African Journal of Biotechnology Vol. 11(26), pp. 6871-6877, 29 March, 2012
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB11.4230
ISSN 1684–5315 © 2012 Academic Journals

Full Length Research Paper

Comparison of quality characteristics of Çökelek and Lor cheeses

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Accepted 5 March, 2012

The objective of this study was to compare some quality characteristics of Çökelek (cottage cheese-like) and Lor (whey cheese) cheeses during a storage period of 21 days. Çökelek and Lor cheeses significantly (P < 0.05, P < 0.01) showed differences in terms of the examined parameters and storage period. Mean value of lipolysis in Çökelek cheese was higher (P < 0.01) than that of Lor cheese. Also storage time affected (P < 0.01) the values of lipolysis in two experiments. It was found that α_{s1}casein was hydrolyzed much faster than those of γ-casein and β-casein in the Çökelek and Lor cheeses, the γ-, β-, and α_{s1}casein levels in two cheeses remained relatively constant during storage. There were no significant differences in water-soluble N (WSN), trichloroacetic acid soluble N (TCA-SN) and phosphotungstic acid soluble N (PTA-SN) contents of the two experiments, but the storage time significantly (P < 0.01) affected these parameters. The counts of coliforms, lactic acid, proteolytic, psycrotrophic bacteria and yeasts-molds between Çökelek and Lor cheese samples were found to be significant (P < 0.01), but total aerobic mesophilic bacteria (TAMB) and *Salmonella thermophilus* counts were not significant statistically. Storage time significantly (P < 0.01) affected the examined microbiological parameters. Sensory evaluations of the experimental cheeses showed differences in terms of cheese types and storage period.

Key words: Çökelek, Lor, lipolysis , proteolysis, microbiology, sensory.

INTRODUCTION

In Turkey, 40 to 50 cheese varieties are known, but only three of them have economic value: white pickled cheese, Kasar cheese and Tulum cheese (Hayaloglu et al., 2002). After white cheese and Tulum cheese, Çökelek cheese and Lor cheese are the most often consumed cheeses in rural parts of Turkey (Kamber, 2008) and these cheeses are often manufactured in family corporations according to traditional methods, however, it is produced in well equipped factories, as well (Bakırcı et al., 2008; Kamber, 2008).

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Abbreviations: WSN, Water-soluble **N; TCA-SN,** trichloroacetic acid soluble **N; PTA-SN,** phosphotungstic acid soluble **N;** TAMB, total aerobic mesophilic bacteria.

Çökelek and Lor cheeses are important dairy products because they have low fat or non fat, contained excess amounts of casein and whey proteins and cheap products of low revenues for people. In general Çökelek and Lor cheeses are very similar in appearance to each other, although they are completely different from each other. Çökelek cheese is obtained by heat treatment from acidified whole-fat milk or medium-skimmed milk while Lor cheese is produced from whey or whey with some added quantities of milk. Çökelek cheese contains casein and serum proteins in its structure because of the applied heat treatment to milk. This cheese is produced in various ways and called different names in some parts of Turkey. Example, it is known as “Eksimik” in Western Anatolia, “Trakya” in the Black Sea, and “Süt Koptu”, “Akkatik”, “Kesik”, “Torak”, “Urda” or “Süt Kirmasi” in parts of the Mediterranean and Eastern Anatolia (Tarakçı et al., 2003; Kamber and Çelik, 2007). In Turkey, 1,500,000 tons of whey is approximately obtained from the

production of white and Kashar cheeses annually (Temiz et al., 2009). A large portion of this amount is used for the production of whey cheese called Lor. In our country, Çökelek and Lor cheeses can be consumed freshly or when ripened in various packs such as “küp” (earthenware) or “tulum” (animal skin). The aim of this study was to compare the changes in some physical, chemical, microbiological, biochemical and sensory properties in Çökelek and Lor cheeses during storage period.

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MATERIALS AND METHODS

Raw cows’ milk and whey used in this study were obtained from the pilot milk-processing plant of the Agricultural Faculty of Atatürk University. Plastic materials (lidded plastic pot) with 1 kg capacity for packaging of Çökelek and Lor cheeses were obtained from local markets of Erzurum, Turkey.

Production of cheeses

Çökelek and Lor cheeses were produced separately in the pilot plant of food engineering department. 100 kg of milk for Çökelek cheese (CC) and 100 kg of whey plus 20 kg of whole milk for Lor cheese (LC) were used. The study was carried out with two replications. All analyses were done in duplicate.

Physical and chemical analysis

Total solids (TS) salt and fat in TS and ash contents of the experimental cheeses were determined by the gravimetric method (IDF, 1982; Kurt et al., 2006). Fat content was measured by the Gerber method (Case et al., 1985). Total nitrogen in the samples was determined by the Kjeldahl method as described by IDF (1993). Salt content was determined according to the Mohr method described by Case et al. (1985). Acidity of the samples was measured using a pH meter (model WTW pH-340-A, Weilheim, Germany) fitted with a combined glass electrode. The titratable acidity was determined as lactic acid percentage by titrating with 0.1 N NaOH, using phenolphthalein as an indicator (Kurt et al., 2006). Fat and salt in TS of the experimental cheeses were determined by calculation.

Nitrogen fractions

The nitrogen content of the extracted cheeses was expressed as a percentage of total nitrogen (WSN/TN, %), which was described as a ripening index. Water-soluble nitrogen (WSN) fractions of the Çökelek and Lor cheeses were determined by the methods of Kuchroo and Fox (1982) and 12% trichloroacetic acid soluble nitrogen (TCA-SN) fractions were determined by the method of Polychroniadou et al. (1999). In that regards, soluble nitrogen in 5% phosphotungstic acid (PTA-SN) was determined using Kjeldahl method as described by Topçu and Saldamlı (2006).

Lipolysis

The level of lipolysis of cheese samples were determined by using the Bureau of Dairy Industry (BDI) method and measured as Acid degree value (ADV) (Case et al., 1985).

Electrophoretic analysis

In urea-polyacrylamide gel electrophoresis (PAGE) analysis, sample preparation, gel staining, identification and quantification of casein fractions were performed according to the method of Creamer (1991), modified by Tarakçı et al. (2004).

Microbiological analysis

For microbiological analysis, samples (10 g) of the cheeses were weighted and diluted in 90 ml in dilution of 0.85% (w/v) NaCl and homogenized in a sterile polyethylene bag using a Stomacher (Seward Laboratory Blender Stomacher 400 Lab Blender, UK) for 5 min. Serial decimal dilutions of the homogenates in 0.85% (w/v) NaCl solution were plated in duplicates on specific media.

The enumeration of lactic acid bacteria (LAB) were counted on de Man, Rogosa and Sharpe (MRS) agar (Oxoid Ltd., England) at 30°C for 48 h under anaerobic conditions (Smith and Alford, 1984). *L streptococci* counts were enumerated using M17 agar (Oxoid Ltd., England). The incubation was performed at 37°C anaerobically for 48 h. Proteolytic bacteria were counted on plate count agar (PCA) agar added with sterile 10% skimmed milk powder (Oxoid Ltd., England) at 30 ± 1°C for 72 h (Lee and Kraft, 1984; Frank et al., 1985). Total aerobic mesophilic bacteria were enumerated using plate count agar (Oxoid Ltd., England), and incubated at 30 ± 1°C for 48 h (Messer et al., 1985). Psycrotrophic bacteria were enumerated on plate count agar (Oxoid Ltd., England) and incubated at 7°C ± 1°C for 10 days (Merck, 2005), coliform bacteria were counted on Violet Red Bile Agar (Merck), and incubated at 37°C for 48 h (Hartman and Lagrange, 1985). Yeasts and moulds were enumerated on potato dextrose agar (PDA) acidified with 10% tartaric acid (Merck) and incubated at 25°C for five days (Koburger and Marth, 1984).

Sensory analysis

Sensory analysis of the cheeses was carried out by a six-member panel familiarized with CC and LC. Panelists evaluated the cheese samples for color/appearance (0 to 5 scale), flavor (0 to 5 scale), odor (0 to 5 scale) and salinity (0 to 5 scale) according to the procedure described by Bodyfelt et al. (1988) with minor modifications.

Statistical analysis

The parameters of experimental cheeses were estimated by the SPSS 13.0 for Windows SPSS Inc., Chicago, IL, USA (24). Means with significant differences for storage times were compared by Duncan’s multiple range tests ($P < 0.05$, $P < 0.01$), while averages with significant differences between CC and LC samples were compared with T-Test ($P < 0.05$, $P < 0.01$).

RESULTS AND DISCUSSION

Physical and chemical properties

The results of T-test analysis for CC and LC are shown in Table 1. Differences between CC and LC in terms of TS, fat, titratable acidity, pH, salt and fat in TS contents were

Table 1. Comparison of the Çökelek and Lor cheeses in terms of parameters analyzed (T-Test).

Property	Cheeses (n = 8)	
	CC	LC
TS (%)	47.85**	36.60**
Fat (%)	19.59**	15.94**
Ash (%)	4.78*	3.30*
Titratble acidity (as LA %)	0.28**	0.20**
pH	4.51**	4.87**
Salt in TS (%)	6.51**	4.50**
Fat in TS (%)	41.31**	43.63**
Liplysis (ADV, mg KOH g^{-1} -fat)	2.72**	0.94**
TN (%)	2.61	2.47
WSN/TN (%)	2.11	2.63
TCA-SN/TN (%)	1.95	2.26
PTA-SN (%)	5.35	5.77
TAMB (log cfu.g^{-1})	5.96	5.79
Coliform bacteria (log cfu.g^{-1})	< 1	< 1
LAB (log cfu.g^{-1})	5.56**	6.03**
S. thermophilus(log cfu.g^{-1})	5.45	4.37
Proteolytic bacteria (log cfu.g^{-1})	5.93**	6.43**
Yeast and Moulds (log cfu.g^{-1})	5.62**	3.85**
Psychrotrophic bacteria (log cfu.g^{-1})	6.16**	5.07**
Appearance	4.63**	3.93**
Taste intensity	4.58**	4.01**
Odour	4.50**	3.92**
Salinity	3.82**	4.46**

**, $P < 0.01$; *, $P < 0.05$. Different letters indicate differences between rows; CC, Çökelek cheese; LC, Lor cheese; n, number of samples; LAB, lactic acid bacteria; TAMB, total aerobic mesophilic bacteria; cfu, coloni-forming unit; TS, total solids; ADV, acid degree value; LA, lactic acid; TN, total nitrogen; WSN, water soluble nitrogen; TCA-SN, trichloroacetic acid soluble nitrogen; PTA-SN, phosphotungstic acid soluble nitrogen.

significant at the level of P < 0.01 while the content of ash was significant at the level P < 0.05 (Table 1). As can be seen from the table, storage time affected physical and chemical properties of CC and LC samples at different levels (P < 0.01, P < 0.05). However, titratable acidity value was relatively maintained in CC during storage and this was insignificant statistically. All of these can be explained with the differences in the composition and processing methods of the experimental cheeses (Fox et al., 1993; Guinee and Fox, 1993; Fox et al., 1999). Similar results were reported for some cheese types by several authors (Akin et al., 2003; Tarakçi et al., 2004; Celik et al., 2005; Hayaloglu et al., 2002). During storage period, the highest mean value of pH was found on day one of storage in LC, but the lowest value was found on day 21 of storage in CC, and these differences were statistically (P < 0.01, P < 0.05) significant (Table 2). This situation can be explained by the lactic acid formation from residual lactose in the cheese (Table 2).

Biochemical properties of experimental cheeses

Lipolysis

Lipolysis degree (ADV) of CC was significantly higher (P < 0.01) compared to LC (Table 1), probably due to the compositional characteristics of the experimental cheeses. Especially, fat content of Çökelek cheese was higher than that of Lor cheese. This result indicates that the level of lipolysis was positively correlated with the fat content and compositional properties (Buffa et al., 2001).

The ADV of CC increased up to day seven of storage, and slightly decreased up to 14 day. Later an increase was observed between day 14 and 21 of storage and the differences between the days of storage were significant (P < 0.05). On the other hand the ADV values of LC increased up to seventh day of storage then decreased until the end of storage and differences between storage times were insignificant (Table 2). The reason for the

Table 2. Mean values of some physical and chemical properties of the experimental cheeses and their statistical evaluations in terms of storage time.

Storage time (day)	(TS) (%)		Fat (%)		Ash (%)		Titratable acidity (as LA %)		pH		Salt in TS (%)		Fat in TS (%)	
	CC**	LC**	CC*	LC*	CC**	LC**	CC	LC*	CC*	LC**	CC*	LC*	CC**	LC**
1	45.91^{b}	39.03a	19.50^{b}	15.50^{b}	5.35^{b}	5.18^{a}	0.27	0.17^{b}	4.53^{a}	4.91^{a}	6.49^{ab}	4.38^{b}	42.48^{c}	39.72^{b}
7	45.32^{c}	34.91^{c}	19.50^{b}	15.75^{b}	6.70^{a}	2.48^{b}	0.30	0.17^{b}	4.52^{a}	4.91^{a}	6.10^{b}	4.63^{a}	43.03^{b}	45.12^{a}
14	43.94^{d}	35.31^{c}	19.50^{b}	15.75^{b}	3.59^{c}	2.85^{b}	0.27	0.21^{a}	4.51^{ab}	4.83^{b}	6.37^{b}	4.40^{b}	44.38^{a}	44.60^{a}
21	56.22^{a}	37.16^{b}	19.88^{a}	16.75^{a}	3.49^{d}	2.67^{b}	0.29	0.24^{a}	4.48^{b}	4.83^{b}	7.08^{a}	4.45^{b}	35.35^{d}	45.08^{a}

**, P <0.01; *, P <0.05. Different letters indicate differences between rows; LA, lactic acid; CC, Çökelek cheese; LC, Lor (whey cheese); TS, total solids.

Table 3. Mean values of some biochemical properties of the experimental cheeses and their statistical evaluations in terms of storage time.

Storage time (day)	Lipolysis (%)		TN (%)		WSN/TN (%)		TCA-SN/TN (%)		PTA-SN/TN (%)	
	CC*	LC	CC	LC	CC	LC*	CC**	LC	CC	LC*
1	2.89^{a}	0.68	1.38	2.32	0.03	0.08^{a}	0.03^{b}	0.03	0.11	0.18^{a}
7	2.93^{a}	1.08	2.99	2.50	0.07	0.09^{a}	0.10^{a}	0.07	0.23	0.08^{b}
14	2.41^{b}	1.03	2.93	2.41	0.09	0.04^{b}	0.05^{b}	0.06	016	0.15^{a}
21	2.64^{ab}	0.95	3.12	2.64	0.05	0.05^{b}	0.05^{b}	0.05	0.14	015^{a}

**, P < 0.01; *, P < 0.05; Different letters indicate differences between rows; CC, Çökelek cheese; LC, Lor (whey cheese); TS, total solids.

slight decrease of ADV from day seven of storage period of CC and LC may be degradation of fatty acids into sub-components such as methyl ketones (Coşkun 1998).

In addition, high number of lipase-producing microorganisms (for example; yeasts and moulds, psychrotrophic bacteria) may affect the levels of lypolysis in cheeses (Tarakçı et al., 2003; Tarakçı et al., 2004). An excessive lipolysis is considered to be undesirable. A moderate level of ADV may also be considered as a rancid flavor by some consumers (Chavarri et al., 2000).

Nitrogen fractions

Proteolysis is the most complex and perhaps the most important, of the three primary biochemical events in the ripening of most cheese varieties. Depending on the depth of information required, proteolysis in cheese is assessed by a wide range of techniques (*34*). WSN, TCA-SN and PTA-SN were expressed as a percentage of total nitrogen (TN) and used to determine the extent of proteolysis in the experimental cheeses (Table 3).

The lowest mean value of total nitrogen was observed on day one of storage, and the highest mean value was also found on day seven of storage in CC. According to variance analysis, there were no statistically significant differences between the cheese batches and days of storage times in terms of nitrogen contents (Tables 1 and 3). WSN is generally used as the index of cheese ripening. T-test results z indicated that the mean contents of WSN, TCA-SN and PTA-SN in LC was higher than those of CC, but these were insignificant statistically. WSN, TCA-SN and PTA-SN values of the experimental cheeses changed irregularly during storage and differences among days of storage in terms of WSN and PTA-SN values were significant (P < 0.05) for LC, but insignificant for CC (Tables 1 and 3). In contrary, differences among storage times were significant (P < 0.01) in terms of TCA-SN values for CC (Table 3). Çökelek and Lor cheeses are produced by adding salt, without rennet addition and under heat treatment. Therefore, the enzymes which originated from milk and microorganisms remain ineffective (Güven et al., 2008). As a result of this, the ripening takes place slowly in these cheeses (Banks, 1992; Guinee and Fox, 1993; Pavia et

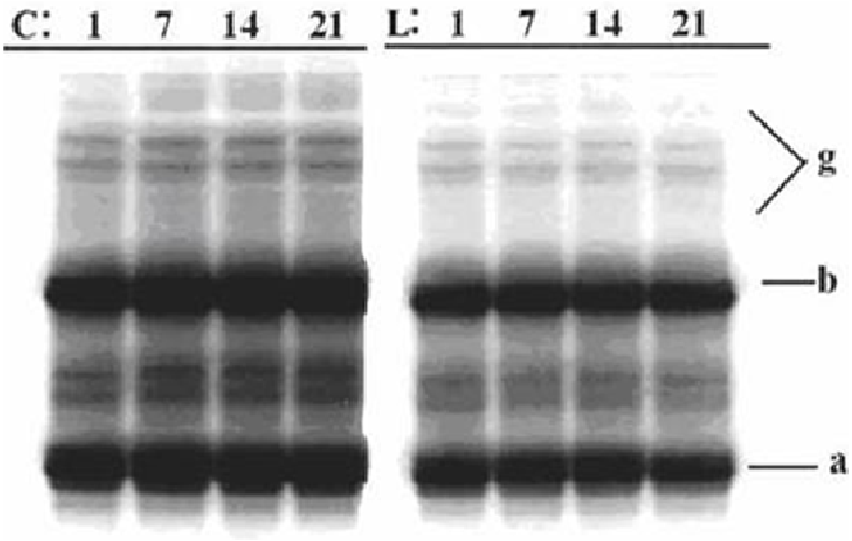


Figure 1. Urea-polyacrylamide gel electrophoresis of the experimental cheeses (C, Çökelek; L, Lor; 1, 7, 14 and 21, storage days; g, γ-caseine; b, β-casein; a, α_s1-casein).

al., 2000; Güven et al., 2008).

Electrophoretic analysis

Urea-PAGE electrophoretograms of CC and LC are shown in Figure 1. For the experimental cheeses, the mode and rate of casein breakdown was similar. This was probably due to the shortness of storage period. It was also observed that the rate of hydrolysis of the three caseins were similar. In two experiments, it was found that α_{s1}casein was hydrolyzed much faster than those of γ-casein and β-casein. During storage period, the residual γ-, β-, and α_{s1}caseins in two cheeses remained relatively constant (data not shown).

Microbiological analysis

The results of microbiological analysis of the experimental cheeses are shown in Tables 1 and 4. The microbiology of the Çökelek and Lor cheeses show differences depending on raw milk and whey quality, survival of heat-sensitive microorganisms and microbial contaminations during cheese making process (Ateş Öksüztepe et al., 2007; Temiz et al., 2009). T-test results revealed that the differences between the CC and LC in terms of total aerobic mesophilic bacteria (TAMB), coliform, and *L streptococci* counts were not found to be significant. However, LAB, proteolytic, and psychrotrophic bacteria, yeast and mold counts were significant at the level of $P < 0.01$. Fox et al. (1993) suggested that total microbial count increases rapidly, reaching a maximum after a week of storage and then declines.

As seen from Table 4, coliform bacteria in CC and LC were not detected (lower about 1 $\log_{10}$ unit). This is probably due to heat treatment applied during manufacture (Yıldız et al., 2010). According to Turkish regulations, the maximum allowable counts of coliform bacteria must be 2 $\log_{10}$ cfu.g^{-1} in Turkish white-brined cheese (Anonymous, 2001). The coliform group bacteria counts found in our study was lower than the results of Kamber and Çelik (2007). Generally *Salmonella thermophilus* counts showed an irregular change in LC, but the counts decreased during storage period in CC (Table 4), but these changes were not significant statistically.

Sensory evaluation

The mean scores for the sensory characteristics of the experimental cheeses are presented in Table 5. Results of sensory evaluations showed that significant ($P < 0.01$) differences were found between cheese types in terms of appearance, taste intensity, odour and salinity scores. It was observed that the storage time affected ($P < 0.01$, $P < 0.05$) the evaluations of panelists in all sensory parameters tested.

Conclusion

These results show that CC and LC significantly differed in terms of their compositional properties. Lipolysis value obtained from CC was higher than that of LC. Also, ripening index and the other parameters of proteolysis were similar to each other. It was observed that the

Table 4. Mean values of some microbiological properties of the experimental cheeses and their statistical evaluations in terms of storage time (log cfu.g^{-1}).

Storage time (days)	TAMB		Coliforms		LAB		*S.thermophilus*		Proteolytic bacteria		Yeast-Moulds		Psychrotrophic bacteria	
	CC	LC**	CC	LC*	CC	LC**	CC	LC**	CC*	LC**	CC**	LC**	CC*	LC**
1	5.81	4.15^{c}	<1	1.56^{ab}	5.91	5.78^{bc}	5.82	4.75^{bc}	5.66^{c}	5.43^{b}	4.27^{c}	<1^{c}	5.73^{b}	<1^{c}
7	5.74	5.34^{b}	<1	1.93^{a}	5.31	5.20^{c}	5.39	4.30^{c}	5.82^{bc}	5.46^{b}	5.70^{b}	4.62^{b}	5.99^{b}	5.53^{b}
14	6.00	7.17^{a}	<1	0.57^{bc}	5.87	6.23^{b}	5.39	4.92^{b}	6.17^{a}	7.19^{a}	6.71^{a}	5.59^{a}	6.81^{a}	7.16^{a}
21	6.32	6.53^{a}	<1	<1^{c}	5.18	6.93^{a}	5.20	5.87^{a}	6.06^{ab}	7.65^{a}	5.79^{b}	5.16^{a}	6.10^{b}	7.60^{a}

**, $P < 0.01$; *, $P < 0.05$. Different letters indicate differences between rows; CC, Çökelek cheese; LC, Lor (whey cheese); TS, total solids; LAB, lactic acid bacteria; TAMB, total aerobic mesophilic bacteria.

Table 5. Sensory evaluations of the experimental cheeses and their statistical evaluations in terms of storage time.

Storage time (days)	Appearance		Taste intensity		Odour		Salinity	
	CC*	LC**	CC*	LC**	CC**	LC**	CC**	LC*
1	4.55^{b}	3.73^{b}	4.85^{a}	3.70^{c}	4.80^{a}	4.00^{b}	3.75^{b}	4.38^{b}
7	4.78^{a}	4.18^{a}	4.23^{b}	3.83^{c}	4.63^{b}	3.65^{d}	3.43^{c}	4.63^{a}
14	4.63^{b}	3.80^{b}	4.60^{a}	4.08^{b}	4.08^{c}	4.23^{a}	4.28^{a}	4.40^{b}
21	4.58^{b}	4.25^{a}	4.63^{a}	4.45^{a}	4.50^{b}	3.80^{c}	3.83^{b}	4.45^{b}

**: $P < 0.01$, *: $P < 0.05$; Different letters indicate differences between rows; CC: Çökelek cheese, LC: Lor (whey cheese).

hydrolysis of caseins took place at the same rate in the experimental cheeses. It was found that there were significant differences between CC and LC with respect to microbiological results except for TAMB, coliform and *L streptococci* counts. As for the sensory evaluations, two traditional cheeses differed from one another in terms of sensorial scores during storage. It can be concluded that these two traditional Turkish cheeses were similar in terms of appearance but differed with respect to some parameters analyzed.

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