shah, 2005).

The cohesiveness values decreased by an average value of 0.12 in all cheeses ($P < 0.05$) (Table 3). The highest decrease was determined in the samples filled into small intestine with 0.1 + 6, whereas the lowest decrease was in the samples filled into the skin bag with 0.09. Similar to the results obtained in the present study, Pastorino, Hansen, and McMahon (2003) reported that cohesiveness values decreased in Cheddar cheese samples during storage. Zisu and Shah (2005) reported that they found higher cohesiveness value in cheese, especially in low-fat products, and researchers reported that this could be from lower moisture content and higher hardness values.

Gumminess is defined as the break-up force required to prepare food for swallowing (Raphaelides, Antoniou, & Petridis, 1995) and is calculated as Hardness × cohesiveness. Like those reported by Sahan et al. (2008), the gumminess of the cheeses filled into small intestine decreased but increased in the other two samples ($P < 0.05$) (Table 3). The differences were associated with the properties of the packaging material.

Chewiness was calculated as gumminess × springiness. Chewiness values of all samples decreased throughout storage, like those determined by Sagdic, Cankurt, Tornuk, and Arici (2017) ($P < 0.05$) (Table 3). The lowest chewiness values were in the samples filled into small intestine with 183.47 N for the samples stored at day 2, whereas the lowest chewiness values were determined in the samples filled into appendix with 112.63 N at the storage day of 90 ($P < 0.05$) (Table 3). Zheng, Liu, and Mo (2016) reported that low-fat cheeses have higher chewiness values, while high-moisture and fat cheeses have lower chewiness values. The proper chewiness value provides rich mouthfeel and increases the consumers' cheese preferences.

4. CONCLUSION

Tulum cheese is traditionally manufactured from ewe or cow milk and packaged and marketed in skin bags. Some taste and aroma issues due to the use of skin bags in recent years have resulted in prejudice against it and high costs have led the producers to use plastic barrels, ceramic palates, or artificial packaging materials. However, the packaging material in which the Tulum cheese is put in, as well as the taste and aroma, have effects on the physicochemical properties of properties of cheese. Specifically, considering it is a ripened cheese, the majority of these packaging materials prevent the formation of organoleptic properties specific to cheese. The studies show that Tulum cheeses that are ripened in different packaging materials acquire different properties, and thus, lose the appreciation of the consumers. This study revealed that in addition to the original packaging material skin bag, the use of small intestine and appendix do not cause the aforementioned negative effects on Tulum cheese, and have positive effects. The uses of various natural packaging materials have eliminated the disadvantages due to the use of original packaging material and have helped to develop a product that will be appreciated by the consumers with no adverse effects in the physicochemical and textural properties of cheese.

AUTHOR CONTRIBUTIONS

Oktay Tomar, Gökhan Akarca, and Veli Gök contributed to the conception and planning of the research. Oktay Tomar and Gökhan Akarca produced the cheese samples. Oktay Tomar and Gökhan Akarca directed the whole experiment. Fatty acids and organic acid analyzes were carried out by Muhammmed Yusuf Çağlar. Veli Gök collected the data. Oktay Tomar, Gökhan Akarca, and Veli Gök participated in the writing of the manuscript.

CONFLICTS OF INTEREST

The authors declare no potential conflicts of interest.

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