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The effect of *Coriandrum sativum* L. addition on microbiological, chemical, and sensory properties of cheese

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Abstract

The present work was carried out to investigate the possibility of using coriander (*Coriandrum sativum* L.) in the production of cheese, its effect on the sensory and microbiological properties, and also on the overall quality of the cheese. For this purpose, different amounts of coriander (0, 1, and 3%) were used to assess its effects on cheese, encoded as C0, C1, and C2, respectively. Throughout the storage period at 2, 7, 15, 30, 60, 75, and 90 days, microbiological, physical, chemical, and sensory analyses were performed. The results demonstrated that the coriander level had a significant ($p < 0.05$) effect on the total viable bacterial count, including the number of lactic acid bacteria, yeast and mould, and lactococci. The effects of coriander on the pH and dry matter, over the storage period, were also significant ($p < 0.05$). Sensory scores declined during the storage period; but even on day 60, the samples were favourably scored. The results show that the addition of coriander had a positive effect on the cheese, and can be used successfully in production. Coriander may increase the consumption of cheese and improve consumer health.

Introduction

Cheese is the generic name for a group of fermented milk-based food products that are produced throughout the world in a great diversity of flavour, texture, and form (Fox *et al.,* 2017). Cheese is obtained from curded milk through the removal of whey from curds, which are then ripened in the presence of special microflora (Asensio *et al.,* 2015). Approximately, 40 to 50 cheese varieties are available in Turkey, from over 1000 varieties produced in the world (Hayaloglu *et al.,* 2002). In Turkey, many varieties are manufactured, but their production is often restricted to certain geographic areas (Turgut *et al.,* 2012).

Herbed cheese ("*otlu peynir*" in Turkish) has been produced and consumed for more than 200 years in eastern parts of Turkey. It is produced using about 25 different herbs, which are indigenous to this region, and give the cheese a characteristic appearance and an aroma of garlic and thyme, while also extending its shelf life. Herbs can be used either individually or as a mixture. The most commonly used herbs belong to the Liliaceae (*Allium* sp.), Apiaceae (*Ferula* sp.), and Lamiaceae (*Thymus migricus*) families (Hayaloglu *et al.,* 2002; Ocak *et al.,* 2015).

Coriander (*Coriandrum sativum* L.) is a fragrant annual herb of the Apiaceae family, widely grown in Asia, North Africa, the Middle East, Southern and Eastern Europe (Barros *et al.,* 2012; Sahib *et al.,* 2013; Bhat *et al.,* 2014). Coriander's fresh leaves and seeds are used for their organoleptic and flavouring properties. The main flavour and taste components in coriander includes various aldehydes, polyphenols, and terpenes, including linalool. Linalool's two enantiomeric forms are linalool and coriandrol (Eriksson *et al.,* 2012). Coriander seeds are used in traditional medicine, and extracts from different parts of coriander have been reported to exhibit antioxidant, anti-inflammatory, antidiabetic, and anticancer activities (Zhang *et al.,* 2015; El-Sayed and Youssef, 2019). Coriander is commonly used to flavour the cuisines of China, Mexico, South America, India, and South East Asia (Wong and Kitts, 2006). The use of coriander in Turkey is very common, and is generally used in "*ayran aşı*" soup and salads. "*Ayran aşı*" soup is a traditional food of Erzurum province, and is often consumed daily during the month of Ramadan.

The main purpose of the present work was to produce a new variety of herbed cheese, containing coriander. It also aimed to evaluate the effects of different amounts of coriander on the properties of the cheese.

Materials and methods

Materials

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Raw cow's milk was obtained from the dairy farm of the Faculty of Agriculture, Atatürk University (Erzurum, Turkey). Rennet of animal origin was used to coagulate the milk, provided by Maysa (Turkey). Coriander was purchased from a local grocery in Erzurum.

Production of cheese

Experimental cheeses were produced at the pilot dairy plant of the Faculty of Agriculture, Atatürk University (Erzurum, Turkey). Cheeses were produced according to the traditional standard of white cheese procedure (Hayaloglu *et al.,* 2002), without using starter cultures. Milk was pasteurised at 65°C for 30 min, cooled to 45°C, and supplemented with $CaCl_2$ (20 g/100 L). The milk was renneted (Mayasan, Turkey) at 34°C, and divided into three equals parts to produce three different cheeses. The first cheese was the control group (C0), produced without coriander. A proportion of 1% coriander was added to the second cheese (C1), and 3% coriander was added to the third cheese (C2). After coagulating for 90 min, the curd was cut into portions (1 - 2 cm^3 each), and the pre-weighed coriander was added at 1 or 3%, based on the weight of the sample before the removal of whey. The curd was stirred and allowed to rest in the whey for 5 - 10 min. Then, the curd was transferred into cheese boats, covered with filter cloth, and drained without any pressure for 20 min. After whey drainage, the cheese was pressed for 3 h, and brined overnight (16% NaCl, w/w). The next day, the curds were placed into plastic boxes filled with brine (12% NaCl, w/w), and stored for 90 days at 4 ± 1°C. All cheese samples were subjected to microbiological, physical, chemical, and sensory analyses on days 2, 7, 15, 30, 60, 75, and 90.

Physical and chemical analysis

Total dry matter (DM) was determined by drying the cheese samples in an oven for 12 h at 102 ± 2°C. The pH values of the cheese samples were measured with a digital pH meter (pH 211, Hanna Instruments, Portugal). Titratable acidity (TA) (lactic acid, %) was determined by the alkali titration method, and expressed as a percentage of lactic acid. The fat content of the cheese samples was determined using the Gerber method. Protein content (measured by a Micro Kjeldahl, Velp Scientifica UDK132, Europa) and the salt content were determined by methods described by Metin and Öztürk (2010). A "nitrogen to protein" conversion factor of 6.38 was used. All analyses were performed in duplicate.

Microbiological analysis

Ten cheese samples (10 g each) were homogenised with 90 mL of saline water (8.5 g/L) with a stomacher (HG 400; Mayo International, Milan, Italy) to make an initial dilution of 10^{-1}. This dilution was used for making serial dilutions of up to 10^{-7} with sterile saline water, in sterile tubes, and then spread-inoculated onto plates, in duplicate. After the incubation time, plates were evaluated, and the colony forming units per gram (CFU/g) of cheese sample were recorded.

i) Lactococci: M17 Agar (Merck, Germany) was used to count presumptive lactococci in cheese samples. M17 Agar allowed the growth of streptococci as small, round, and white colonies. Plates were incubated in aerobic conditions at 37°C for 72 h (Harrigan, 1998).

ii) Lactic acid bacteria (LAB): De Man, Rogosa, and Sharpe Agar (MRS, Merck, Germany) was used for counting LAB in cheese samples. Inoculated plates were incubated under anaerobic condition (Anaerocult C, Merck, Germany) at 37°C for 72 h (Harrigan, 1998).

iii) Total viable count (TVC): Plate count agar (PCA, Merck, Germany) was used to determine TVC. Inoculated agar plates were incubated at 30 - 32°C for 24 h.

iv) Coliforms: Violet Red Bile Agar (Merck, Germany) was used (35 - 37°C for 24 h).

v) Yeast and mould counts were determined on Potato Dextrose Agar (Merck, Germany) and acidified with 10% tartaric acid (Merck, Germany). Plates were incubated at 23 - 25°C for 5 -7 d, as described by Harrigan (1998).

The pour plate technique was used, and all microbiological analyses were performed in duplicate.

Sensory evaluation

The sensory profiles of the cheeses were compiled by seven expert panellists for all properties (appearance, texture, odour, flavour, and general acceptability), as described by Bodyfelt *et al.* (1988). Sensory criteria were adopted by considering the properties of the herbed cheese. The panellists were selected from non-smokers who were familiar with white cheese. They evaluated cheeses that had been stored for up to 90 d. Water and bread were also provided to the panellists to cleanse their palate between samples.

Statistical analysis

Univariate statistical analyses were used to evaluate the microbiological, physicochemical, and sensory assessments made on days 2, 7, 15, 30, 60, 75, and 90. All analyses were conducted twice. Data obtained were compared by Duncan's multiple range tests to determine the statistical significance of differences ($p < 0.05$), using the software SPSS 20.0 for Windows (Chicago, IL., USA).

Results and discussion

Physical and chemical characteristics

Table 1 shows the results of chemical and microbiological analysis of cheese samples throughout 90 days of storage. The mean pH values of the cheese types ranged from 6.186 (for C0 and C2) to 6.239 (for C1). The concentration of coriander had a significant effect ($p < 0.05$) on the pH value of the cheeses, but storage time did not affect the pH values. This finding may be explained by the high salt concentration used; the salting process can affect the pH of cheese due to its adverse effect on microbial activity (Güven *et al.,* 2006). The highest TA value was found in C2 (0.16%), and the lowest was in C0 (0.156%) (Table 1). Both the addition of coriander and the time in storage slightly increased the mean TA value of samples, but the differences were not significant ($p > 0.05$). The mean DM of cheese samples ranged from 37.695% (C2) to 40.428% (C0), and these differences were found to be significant ($p < 0.05$) (Table 1). The DM of cheeses with coriander were < 40%; and according to the Turkish Food Codex Regulation (2015), the DM content of cheeses should be at least 40%. The DM increased during the storage period, but the differences between means were not significant ($p > 0.05$).

The mean salt content ranged from 5.461 - 5.704%. The differences between the mean values were not affected by the storage time or by the addition of coriander ($p > 0.05$). In the same way, there were no significant ($p > 0.05$) differences between the cheese samples in terms of the amount of protein (Table 2).

The highest proportion of fat was found in C2 (12.734%), while the lowest in C0 (12.464%) (Table 1). The addition of coriander and the storage period did not significantly affect the amount of fat ($p > 0.05$). The amount of fat increased during the storage period, but the differences were not significant ($p > 0.05$). Fat-in-dry matter (FDM) values were significantly affected ($p < 0.05$) by the different concentrations of coriander. Increasing the amount of coriander resulted in higher FDM values. This increase can be explained by the decrease in the dry matter of the cheese. The highest mean FDM value (33.823%) was found in C2, while the lowest value (30.891%) in C0. The FDM value increased during storage, but the differences were not significant ($p > 0.05$).

According to the Turkish Food Codex Regulation (2015), white cheese is divided into four groups, based on the FDM value. By this measure, the FDM value of half-fat cheeses must be 25 - 45%. In the present work, the FDM value of cheeses met the Turkish legislative specification for half-fat cheese.

Viable counts

The changes in the TVC, as well as the counts of yeast and mould, LAB, and presumptive lactococci in cheese samples throughout the storage period are shown in Table 2. There were significant differences ($p < 0.01$) among C0, C1, and C2 regarding TVC. The TVC was affected both by the addition of coriander and the storage time.

The mean TVC of the cheese types ranged from log 5.457 - 5.816 CFU/g. C0 had the highest TVC, while C2 had the lowest (Table 2). The TVC increased during the ripening period in all cheese samples. However, C2 had approximately 0.3 log unit lower TVC than that of C0 at the end of storage. This result suggests that coriander has an inhibitive effect on microbial growth, over a certain period. The addition of different amounts of coriander had a significant effect on the TVC. Similar results were also found for LAB, presumptive lactococci, and yeast and mould counts.

The highest TVC (log 6.42 CFU/g) was found on the 90th day, and the lowest (log 4.96 CFU/g) was found on the 2nd day (Table 2); this difference was found to be significant ($p < 0.05$). The interaction between the level of coriander and storage time resulted in a significant effect on the TVC ($p < 0.05$). The changes in TVC reported in the present work are the opposite of those reported by Çakır and Çakmakçı (2018), for Tulum cheese, which showed a continuous decrease during 60 days of ripening. In the present work, TVC increased in all cheese samples until the 75th day of storage. Unchanged TVC is a consequence of the thermal treatment of curd, whereas white cheese does not undergo thermal curd processing. According to the Turkish Food Codex of microbiological criteria (Turkish Food Codex Regulation, 2015), only melted cheese requires that TVC and yeast and mould count to be assessed.

Table 1. The changes in chemical characteristics of cheese samples added with coriander during storage.

Treatment	Ripening time (days)	Dry matter (%)	Fat (%)	Fat in dry matter (%)	Total protein (%)	Salt (%)	pH	Acidity (%)
C0	2	38.685 ± 1.520	12.345 ± 0.629	31.905 ± 0.374	12.390 ± 0.848	4.975 ± 2.045	6.200 ± 0.016	0.145 ± 0.007
	7	40.031 ± 2.290	11.295 ± 0.777	28.270 ± 1.810	12.870 ± 0.919	5.361 ± 1.627	6.225 ± 0.035	0.140 ± 0.007
	15	40.775 ± 1.166	12.275 ± 0.530	30.135 ± 2.156	13.100 ± 0.155	6.090 ± 0.466	6.175 ± 0.106	0.155 ± 0.072
	30	40.610 ± 1.583	12.880 ± 0.141	31.730 ± 0.890	12.805 ± 1.326	5.600 ± 1.216	6.250 ± 0.071	0.160 ± 0.014
	45	39.077 ± 4.750	12.780 ± 0.555	32.925 ± 3.613	12.500 ± 0.025	5.461 ± 1.203	6.175 ± 0.106	0.160 ± 0.014
	60	41.625 ± 0.572	12.960 ± 0.226	31.140 ± 0.975	11.770 ± 0.890	5.333 ± 0.504	6.125 ± 0.035	0.185 ± 0.021
	90	42.195 ± 0.685	12.715 ± 0.374	30.130 ± 0.395	13.780 ± 0.042	5.410 ± 1.202	6.150 ± 0.070	0.150 ± 0.014
	mean	**40.428 ± 2.04[a]**	**12.463 ± 0.614**	**30.891 ± 1.989[a]**	**12.745 ± 0.826**	**5.461 ± 0.995**	**6.186 ± 0.070[a]**	**0.156 ± 0.017**
C1	2	37.700 ± 2.942	11.585 ± 0.487	30.875 ± 3.698	12.760 ± 1.272	5.315 ± 1.689	6.275 ± 0.036	0.145 ± 0.007
	7	39.980 ± 3.634	12.525 ± 1.605	31.275 ± 1.166	12.960 ± 2.573	5.720 ± 1.145	6.300 ± 0.035	0.165 ± 0.007
	15	39.500 ± 4.624	12.965 ± 0.374	32.990 ± 2.913	12.055 ± 0.544	6.120 ± 0.339	6.200 ± 0.071	0.140 ± 0.008
	30	39.215 ± 3.741	12.930 ± 0.707	33.035 ± 1.350	12.765 ± 2.057	5.570 ± 1.060	6.200 ± 0.070	0.155 ± 0.007
	45	38.001 ± 1.837	12.930 ± 0.975	34.005 ± 0.920	13.430 ± 0.452	5.400 ± 1.499	6.200 ± 0.070	0.160 ± 0.014
	60	39.970 ± 1.781	12.615 ± 1.859	31.490 ± 3.252	12.980 ± 1.173	5.716 ±1.378	6.275 ± 0.106	0.180 ± 0.028
	90	40.645 ± 1.562	13.475 ± 0.210	33.185 ± 1.746	12.815 ± 1.364	5.459 ± 1.284	6.225 ± 0.050	0.155 ± 0.007
	mean	**39.287 ± 2.485[b]**	**12.718 ± 0.961**	**32.408 ± 2.085[b]**	**12.824 ±1.184**	**5.614 ± 0.964**	**6.239 ± 0.594[b]**	**0.157 ± 0.016**
C2	2	36.280 ± 2.276	11.815 ± 0.968	32.710 ± 4.723	12.935 ±1.011	5.290 ± 1.654	6.200 ± 0.035	0.175 ± 0.007

	7	37.200 ± 0.833	12.755 ± 0.219	34.300 ± 1.357	11.955 ± 1.152	5.631 ± 0.970	6.225 ± 0.106	0.155 ± 0.021
	15	37.880 ± 0.890	13.000 ± 0.282	34.320 ± 0.565	11.680 ± 0.763	5.083 ± 0.565	6.275 ± 0.035	0.155 ± 0.021
	30	37.236 ± 0.217	12.875 ± 0.940	34.585 ± 2.722	13.005 ± 0.289	5.766 ± 0.885	6.125 ± 0.012	0.155 ± 0.007
	45	37.701 ± 1.214	12.895 ± 0.940	34.265 ± 3.590	12.240 ± 0.791	5.520 ± 1.329	6.150 ± 0.035	0.165 ± 0.006
	60	39.235 ± 0.742	13.090 ± 0.480	33.380 ± 1.753	12.835 ± 1.378	5.695 ± 1.209	6.175 ± 0.012	0.145 ± 0.007
	90	38.330 ± 1.244	12.710 ± 0.579	33.200 ± 2.588	12.040 ± 1.032	5.432 ± 0.577	6.150 ± 0.02	0.170 ± 0.081
	mean	**37.695 ± 1.265^{b}**	**12.734 ± 0.652**	**33.823 ± 2.156^{b}**	**12.384 ± 0.878**	**5.488 ± 0.819**	**6.186 ± 0.456^{a}**	**0.160 ± 0.014**
Overall Mean	2	37.555 ± 2.097^{a}	11.915 ± 0.660	31.830 ± 2.811	12.695 ± 0.856	5.193 ± 1.395	6.225 ± 0.045	0.155 ± 0.016^{ab}
	7	39.070 ± 2.435^{ab}	12.192 ± 1.009	31.282 ± 2.927	12.595 ± 1.416	5.571 ± 1.004	6.250 ± 0.077	0.153 ± 0.015^{a}
	15	39.385 ± 2.528^{ab}	12.747 ± 0.483	32.482 ± 2.507	12.278 ± 0.783	5.764 ± 0.588	6.200 ± 0.058	0.150 ± 0.0126^{a}
	30	37.020 ± 2.368^{ab}	12.895 ± 0.530	33.117 ± 1.910	12.858 ± 1.110	5.645 ± 0.828	6.208 ± 0.052	0.157 ± 0.009^{ab}
	45	38.260 ± 2.431^{a}	12.868 ± 0.614	33.732 ± 2.403	12.723 ± 0.692	5.460 ± 1.046	6.175 ± 0.086	0.162 ± 0.025^{ab}
	60	40.272 ± 1.417^{b}	12.888 ± 0.888	32.003 ± 2.020	12.528 ± 1.079	5.581 ± 0.828	6.192 ± 0.052	0.170 ± 0.012^{b}
	90	40.390 ± 2.253^{b}	12.967 ± 0.507	32.173 ± 2.117	12.878 ± 0.971	5.433 ± 0.909	6.175 ± 0.618	0.158 ± 0.015^{b}
Herb added	3	*	NS	*	NS	NS	NS	*
Ripening time	7	NS	NS	NS	NS	NS	NS	NS

C0 = white cheese (0%, Control); C1 = cheese with 1% coriander; C2 = cheese with 3% coriander. Means of treatments with similar superscripted lowercase letter in a column did not differ significantly from Duncan's multiple range tests at 5% significance (**p** > 0.05). * = significant; NS = not significant.

Table 2. Changes in microbiological characteristics of cheese samples added with coriander during ripening (log CFU/g).

Treatment	Ripening time (days)	Lactobacilli count	Lactococci count	TVC count	Yeast and mould count	Coliform count
C0	2	4.666 ± 0.045	4.942 ± 0.018	5.042 ± 0.124	3.253 ± 0.069	2.912
	7	4.671 ± 0.098	5.096 ± 0.049	5.337 ± 0.035	3.477 ± 0.011	2.25
	15	4.438 ± 0.056	4.988 ± 0.076	5.317 ± 0.050	3.580 ± 0.005	2.54
	30	4.255 ± 0.034	5.041 ± 0.011	5.540 ± 0.088	3.759 ± 0.164	< 2
	45	4.113 ± 0.047	6.525 ± 0.109	6.363 ± 0.118	3.991 ± 0.301	< 2
	60	4.073 ± 0.103	5.801 ± 0.707	6.567 ± 0.502	3.990 ± 0.301	< 2
	90	4.118 ± 0.059	6.306 ± 0.129	6.543 ± 0.096	3.980 ± 0.190	< 2
	mean	**4.343 ± 0.246^{a}**	**5.528 ± 0.068^{a}**	**5.816 ± 0.629^{a}**	**3.719 ± 0.313^{a}**	**-**
C1	2	4.454 ± 0.033	4.712 ± 0.017	5.000 ± 0.086	2.900 ± 0.770	2.45
	7	4.239 ± 0.088	4.977 ± 0.033	5.115 ± 0.162	3.239 ± 0.377	2.054
	15	4.021 ± 0.029	4.98 ± 0.029	5.272 ± 0.041	3.631 ± 0.071	< 2
	30	4.029 ± 0.002	5.349 ± 0.068	5.613 ± 0.012	3.230 ± 0.461	< 2
	45	3.977 ± 0.033	6.362 ± 0.011	6.201 ± 0.171	4.023 ± 0.169	< 2
	60	3.866 ± 0.124	5.279 ± 0.015	6.338 ± 0.084	4.230 ± 0.001	< 2
	90	3.874 ± 0.041	6.380 ± 0.176	6.438 ± 0.056	3.845 ± 0.001	< 2
	mean	**4.066 ± 0.208^{b}**	**5.434 ± 0.64^{ab}**	**5.711 ± 0.589^{ab}**	**3.585 ± 0.492^{ab}**	**-**
C2	2	4.389 ± 0.124	4.618 ± 0.022	4.848 ± 0.078	2.690 ± 0.124	2.345
	7	4.278 ± 0.032	4.827 ± 0.069	4.946 ± 0.076	3.057 ± 0.081	2.174
	15	4.000 ± 0.001	4.653 ± 0.021	5.094 ± 0.074	3.554 ± 0.069	< 2
	30	4.155 ± 0.107	4.958 ± 0.117	5.079 ± 0.176	3.544 ± 0.018	< 2
	45	3.945 ± 0.347	5.989 ± 0.647	5.683 ± 0.113	3.579 ± 0.033	< 2
	60	3.778 ± 0.313	5.602 ± 0.010	6.273 ± 0.008	4.090 ± 0.079	< 2
	90	3.900 ± 0.077	6.190 ± 0.020	6.275 ± 4.434	3.874 ± 0.038	< 2
	mean	**4.064 ± 0.252^{b}**	**5.434 ± 0.65^{b}**	**5.457 ± 1.542^{b}**	**3.484 ± 0.471^{b}**	**-**
Overall Mean	2	4.503 ± 0.143^{a}	4.757 ± 0.149^{a}	4.963 ± 0.119^{a}	2.947 ± 0.264^{a}	2.569
	7	4.396 ± 0.223^{a}	4.966 ± 0.127^{ab}	5.133 ± 0.193^{ab}	3.258 ± 0.244^{b}	2.159
	15	4.153 ± 0.226^{b}	4.874 ± 0.174^{ab}	5.227 ± 0.114^{ab}	3.588 ± 0.056^{c}	-
	30	4.146 ± 0.112^{b}	5.116 ± 0.194^{b}	5.411 ± 0.275^{ab}	3.511 ± 0.323^{c}	-
	45	4.011 ± 0.176^{c}	6.292 ± 0.382^{d}	6.082 ± 0.335^{ab}	3.864 ± 0.270^{d}	-
	60	3.906 ± 0.208^{c}	5.561 ± 0.394^{c}	6.393 ± 0.144^{b}	4.101 ± 0.175^{d}	-
	90	3.987 ± 0.163^{c}	6.292 ± 0.130^{d}	6.419 ± 2.634^{ab}	3.900 ± 0.433^{d}	-
Herb added	3	*	*	*	*	-
Ripening time	7	NS	NS	NS	NS	-

C0 = white cheese (0%, Control); C1 = cheese with 1% coriander; C2 = cheese with 3% coriander. Means of treatments with similar superscripted lowercase letter in a column did not differ significantly from Duncan's multiple range tests at 5% significance ($p > 0.05$). * = significant; NS = not significant.

Despite the frequent occurrence of yeasts in many dairy products, it is generally accepted that they have undesirable effects on the quality of the products (Viljoen, 2001). The numbers of yeast and mould in the cheeses were found to be log 3.484 - 3.719 CFU/g. There were significant differences ($p < 0.05$) between the C0, C1, and C2 cheeses regarding the yeast and mould count. C0 had the highest mean count (log 3.719 ± 0.313 CFU/g), while C2 had the lowest (log 3.484 ± 0.471 CFU/g) (Table 2). Storage time also had a significant effect on yeast and mould counts ($p < 0.01$). The highest number (log 4.104 CFU/g) was found on the 75th day, and the lowest number (log 2.947 CFU/g) was found on the 2nd day (Table 2). The mean yeast and mould count of cheese samples increased by approximately 1 log during the ripening period. The yeast and mould counts decreased significantly ($p < 0.05$) as the amount of coriander increased. According to the Turkish Food Codex of microbiological criteria (Turkish Food Codex Regulation, 2015), there is no restrictive limitation on the number of yeast and mould cells present.

After the first days of storage, the total coliform count began to decrease in all cheese samples. Coliform bacteria were not detected (log < 2 CFU/g) in C1 and C2 after the 15th day, whereas in C0, it took until the 30th day to reach the same value. The highest number of coliform bacteria was found in C0 on the 2nd day (log 2.91 CFU/g), and the lowest in C2 on the 7th day (log 2.17 CFU/g) (Table 2). Additionally, C2 had lower counts of coliform than C1. The total coliform counts in the cheese samples decreased as the amount of coriander increased. This result indicates that the use of coriander reduces the population of coliform bacteria in the cheese.

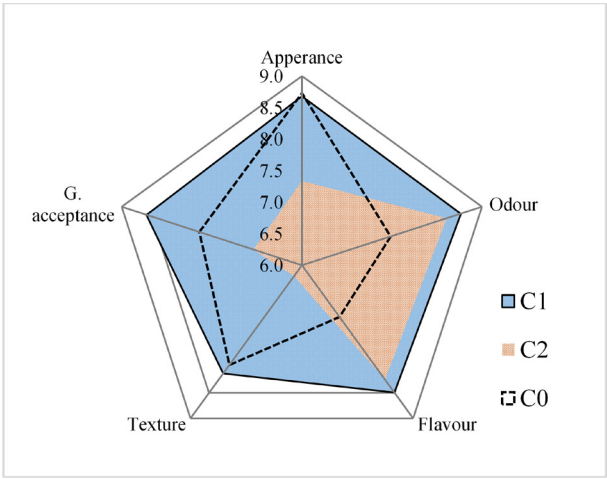
The mean LAB content of the cheese samples was found to be log 4.064 - 4.343 CFU/g. The LAB content was affected both by the addition of coriander ($p < 0.01$) and the storage period ($p < 0.01$). C0 had the highest LAB content, while C2 the lowest (Table 2). This finding can be explained by the fact that coriander was a critical factor influencing the viability of LAB. An increase in coriander led to a decrease in the LAB number. The highest LAB number (log 4.503 CFU/g) was found on the 2nd day, and the lowest (log 3.906 CFU/g) was found on the 75th day (Table 2), having decreased during the storage period. After the 60th day of storage, the LAB number was stable, and differences between samples were not significant ($p > 0.05$). These results were consistent with the results reported by Çakmakçı *et al.* (2008) for Tulum cheese. The mean LAB number was found to be lower than that of presumptive lactococci by 2 log units, which can be explained by the fact that LAB is more sensitive to salt and cold storage conditions, as compared to lactococci (Rallu *et al.,* 2000).

The mean presumptive lactobacilli number for the cheeses was log 5.262 - 5.528 CFU/g (Table 2). C1 and C2 had the lowest presumptive lactobacilli number, while C0 had the highest; this difference was found to be significant ($p < 0.05$). This can be explained by the fact that the addition of coriander was a critical factor influencing the viability of presumptive lactococci, similarly to LAB. The presumptive lactobacilli number was also influenced by the storage time ($p < 0.01$) increasing during storage. The highest number (log 6.292 CFU/g) was found on 90th day, and the lowest value (log 4.757 CFU/g) was found on the 2nd day (Table 2). After the 30th day of storage, the numbers of presumptive lactococci were significantly different between cheeses ($p < 0.05$), which can be explained by coriander having an inhibitory effect on presumptive lactococci, especially after 30 days.

Sensory analyses

The quality of food products is largely determined by sensory perception, which is a complex process that is influenced by many factors such as the content of flavour components, texture, and appearance (Smit *et al.,* 2005). Five sensory attributes were analysed for a descriptive analysis. The sensory property scores of the cheeses with and without coriander are presented in Table 3 and Figure 1, respectively. The addition of coriander to the cheese had an effect on all of the sensory scores. Significant differences ($p < 0.01$) were found among C0, C1, and C2 with respect to appearance, texture, odour, flavour, and general acceptability scores.

Figure 1. Sensory scores of cheese samples added with coriander.



Storage time was found to be significant ($p < 0.01$) for odour, flavour, and general acceptability.

The mean appearance scores of the cheese samples ranged from 7.34 for C2 to 8.73 for C0 (Table 3). The odour and flavour scores are considered to be related to the shelf life of the cheese. There were significant differences ($p < 0.01$) among C0, C1 and C2 for the odour and flavour scores. For

Table 3. The changes in sensory characteristics of cheese samples added with coriander during ripening.

Treatment	Ripening time (days)	Appearance	Odour	Flavour	Texture	General acceptability
C0	2	8.930 ± 0.110	7.910 ± 0.049	7.060 ± 0.085	8.010 ± 0.156	7.850 ± 0.141
	7	8.880 ± 0.018	7.650 ± 0.707	7.360 ± 0.558	8.420 ± 0.424	7.980 ± 0.240
	15	8.980 ± 0.035	7.670 ± 0.254	7.310 ± 0.566	8.290 ± 0.233	8.700 ± 0.283
	30	8.960 ± 0.049	7.410 ± 0.084	7.460 ± 0.007	7.870 ± 0.035	8.070 ± 0.396
	45	8.960 ± 0.064	7.650 ± 0.350	6.830 ± 0.417	8.020 ± 0.141	8.130 ± 0.629
	60	8.450 ± 0.615	7.910 ± 0.050	6.740 ± 0.551	7.420 ± 0.395	6.860 ± 0.353
	90	7.980 ± 0.035	5.910 ± 0.420	6.310 ± 0.210	7.610 ± 1.010	6.350 ± 0.629
	mean	**8.730 ± 0.411^{a}**	**7.480 ± 0.710^{a}**	**7.006 ± 0.500^{a}**	**7.940 ± 0.475^{a}**	**7.700 ± 0.188^{a}**
C1	2	8.930 ± 0.106	8.820 ± 0.092	7.980 ± 0.028	8.080 ± 0.248	8.850 ± 0.078
	7	8.875 ± 0.176	8.870 ± 0.021	8.455 ± 0.700	8.290 ± 0.478	8.600 ± 0.240
	15	8.365 ± 0.516	8.920 ± 0.049	8.910 ± 0.078	8.310 ± 0.269	8.750 ± 0.282
	30	8.975 ± 0.035	8.770 ± 0.162	8.710 ± 0.360	8.110 ± 0.177	8.890 ± 0.565
	45	8.375 ± 0.530	8.520 ± 0.516	8.590 ± 0.240	8.160 ± 0.368	8.610 ± 0.226
	60	8.980 ± 0.035	8.520 ± 0.516	8.430 ± 0.424	7.920 ± 0.354	8.450 ± 0.064
	90	8.280 ± 0.388	8.170 ± 0.403	8.420 ± 0.049	7.970 ± 0.106	8.030 ± 0.742
	mean	**8.680 ± 0.392^{b}**	**8.650 ± 0.349^{b}**	**8.500 ± 0.379^{c}**	**8.120 ± 0.242^{a}**	**8.630 ± 0.370^{b}**
C2	2	7.480 ± 0.671	8.570 ± 0.162	7.990 ± 0.021	6.510 ± 0.548	7.730 ± 1.096
	7	7.580 ± 0.388	8.720 ± 0.332	8.60 ± 0.353	6.010 ± 0.159	6.950 ± 0.064
	15	6.870 ± 1.237	8.170 ± 0.403	8.310 ± 0.558	5.960 ± 0.298	6.810 ± 0.057
	30	6.970 ± 1.364	8.330 ± 0.028	8.260 ± 0.417	6.260 ± 0.194	6.930 ± 0.085
	45	7.460 ± 0.650	8.460 ± 0.014	8.310 ± 0.487	6.230 ± 0.159	6.700 ± 0.424
	60	7.530 ± 0.318	8.210 ± 0.070	8.210 ± 0.630	6.310 ± 0.265	6.570 ± 0.480
	90	7.480 ± 0.671	8.430 ± 0.021	7.990 ± 0.210	6.120 ± 0.004	6.020 ± 0.127
	mean	**7.340 ± 0.677^{b}**	**8.410 ± 0.243^{b}**	**8.240 ± 0.373^{b}**	**6.200 ± 0.268^{b}**	**6.810 ± 0.605^{c}**
Overall Mean	2	8.440 ± 0.809	8.430 ± 0.424^{a}	7.650 ± 0.518^{ab}	7.532 ± 0.840	8.140 ± 0.739a
	7	8.410 ± 0.702	8.410 ± 0.687^{a}	8.140 ± 0.745^{a}	7.573 ± 1.245	7.840 ± 0.762^{ab}
	15	8.070 ± 1.137	8.250 ± 0.600^{a}	8.170 ± 0.804^{a}	7.519 ± 1.220	8.090 ± 1.005^{a}
	30	8.300 ± 1.202	8.240 ± 0.514^{a}	8.140 ± 0.617^{a}	7.420 ± 0.904	7.960 ± 0.890^{a}
	45	8.260 ± 0.772	8.210 ± 0.512^{a}	7.910 ± 0.901^{ab}	7.470 ± 0.978	7.810 ± 0.914^{ab}
	60	8.330 ± 0.729	8.210 ± 0.356^{a}	7.790 ± 0.921^{ab}	7.220 ± 0.769	7.290 ± 1.026^{bc}
	90	7.910 ± 0.501	7.500 ± 1.247^{b}	7.570 ± 1.010^{b}	7.240 ± 0.990	6.790 ± 0.957^{c}
Herb added	3	*	*	*	*	*
Ripening time	7	NS	NS	NS	NS	NS

C0 = white cheese (0%, Control); C1 = cheese with 1% coriander; C2 = cheese with 3% coriander. Means of treatments with similar superscripted lowercase letter in a column did not differ significantly from Duncan's multiple range tests at 5% significance ($p > 0.05$). * = significant; NS = not significant.

odour and flavour, both the amount of coriander and the storage time were found to be significant ($p < 0.01$). C1 received significantly higher odour scores as compared to the others ($p < 0.05$). The odour scores decreased during the ripening period, but significant ($p < 0.05$) differences were observed only after the 75th day of storage. Similarly, the highest flavour scores were obtained for C1 on the 7th and 30th days, and the lowest flavour scores were obtained for C0 on the 90th day. The flavour scores did fluctuate, and the differences were significant ($p < 0.05$). The mean texture scores of the cheese samples ranged from 6.20 for C2 to 8.12 for C1 (Table 3). The texture scores were not significantly influenced by the storage time ($p > 0.05$). The highest mean general acceptability score was given to the 1% coriander cheese. General acceptability scores were affected both by the addition of coriander ($p < 0.01$) and by the storage period ($p < 0.01$). As expected, general acceptability scores decreased with increasing storage time. The highest acceptability score (8.14) was found on the 2nd day, while the lowest value (6.79) was found the 90th day (Table 3). There was no significant difference ($p > 0.05$) in the general acceptability scores between the 2nd and the 30th day; however, after the 60th day, scores differed significantly from those at the start ($p < 0.05$).

Conclusion

Although many herbs can be used in the production of cheese, the present work is the first attempt of investigating the addition of coriander. It was found that the addition of coriander did not have a significant effect on some of the physical and chemical properties of the cheese. In general, the use of coriander did not influence the titratable acidity, salt content, total protein content, or fat content of the cheese. However, coriander did influence the pH and solid matter content. Moreover, the addition of coriander significantly affected the microbial flora of the cheese. Most notably, as the amount of coriander increased, the counts of TVC, LAB, presumptive lactococci, and yeast and mould decreased. The results also showed that coriander increases the flavour and attractiveness of cheese.

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