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Quality evaluation of kashar cheese: influence of palm oil and ripening period

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Abstract

Vegetable oils are used as milk fat replacers in cheese production to alter sensory, nutritional profile, and to produce cholesterol free or low-cost cheeses. The aim of this study is to investigate the effect of palm oil usage on kashar cheese's physicochemical, textural and sensorial quality characteristics during ripening. The results showed that replacement of milk fat with palm oil was not statistically significant in terms of moisture, salt, fat content, and titratable acidity. β-sitosterol content, which is a marker of vegetable oil addition in cheese, was found in the detectable range by chromatographic analysis for the palm oil added samples (PO). Hardness, chewiness, and gumminess values were significantly affected by the palm oil replacement and also during the ripening period of 90 days. Changes in L* values were apparent during ripening and the brightness of the PO groups was lower than that of the control group. Higher sensorial scores for PO indicated that palm oil usage may not be noticeable by the consumers. The overall results provide essential information, demonstrating that cost-saving palm oil can be successfully used in kashar cheese production where the milk fat replacement did not alter the physicochemical, textural and sensorial quality characteristics.

Keywords: kashar cheese; palm oil; quality; ripening; texture.

Practical Application: The findings of this research can be bases for new studies regarding quality attributes, consumer perception, and new cost-saving products by the trial of palm oil usage in a semi-hard sliceable cheese production.

1 Introduction

Kashar (Kaşar) cheese is a sliceable semi-hard cheese that is mainly produced by the fermentation of curd, which is then boiled in hot water and kneaded. It is the second mostly consumed local cheese in Turkey and it is similar to the cheeses in the Balkan countries (Kashkaval, kasseri) and in Italia (Caciocavallo, Provolone, Mozzarella) in terms of its production and chemical properties (Balkır & Metin, 2011).

The composition of cheese play an important role in human nutrition, and recent literature suggests that a variety of cheese products have been formulated according to the changing demands of the customer to meet the functionality (Murtaza et al., 2017; Almeida et al., 2017; Hong et al., 2017). The composition of cheese and yield and have been important parts of cheese making where they are the basis for payment, and cheese making efficiency (Johnson 2017). In kashar cheese production, to produce 1 kg of kashar cheese, 10-11 kg milk is used (Balkır & Metin, 2011). To increase the yields and lower the costs, the producers resort to other methods such as replacing the milk fat by various vegetable oils where in some local food authorities, this attempt can be regarded as adulteration. In recent years, vegetable oils are used as milk fat replacers in different researches about cheese production to alter sensory, nutritional profile and to produce cholesterol free cheese (Kesenkaş et al., 2009; Arslan et al., 2010; Dinkci et al., 2011). These low-cost products of cheeses or cheese analogues have to be organoleptically acceptable and exhibit textural properties similar to the milk fat product. Those organoleptic and textural properties can generally be attributed to the production technology, source of the milk, moisture content, and length of aging, in addition to the type of microorganisms (Santiago-López et al., 2018). Although there are studies using vegetable oils in different types of cheeses, the effect of palm oil usage by substituting milk fat in kashar cheese quality has not been explored extensively in the literature.

Therefore, the aim of this study is to investigate the effects of the replacement of milk fat with palm oil on physicochemical, textural and sensorial quality characteristics of kashar cheese. The study is of importance due to its contribution by making comparison between the palm oil-added kashar cheese, and kashar cheese produced with milk fat to determine whether there are differences in fundamental quality criteria.

2 Materials and methods

2.1 Materials and kashar cheese production

The cow milk used in the cheese production was procured from Meram County of Konya Province, Turkey. As a proteolytic enzyme preparation derived by the fermentation of a selected strain of *Rhizomucor miehei*, the rennet is microbial enzyme in the liquid form. The proteolytic enzyme is put on the market under the name of Yayla 120 and was procured from Maysa Gıda (İstanbul, Turkey). In the production, 40% calcium chloride solution was used (Merck). The palm oil was procured from Marsa Yağ Sanayi ve Tic. Aş. (Adana, Turkey). The Lb.helv.7®

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(L. Helveticus) culture (Peyma-Chr. Hansen's Peynir Mayası San. ve Tic. A.Ş., İstanbul, Turkey) was used as the starter culture.

In kashar cheese production, pasteurized milk was cooled to 34 - 38 °C, then $CaCl_2$, starter, and rennet were added to the milk. At the end of renneting, coagulum was cut and heated to 37 °C - 40 °C. At the end of the heating process, the curd reaching an acidity of 5.50 - 5.80 pH was transferred to curd draining vats. Cheesecloths were combined, and pressure plates were placed to press the curd. The curd at a pH around 5.20 - 5.50 was cut into rectangular blocks. When acidity reached a pH value of 4.80 - 5.15, the curd was boiled in the brine at 73 - 85 °C with a 5% salt concentration. Then the curd was placed in kashar molds and left to settle. The molds were removed the next morning and the cheeses were transferred to a settling chamber. The cheeses were rested in the settling chamber for 1 day and turned over 2- 3 times during the day and the dried samples were vacuum packaged in PVC packages.

2.2 Experimental design

In the study, three different production trials were carried out to see the effect of palm oil addition in different concentrations. A control production was also carried to compare the effect of palm oil addition with a standard kashar cheese production using standard milk fat. Information about the cheese samples containing only milk fat (MF), and palm oil replaced samples (PO1 and PO2) are as follows:

- MF: Kashar cheeses produced from standard milk (3.5% w/w)
- PO1: Kashar cheeses produced from palm oil and milk fat in the same ratio by weight 1:1 (w/w)
- PO2: Kashar cheeses produced by separating the milk fat and replacing it by palm oil (3.5% w/w)

The vacuum-packaged samples were stored 90 days in cold. Experimental production was carried out in two replicates. For the analyses, the samples were collected at days 7, 30, and 90 and the analyses were performed in triplicate.

2.3 Physicochemical analyses of raw milk and kashar cheese

Total solids of the milk samples were determined by gravimetric method, density of the sample was determined by lactodensimeter, fat content by Gerber method and titratable acidity was determined by Soxhelet-Henkel (SH) method, as previously described (The Institute of Turkish Standards, 1981). Total solids of the cheeses were determined according to the Turkish National Standards TS EN ISO 5534 (The Institute of Turkish Standards, 2006). Fat content of cheese samples was determined by Van-Gulik method (The Institute of Turkish Standards, 1978). Salt contents of the cheeses were determined according to Turkish National Standard TS EN ISO 5943 by potentiometric titration method (The Institute of Turkish Standards, 2007). The pH of the samples was measured using pH meter (WTW-315i, Germany).

2.4 Detection of the vegetable oils in kashar cheese

To determine whether the vegetable oil added to cheese samples was at a detectable level according to the relevant legislation, the previously proposed methods were employed (The Institute of Turkish Standards, 2003, 1989; International Olive Oil Council, 2001). The principle of analyze is based on the determination of a plant sterol; β-sitosterol. By following the method, KOH and ethanolic pyrogallol solutions were added to the test sample and the saponification of the sample at 70 °C was achieved. Then, the currently present sterols were scraped off the medium using thin-layer chromatography. After trimethylsilyl derivatization, 1 μl of samples were analyzed in gas choromatography (GC-Agilent/Hewlett-Packard 6890, USA) equipped with FID detector at 280 °C, and Supelco SP-2380 fused silica capillary column (60 m, 0.25 mm i.d., 0.2 μm film thickness, Nitrogen carrier gas, 1 ml/min flow rate).

2.5 Color analysis

The color of cheese samples was quantitatively determined at room temperature (21 ± 1 °C) using Konica Minolta CR-400 chromameter (Konica Minolta Inc., Osaka, Japan). The L*, a*, and b* color dimensions were read for the cheese samples where L* value represents darkness from black (0) to white (100), a* value represents color ranging from red to green and the b* value represents yellow to blue (Akdeniz et al., 2012).

2.6 Texture profile analysis

Cheese samples of 25 × 25 × 20 mm dimensions were used for texture profile analysis. Samples were wrapped in stretch films and equilibrated to room temperature (21 ± 1 °C). Analysis was performed using texture profile analysis (TPA) instrument (TA.XT2-Texture Analyzer, Texture Technologies Corp., Scarsdale, NY/ Stable Microsystems, Godalming, UK) using P/25 probe (25 mm diameter); and operated at a crosshead speed of 1 mm/s with a compression of 45%. From the resulting force-time curve, the values for texture attributes were determined (Kahyaoglu et al., 2005). All measurements were done in triplicate throughout the storage.

2.7 Sensory analysis

Kashar samples were subjected to sensory evaluation by a total of 7 pre-trained individuals. Each sample was equilibrated to room temperature (21 °C ± 1) and presented in duplicates on white dishes. Sensory evaluation was carried out with scoring tests according to the Turkish Standard TS 3272 (The Institute of Turkish Standards, 1999). In this scoring scale, the product is graded on a 100-point scale as follows: 10 points maximum for color, 30 points maximum for appearance, 20 points maximum for texture, and 40 points maximum for odor, and taste (flavor).

3 Results and discussion

3.1 Results of physicochemical analysis for raw milk and cheese samples

In kashar production, the properties of raw cow milk, is of prior importance. Primary analyzes of raw milk were performed. The results of the total dry matter (9.8% ± 0.02), density (1.031g/mL ± 0.00), pH (6.60 ± 0.1), and fat contents (4.7% ± 0.02) of the raw milk used in the study were close to the standards for cow milk composition and the values revealed that the milk used in the study had the properties of normal fresh milk (The Institute of Turkish Standards, 1981). The fat percentage of the raw milk was later standardized (3.50% ± 0.03) prior to the production of the test cheeses.

Ripening period is important for the kashar cheese to gain a unique flavor, taste, and aroma. Changes in some physiochemical parameters of kashar cheese throughout storage are presented in Table 1.

The analysis of variance indicated that the replacement of milk fat with palm oil did not significantly affect physicochemical properties ($p>0.05$). On the contrary, ripening time was effective on all cheese samples. The maximum water amount was about 40% which is within the standard limits for the water amount in kashar cheese at the end of ripening (The Institute of Turkish Standards, 1999). The total solid amounts in all three kinds of cheese tended to increase with time and thus, the water content of the samples decreased during ripening. Similar results were also reported (Nizamlıoğlu et al., 1996).

As it is the case in many countries, in Turkey, the fat-based classification of cheeses is made by considering the fat amount in the dry matter. According to this classification, the fat percentage in full-fat kashar cheese is 45% or more, while the fat percentage in low-fat kashar cheese should be between 25% and 45% (The Institute of Turkish Standards, 1999). The data obtained in literature studies showed that the fat percentage of kashar cheese was between 40% and 48% (Nizamlıoğlu et al., 1996; Akin, 2012).

The salt in cheese is a component that adds flavor to the cheese, increases its durability, and affects the consistency and yield. Since the salt amount is determined based on the dry matter of the cheeses by the standards (The Institute of Turkish Standards, 1999), the salt contents of the analyzed samples were calculated based on their dry matter content. In the cheeses, the dry matter salt content usually ranged from 6.60% to 8.08% (Table 1). During ripening, salt content in all samples slightly increased. Similar results were also stated by other workers (Ercan, 2009; Tarakci & Kucukoner, 2006). Dry matter salt content is an important factor affecting the quality and the TS 3272 standard states that the dry matter in kashar cheeses can contain 3% to 7% salt by weight (The Institute of Turkish Standards, 1999). According the relevant standards and codes, the analyzed samples were slightly above the permitted limits.

The acidity level is an important factor due to its guidance throughout the formation of texture, taste, and aroma during the stages from coagulation to ripening. Table 1 shows the changes occurring during storage in the titratable acidity (SH) of the samples. Titratable acidity increased continually during the storage period possibility due to lactic acid and hydrogen formation (Kesenkaş et al., 2012). Similar results were also stated by other workers (Tarakci & Kucukoner, 2006; Kurultay et al., 2000, Uzkuç et al., 2018). The pH of the cheese is affected by factors such as the activity of the starter culture used in the production, the amount of lactose in the curd, whether the boiling temperature homogenously affected the cheese, the duration of boiling, and the dry matter and dry matter composition of the cheese. The results given in Table 1 showed that the pH values differed depending on the samples and regularly decreased in all samples during ripening. The consequent decrease occurred in pH for MF sample at the end of storage while a significant increase was observed ($p<0.05$) for PO1 and PO2 throughout the ripening. This fluctuation may be due to the end products of proteolysis (Pisano et al., 2006). The results agree with the results reported in previous studies (Demirci & Dıraman, 1990) and decrease in the pH values of kashar cheeses also decreased during ripening (Sert et al., 2007).

3.2 The detection of β-sitosterol in the cheese samples

As the phytosterol with the highest prevalence among the vegetable oils; β-sitosterol is used to discriminate the vegetable oils replacement in kashar samples. Pure milk fat contains 98% cholesterol and shows minor peaks that have the same retention time as phytosterols (Contarini et al., 2002). According to the local standards, the presence of a peak that emerged at the same time as the peak of β-sitosterol and had a height 2% longer than that of β-sitosterol indicates that the cheese sample contains vegetable oil (The Institute of Turkish Standards, 2003, 1989).

The evaluation of the analysis results (Table 2) according to the above-described criterion showed that no β-sitosterol peak was found in the kashar cheese sample produced from standard milk (MF). The relative β-sitosterol peak heights in the palm oil-added PO1 and PO2 kashar cheeses were 20.65%

Table 1. Physicochemical properties of cheese samples.

Samples	Storage Period (day)	Total solids (%)	Salt (%)	Salt in total solids (%)	Fat in total solids (%)	Titratable acidity (°SH)	pH
MF	7	53.00^{a}	3.5^{a}	6.60^{a}	47.17^{a}	0.62^{a}	5.18^{a}
	30	53.50^{a}	3.70^{b}	6.92^{b}	45.79^{b}	0.74^{b}	5.02^{a}
	90	55.00^{b}	3.80^{c}	6.91^{b}	45.45^{b}	0.84^{c}	4.94^{b}
PO1	7	53.90^{a}	3.70^{a}	6.86^{a}	44.53^{a}	0.60^{a}	5.13^{a}
	30	55.13^{b}	3.80^{b}	6.89^{a}	44.44^{a}	0.80^{b}	4.92^{b}
	90	55.31^{b}	3.90^{c}	7.05^{b}	43.39^{a}	0.90^{c}	4.81^{c}
PO2	7	52.30^{a}	3.90^{a}	7.45^{a}	46.85^{a}	0.58^{a}	5.19^{a}
	30	52.82^{a}	4.10^{b}	7.76^{b}	45.44^{b}	0.95^{b}	5.02^{b}
	90	53.2^{b}	4.30^{c}	8.08^{c}	43.23^{c}	1.00^{c}	4.77^{c}

and 72.13%, respectively. The results were consistent for the PO1 and PO2 samples produced by increasing amounts of palm oil. Therefore, the results indicated that the amounts of the palm oil added to the kashar cheeses during the production trial were at detectable levels.

3.3 Color analysis results

Water loss occurs in kashar cheeses during storage. Moreover, the mobility of the components (i.e. fat, salt) and exposure to light can cause non-uniform coloration in cheese molds, which results in irregularities in color. Color analysis was performed to investigate whether there is any difference in the coloration of the kashar cheeses produced from standard milk and palm oil-added milk at the end of the ripening process and the results are given in Table 3.

The L* values of the samples varied from 85.87-87.42 initially and 81.45-83.34 at the 90 days of the ripening period. It was stated that the fat globules and casein micelles forming the colloidal portion of milk scatter the light in the visible spectrum (Metzger et al., 2000), thus their content play a major role in the white coloration of cheese. In this study, the brightness of the PO1 and PO2 cheese groups with a slightly reduced fat content (see Table 1) was lower than that of the control group. Similarly, it was reported that the low-fat control cheese had a more translucent surface and denser color than full-fat cheese (Koca & Metin, 2004). Changes in L* values were apparent as the storage period progressed, similar case has been previously reported (Dinkci et al., 2011). The reason for the fact that samples became darker during storage may be attributed to the Maillard browning reaction that occurs during storage between lactose and cheese protein especially casein (Corzo et al., 2000). The a* value represents color ranging from red (+) to green (–). It was reported that the values of a* in milk products have been primarily attributed to their fatty acid profiles (Paz et al., 2017). The greenness values were higher in the PO1 and PO2 samples (that contained lower amounts of fat) and the values tended to decrease with time. In previous studies, fat reduction was reported to cause a greenish tint in the samples (Sahan et al., 2008) and in a study on fat-reduced cheeses, the greenness (-a) was reported to increase (Boran, 2012). The b* value represents yellow (+) to blue (–).The yellowish color is a characteristic for Kashar cheese. Results showed that b* values increased as the storage period progressed. Results were in good agreement with the literature. It was reported that the yellowness index of cheese color has high correlation with the b* value and increased during cheese ripening (Buffa et al., 2004).

Table 2. The evaluation of palm oil addition by β-sitosterol peaks hights from GC results.

Sample	β-sitosterol Relative Peak Hight (%)	Decision for Palm Oil Existence
MF	0	No
PO1	20.65	yes
PO2	72.13	yes

Table 3. The color values of kashar cheeses.

Sample	Storage period (day)	L*	a*	b*
MF	7	87.42^{a}	-3.11^{a}	10.04^{a}
	30	85.81^{a}	-2.91^{b}	10.89^{b}
	90	83.34^{b}	-2,78^{ab}	11.40^{c}
PO1	7	86.12^{a}	-4.32^{a}	10.21^{a}
	30	84.82^{b}	-4.29^{a}	11.06^{b}
	90	82.90^{c}	-4.24^{a}	12.60^{c}
PO2	7	85.87^{a}	-4.21^{a}	9.61^{a}
	30	83.21^{b}	-3.65^{b}	10.89^{b}
	90	81.45^{c}	-2.85^{c}	11.23^{c}

Different superscripts letters for a sample within columns indicate significant differences (Duncan test, $p < 0.05$).

3.4 Texture profile analysis results

The texture of the cheese is affected by production and ripening. Texture profile analysis of the samples throughout the storage period is shown in Table 4. Overall analysis of variance indicated that hardness, chewiness, and gumminess values were significantly affected by the treatment and also by the ripening period ($p<0.05$). Hardness is a measure of the amount of force required to compress the cheese samples. Hardness values of the cheese groups varied between 10.843 N -98.458 N and the control samples (MF) had the highest scores. A similar case was also observed by other researchers where full-fat cheese compared with cheese containing 100% sunflower oil (El-Salam, 2015).

Table 4. Effect of treatment and storage period on textural properties.

Sample	Storage period (day)	Hardness	Springiness	Cohesiveness	Gumminess	Chewiness
MF	7	98.458^{a}	0.861^{a}	0.736^{a}	72.037^{a}	62.050^{a}
	30	72.047^{b}	0.817^{b}	0.684^{b}	47.580^{b}	40.753^{b}
	90	55.637^{c}	0.829^{ab}	0.713^{a}	39.640^{c}	32.837^{c}
PO1	7	41.876^{a}	0.842^{a}	0.744^{a}	31.167^{a}	26,223^{a}
	30	15.680^{b}	0.760^{b}	0.668^{b}	11.033^{b}	0.796^{b}
	90	15.263^{b}	0.840^{a}	0.722^{a}	11.013^{b}	0.933^{b}
PO2	7	56.638^{a}	0.859^{a}	0.737^{a}	41.708^{a}	35.834^{a}
	30	25.000^{b}	0.793^{b}	0.710^{a}	17.723^{b}	13.903^{b}
	90	10.843^{c}	0.791^{b}	0.723^{a}	0.785^{c}	0.598^{c}

Different superscripts letters for a sample within columns indicate significant differences (Duncan test, $p < 0.05$).

Hardness values of all cheese samples continuously decreased as storage progressed ($p<0.05$). A tighter protein-matrix consisting of lower fat, and higher protein (serum proteins and casein) content lead harder cheese structure. The decrease in hardness values of the kashar samples as storage progressed is proposed to the breakdown of casein, especially α_{s1} fraction into lower molecular weight peptide (Kesenkaş et al., 2012). A similar trend was also observed in different researches on cheddar (Fenelon & Guinee, 2000), Telli (Kesenkaş et al., 2012) and kashar cheese (Sahan et al., 2008). During storage, the moisture content of all samples reduced (Table 1). Therefore, increase in hardness may also be attributed to the reduction of the free moisture content of the samples (Noronha et al., 2008).

The springiness and cohesiveness values showed some fluctuations during the storage period. For the PO2 sample, the decrease in springiness was significant during the storage. Decrease in springiness might have occurred during ripening with the effects of the proteolytic breakdown of the protein matrix (Sahan et al., 2008; Jaster et al., 2019). Gumminess followed the same trend of hardness and chewiness and showed differences of means between the cheese types. Highest gumminess values were obtained for MF and decreased throughout the later period of storage. Similar results were also stated by other workers (Kahyaoglu et al., 2005; Romani et al., 2002; Sahan et al., 2008). Palm oil addition showed effects on gumminess and chewiness and decreased their values compared to the control cheese group where similar results were previously described for sunflower oil added cheese samples (El-Salam, 2015).

3.5 Sensory characteristic of kashar cheese

Sensorial and descriptive analysis are generally used to better comprehend and accommodate consumer demands for new food products, and to develop more attractive products and meet consumers' expectations (Silva et al., 2018; Esmerino et al., 2017b). The means of the sensory scores of all sensory characteristics are given in Figure 1. Results showed that the color of palm oil blended kashar cheeses (PO1 and PO2) were different from that of MF sample ($p < 0.05$). Highest scores were for the palm oil blended cheese. The same scoring trend was also observed for the appearance and texture. None of the samples, with respect to odor and taste, received the maximum score of 40 as stated by the Turkish Standard Institution about kashar standards (The Institute of Turkish Standards, 1999).

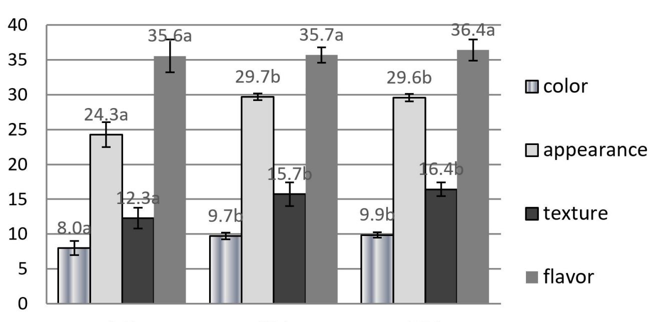

Figure 1. Scores of sensory characteristics of kashar cheese (Different letters within same sensory attribute indicate significant differences; Duncan test, $p< 0.05$).

The cheese flavor is mainly derived from the breakdown of milk proteins, fats and lactose by enzyme activities. Expected flavor changes within the samples might be attributed to the palm oil addition. However, there was no significant difference within the flavor (odor and taste) within the samples ($p >0.05$). Palm oil is rich in palmitic acid (44.3% in saturated fatty acids) and oleic acid (38.7% in unsaturated fatty acids) (Macit & Sanlier, 2014). Although lipid fraction in cheese contributed to the development of cheese flavor (Matera et al., 2018; De-Luca et al., 2018), it was reported that palmitic and oleic acids do not contribute to cheese odor and taste as much as short- and medium-chain fatty acids (Sablé & Cottenceau, 1999; Güler, 2005). This case might be the possible reason of the unperceivable odor and taste of the palm oil in the PO samples and the results provided more realistic information on the physiological responds approaching the real consumers' perception about kashar. The sensorial results in this study are crucial to find strategies to create formulation/ reformulation of kashar ensuring the market success where the local regulations as well as the knowledge about the differences between consumers from different regions are also important tools for marketing (Esmerino et al., 2017a; Soares et al., 2017).

4 Conclusion

The functional characteristics such as physicochemical, textural and sensorial properties are important attributes that influence the quality of kashar cheese. Results of this study showed that palm oil can be used in kashar cheese production without any considerable quality loss, and there was a comparable differences between the palm oil added and full milk fat kashar cheeses especially in sensorial and textural properties. Higher sensorial scores for palm oil added samples indicated that palm oil usage in kashar cheese production is an acceptable attribute with respect to consumers' perceptions and quality evaluation. Although there is a well-known commercial potential for palm oil, the impact of its dietary consumption become debatable. In the future studies, the commercial potential of the palm oil addition should be introduced entirely and briefly for the kashar cheese production regarding health risks/benefits and cost-saving issues.

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