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The effects of different salting and preservation techniques of kaşar cheese on cheese quality

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Abstract: The aim of this research is to determine the effects of different salting and preservation techniques on the quality of kaşar cheese. Physical, chemical, and microbiological analyses were performed on days 1, 7, 15, 30, 60, 90, and 120 of the maturation of 270 samples of kaşar cheese produced for this research. Additionally, sensory analyses were performed on days 30, 60, 90, and 120 of maturation. The total number of aerobic mesophilic bacteria, *Lactococcus, Staphylococcus-Micrococcus*, and psychotropic bacteria was lower and the number of yeast-mold and lactobacilli was higher in cheese examples salted in a boiler than those salted in brine. Salting in brine can be used alongside salting in a boiler. The cheese salted in a boiler can be preserved for 90 days by waxing it with respect to sensory features. Vacuum-packed cheese can be preserved for 60 days, whereas cheese salted in brine can be preserved for 60–120 days. It has been determined that vacuum-packed and wax-covered cheese does not have a negative effect on the quality of the cheese, nor is maturation delayed. It has been concluded that cheese wax can be used as an alternative packaging material along with vacuum packaging.

Key words: Kaşar cheese, salting technique, vacuum packaging, waxing

1. Introduction

Kaşar cheese is a hard cheese with a specific flavor, color, taste, and aroma, obtained by processing raw or pasteurized milk in compliance with the applicable standards (1). As the most produced and traded cheese in Turkey after white cheese, kaşar is mainly produced with the dry salting method. Excessive salt is consumed in the course of the dry salting process (approximately 7 kg per 100 kg of cheese), a process that needs considerable time and effort. High water loss is achieved with a low-performance brine method; this results in a more regular salt penetration into the cheese, which makes it easier to adjust the salt content as desired (2). In recent years, kaşar types usually consumed as mature are sold in vacuum packages. The vacuum package used in cheese packaging results in surface desiccation of the cheese and prevents any oxidizing effects that would adversely affect its taste and flavor. Vacuum packaging and storage at refrigerator temperature not only extend the shelf life of the cheese but also ensure that every shape and size of cheese will have a better and more efficient distribution (3). The purpose of waxing in semihard and hard cheeses is to give the cheese a clean and pleasant appearance, prevent water loss to reduce waste, and eliminate encrustation due to water loss, so that the development of microorganisms on the cheese surface is prevented, which, in turn, reduces the steps needed for cheese maintenance in the maturation depot (4).

2. Materials and methods

2.1. Cheese-making

The production of cheese was completed in 3 phases (Figure). Two packing materials were used for the packaging of the cheese samples (polyamide + polyethylene mixture, 90-µm thickness, and cheese wax).

2.2. Chemical analyses

Total solid content (%) in the samples was determined with the gravimetric method, where the dry matter oil content was divided by the total amount of dry matter (6). The Gerber method was used for the determination of oil content (%), while acidity was determined in % lactic acid by means of the titration method (7). The nitrogen content of samples in % was established with the micro-Kjeldahl method, and the result was multiplied by a factor of 6.38 to find the protein amount (%) (8). Salt content (%) was determined with the Mohr method (7), and the pH value with a pH meter (WTW3510i) (9). Although the ratio of

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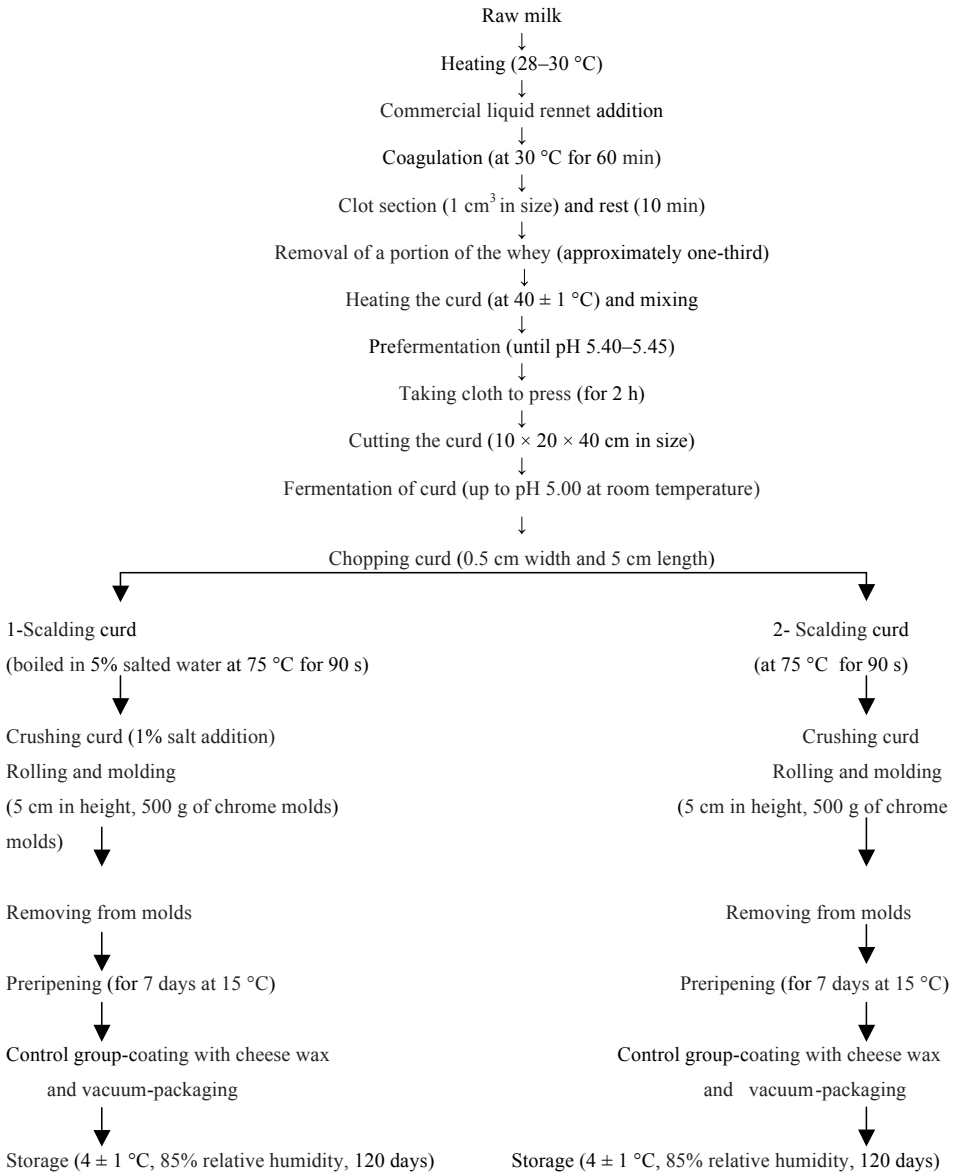

Figure. Flow chart of experimental kaşar cheese production (5).

water-soluble nitrogen was determined according to the method of Kuchroo and Fox (10), the maturation degree was defined by dividing the water-soluble nitrogen amount into total nitrogen contents. A portable hygrometer (Aqua LAB 4TE) was used to measure the water activity. The lipolysis value was determined with the BDI method (11).

2.3. Microbiological analyses

For the microbiological analyses, a 25-g cheese sample was weighed in a sterile Stomacher plastic pouch under aseptic conditions, and 225 mL of buffered peptone water was added to the sample before homogenization in a homogenizer (Stomacher). Afterwards, appropriate dilutions were prepared from the homogenate to form suitable diluents. The total aerobic mesophilic bacteria count was performed according to Halkman (12) for 72 h at 30 °C under aerobic conditions in a plate count agar (PCA) medium (Merck 1.05463), the lactic acid bacteria count according to Hagen and Narvhus (13) for 72 h at 37 °C under aerobic conditions in a de Man–Rogosa–Sharpe agar (Merck 1.10660) medium (Anaerocult A system, Merck 1.13829), the coliform bacteria count according to Turkish standards (14) for 24 h at 30 °C in a violet red bile agar medium (Oxoid, CM107), the *Staphylococcus-Micrococcus* count according to Harrigan (15) for 48 h at 37 °C in mannitol salt agar medium (Merck, 105404), *Lactococcus* count according to Turkish standards (16)

for 48 h at 37 °C in M17 medium (Oxoid, CM0785), *Staphylococcus aureus* count according to Turkish standards (17) for 24 h at 37 °C in a Baird–Parker agar (BP-Merck, 1.05406) medium supplemented with egg-yolk tellurite (Merck, 1.03785), the psychrophilic bacteria count according to Halkman (12) for 10 days at 6.5 °C in a PCA medium (PCA-Merck 1.05463), and the yeast and mold count according to Halkman (12) for 5–7 days at 25 °C in a potato dextrose agar medium (Merck 1.10130).

2.4. Sensorial analyses

The sensorial characteristics (taste, smell, section, appearance, structure, and color) were analyzed according to the method defined in Turkish standards (18).

3. Results and discussion

Tables 1–4 include the microbiological and chemical analysis results for kaşar cheese produced with different salting and packaging methods. When comparing the findings of previous studies on kaşar cheese with those cited here, it is observed that the pH values recorded in our study are similar to those obtained by Gürsoy (19), namely pH 5.01–5.14, and lower than those obtained by Atasever et al. (20), namely pH 5.72–6.11. The values determined in the wax-covered samples are lower than the values of pH 5.32–5.20 determined by Yılmaz (21) in kaşar cheese covered by wax. The pH values recorded in the vacuum-packed cheeses are lower than pH 5.49, as determined by Öksüztepe (22). The titration acidity we found ranged from 0.13 to 1.12 l.a., similar to the values of Coşkun and Öztürk (23), and from 0.69 to 0.83 l.a., similar to Tunçtürk et al. (24). Titration acidity in the wax-covered cheese samples was similar to the value of 0.87 l.a. of Ürkek (25), and 0.45–0.94 lower than that of Yılmaz (21). Titration acidity in the vacuum-packed samples was similar to the value of 0.49 l.a. found by Oysun and Can (26). The rate of dry matter in the cheese samples was higher than the value determined by Öztek (5) (46.49%–68.41%). The rate of dry matter in the wax-covered cheese samples was higher than the value found by Yılmaz (21) (57.6%–62.25%). The oil rate of dry matter in wax-covered cheese samples was found to fall between the values obtained by Yılmaz (21) (45.32%–45.80%). The findings of dry matter oil rate in the vacuum-packed cheeses were higher than the findings of Öksüztepe et al. (22). The protein values obtained in the

Table 1. Some microbiological analysis results for kaşar cheese produced by different salting methods (log CFU/g).

Characteristic	Sample	Day 1	Day 7	Day 15	Day 30	Day 60	Day 90	Day 120	F value
Total aerobic mesophilic bacteria	A	7.09 ± 0.75	7.70 ± 0.26	7.56 ± 0.60	7.83 ± 0.70	7.61 ± 0.67	7.66 ± 0.58	7.34 ± 0.64	1.11
	B	7.19 ± 0.94	7.22 ± 1.05	7.66 ± 1.01	7.59 ± 0.68	7.92 ± 0.56	8.03 ± 0.69	7.90 ± 0.85	1.54
	t value	0.22	1.32	0.25	0.73	1.34	0.86	2.12	
Lactobacillus	A	6.59 ± 1.36b	6.99 ± 1.19ab	7.89 ± 0.74a	8.16 ± 0.48a	8.65 ± 0.42ab	8.44 ± 0.50a	7.72 ± 2.20ab	3.92**
	B	6.51 ± 2.61b	6.73 ± 2.68ab	8.09 ± 0.60a	7.99 ± 0.40a	6.50 ± 3.72ab	8.04 ± 0.71a	7.26 ± 2.79ab	0.87
	t value	0.08	0.26	0.63	0.80	1.72	1.34	0.38	
Yeast and mold	A	1.16 ± 1.69B	2.48 ± 2.45B	2.76 ± 1.98	3.50 ± 1.64	3.50 ± 1.64	3.30 ± 1.62	3.02 ± 0.75	4.94**
	B	2.27 ± 1.76A	3.59 ± 0.52A	3.22 ± 1.96	3.20 ± 2.21	3.20 ± 2.21	3.06 ± 2.41	2.08 ± 2.17	0.36
	t value	2.58*	2.12*	0.22	0.36	0.36	0.85	2.06	
Lactococcus	A	5.61 ± 2.33	7.21 ± 0.82	6.98 ± 0.65	6.72 ± 0.36	6.72 ± 0.36	6.61 ± 0.23	5.80 ± 2.24	1.79
	B	6.12 ± 2.43	6.33 ± 2.51	6.89 ± 0.51	6.90 ± 0.26	6.90 ± 0.26	6.45 ± 0.51	6.72 ± 0.64	0.44
	t value	0.45	1.00	0.30	1.19	1.19	0.83	1.19	
Staphylococcus-Micrococcus	A	4.21 ± 2.07ab	4.20 ± 1.74ab	4.57 ± 0.75a	3.45 ± 2.05abc	3.45 ± 2.05abc	2.55 ± 1.97bc	1.60 ± 1.91c	3.43**
	B	3.96 ± 2.27ab	4.54 ± 1.76ab	5.17 ± 0.51a	3.65 ± 2.12abc	3.65 ± 2.12abc	3.91 ± 2.39bc	3.29 ± 2.51c	1.05
	t value	0.24	0.40	1.97	0.21	0.21	1.31	1.59	
Psychrophilic	A	2.48 ± 2.25b	2.61 ± 2.03ab	2.78 ± 2.13b	4.16 ± 1.72a	3.27 ± 2.53a	3.32 ± 2.04a	2.37 ± 2.34ab	1.85
	B	2.92 ± 2.65b	3.83 ± 2.20ab	3.02 ± 2.89b	4.53 ± 0.45a	4.40 ± 1.86a	4.24 ± 1.64a	4.10 ± 1.64ab	1.67
	t value	0.06	1.22	1.62	0.62	1.07	1.04	1.82	

*: $P < 0.05$; **: $P < 0.01$.

a–c: Differences between the averages not marked with an identical letter code in the same column are significant.

A, B: Differences between the groups not marked with an identical letter code in the same column are statistically significant.

A: Samples covered with wax in a cauldron by salting and vacuum-packed.

B: Samples covered with wax in brine and vacuum-packed.

Table 2. Some chemical analysis results for the kaşar cheese produced by different salting methods (mean ± SD).

Characteristic	Sample	Day 1	Day 7	Day 15	Day 30	Day 60	Day 90	Day 120	F value
pH value	A	5.22 ± 0.04aB	5.17 ± 0.02bB	5.13 ± 0.01cB	5.09 ± 0.01dB	5.06 ± 0.01deB	5.02 ± 0.01efB	4.99 ± 0.01fB	219.19**
	B	5.39 ± 0.02aA	5.34 ± 0.02bA	5.27 ± 0.02cA	5.21 ± 0.03dA	5.16 ± 0.03deA	5.12 ± 0.04efA	5.06 ± 0.04fA	113.34**
	t value	9.90**	15.40**	14.83**	9.23**	7.92**	6.68**	5.20**	
Titratable acidity (% l.a.)	A	0.19 ± 0.02gB	0.26 ± 0.01fB	0.35 ± 0.02eB	0.42 ± 0.03dB	0.47 ± 0.04cB	0.55 ± 0.04bB	0.68 ± 0.10a	98.99**
	B	0.23 ± 0.04gA	0.33 ± 0.07fA	0.46 ± 0.05eA	0.54 ± 0.05dA	0.61 ± 0.02cA	0.70 ± 0.04bA	0.80 ± 0.07a	121.21**
	t value	2.14*	2.52*	5.44**	5.64**	8.39**	6.97**	1.19	
Dry matter (%)	A	53.09 ± 1.92fB	53.42 ± 2.03efB	54.42 ± 2.31eB	56.14 ± 2.20dB	59.16 ± 2.20bcB	61.22 ± 2.61bB	64.20 ± 2.39aB	32.16**
	B	58.05 ± 1.34fA	58.85 ± 1.57efA	60.76 ± 1.56eA	62.14 ± 1.79dA	63.62 ± 2.36bcA	65.14 ± 2.24bA	67.28 ± 2.83aA	57.60**
	t value	6.32**	6.32**	6.79**	6.33**	4.13**	3.41**	2.57*	
Dry matter in fat (%)	A	42.36 ± 1.10cB	42.63 ± 1.15bcA	42.81 ± 1.19bcB	43.37 ± 1.18abB	43.68 ± 1.25abB	44.06 ± 1.33aB	44.52 ± 1.36aB	3.99*
	B	46.48 ± 2.06cA	47.28 ± 2.16bcA	47.90 ± 2.41bcA	48.12 ± 2.32abA	48.31 ± 2.25abA	49.28 ± 0.45aA	49.41 ± 2.04aA	2.43*
	t value	5.28**	5.68**	5.65**	5.45**	5.38**	5.64**	4.23**	
Protein (%)	A	25.87 ± 1.66d	27.39 ± 1.35c	28.78 ± 1.82bc	30.23 ± 1.44abA	31.52 ± 1.36aA	29.05 ± 1.19bc	27.85 ± 1.35c	14.43**
	B	27.09 ± 1.12d	27.86 ± 0.94c	28.25 ± 1.08bc	28.82 ± 1.28abB	29.43 ± 1.61aB	28.34 ± 1.60bc	27.57 ± 1.68c	2.93*
	t value	1.82	0.86	0.75	2.18*	2.96**	1.06	0.38	
Dry matter in protein (%)	A	48.35 ± 3.48bc	50.88 ± 2.62abA	52.87 ± 3.67abA	54.15 ± 2.99aA	53.43±3.05a	47.51±2.54c	43.43 ± 2.62d	14.78**
	B	46.71 ± 2.69bc	47.50 ± 2.84abB	46.53 ± 2.33abB	46.42 ± 2.77aB	46.34±3.69a	43.58±3.40c	41.31 ± 3.86d	4.91**
	t value	1.11	2.90**	4.37**	5.67**	0.90	0.73	1.57	
Dry matter in salt (%)	A	4.51 ± 0.25fB	5.04 ± 0.34eB	5.55 ± 0.28dB	6.00 ± 0.22c	6.21 ± 0.13bB	6.41 ± 0.20bB	6.64 ± 0.13aB	95.39**
	B	5.18 ± 0.49fA	5.55 ± 0.37eA	5.86 ± 0.24dA	6.21 ± 0.26c	6.58 ± 0.20bA	6.77 ± 0.10bA	6.84 ± 0.11aA	44.03**
	t value	3.57**	2.97**	2.51*	1.83	4.50**	4.65**	3.54**	
Dry matter in ash (%)	A	7.53 ± 0.37g	8.14 ± 0.25f	8.66 ± 0.47e	9.07 ± 0.38d	9.44 ± 0.16c	9.65 ± 0.15b	9.87 ± 0.20a	68.75**
	B	7.79 ± 0.30g	8.25 ± 0.22f	8.76 ± 0.48e	9.16 ± 0.37d	9.55 ± 0.17c	9.75 ± 0.16b	10.02 ± 0.22a	84.27**
	t value	1.57	0.98	0.47	0.53	1.36	1.32	1.49	
Total nitrogen (%)	A	4.07 ± 0.26d	4.28 ± 0.21c	4.54 ± 0.30bc	4.73 ± 0.22ab	4.93 ± 0.21a	4.54 ± 0.18bc	4.36 ± 0.21c	13.67**
	B	4.24 ± 0.17d	4.36 ± 0.14c	4.42 ± 0.17bc	4.51 ± 0.20ab	4.60 ± 0.25a	4.43 ± 0.25bc	4.31 ± 0.26c	2.91*
	t value	0.28	0.01	0.38	0.22	0.06	1.37	0.16	
Water-soluble nitrogen	A	0.17 ± 0.10b	0.21 ± 0.10b	0.25 ± 0.10b	0.29 ± 0.11b	0.31 ± 0.09b	0.35 ± 0.10b	0.37 ± 0.10a	4.65**
	B	0.10 ± 0.05b	0.15 ± 0.06b	0.22 ± 0.08b	0.25 ± 0.08b	0.26 ± 0.08b	0.28 ± 0.08b	0.38 ± 0.12a	1.79
	t value	1.88	1.53	0.61	0.86	1.29	1.56	0.79	
Ripening degree	A	4.16 ± 2.13eA	5.06 ± 2.10de	5.52 ± 1.94cd	6.37 ± 2.12bc	6.65 ± 1.70bc	7.89 ± 2.18ab	8.90 ± 2.51a	5.59**
	B	2.41 ± 1.25eB	3.60 ± 1.48de	5.11 ± 1.77cd	5.77 ± 1.79bc	5.91 ± 1.76bc	6.41 ± 1.76ab	6.76 ± 1.67a	8.35**
	t value	2.12*	1.69	0.47	0.64	0.90	1.58	2.03	
Water activity	A	0.95 ± 0.01A	0.95 ± 0.01A	0.94 ± 0.01	0.94 ± 0.00	0.94 ± 0.01A	0.92 ± 0.01A	0.90 ± 0.13	2.39*
	B	090 ± 0.05B	0.90 ± 0.05B	0.89 ± 0.15	0.89 ± 0.10	0.89 ± 0.04B	0.88 ± 0.05B	0.87 ± 0.15	0.94
	t value	3.61**	2.87*	1.52	2.04	3.26**	3.42**	1.00	
Lipolysis value (ADV)	A	0.66 ± 0.31d	0.78 ± 0.31d	0.90 ± 0.32cd	1.04 ± 0.25c	1.34 ± 0.38b	1.59 ± 0.53aB	1.73 ± 0.42aB	11.47**
	B	0.77 ± 0.35d	0.87 ± 0.35d	1.10 ± 0.43cd	1.26 ± 0.41c	1.60 ± 0.39b	2.19 ± 0.69aA	2.47 ± 0.58aA	11.30**
	t value	0.74	0.55	1.09	1.31	1.39	2.06*	2.12*	

ADV: Acid degree volume

*: P < 0.05; **P: < 0.01.

a–g: Differences between the averages not marked with an identical letter code in the same column are statistically significant.

A, B: Differences between the groups not marked with an identical letter code in the same column are statistically significant.

Table 3. Some microbiological analysis results for the cheeses produced by different packing methods (log CFU/g).

Characteristic	Sample	Day 1	Day 7	Day 15	Day 30	Day 60	Day 90	Day 120	F value
Total aerobic mesophilic bacteria	1	6.90 ± 0.88	7.34 ± 0.73	7.50 ± 0.78	7.69 ± 0.32	7.79 ± 0.70	8.20 ± 0.59A	7.84 ± 0.92	1.92
	2	7.32 ± 0.90	7.68 ± 0.86	7.59 ± 0.82	7.49 ± 0.63	7.63 ± 0.77	8.01 ± 0.56AB	7.60 ± 0.69	0.11
	3	7.21 ± 0.79	7.36 ± 0.86	7.73 ± 0.97	7.95 ± 0.97	7.86 ± 0.43	7.32 ± 0.65B	7.42 ± 0.57	0.82
	F value	0.38	0.32	0.10	0.21	0.19	4.07	0.42	
Lactobacillus	1	5.15 ± 2.88	6.18 ± 3.09	7.69 ± 0.37	7.71 ± 0.29B	8.57 ± 0.35	8.37 ± 0.39	7.01 ± 0.47	2.56
	2	7.11 ± 0.97	6.96 ± 1.64	8.27 ± 0.75	8.28 ± 0.51A	7.12 ± 0.94	8.47 ± 0.62	8.66 ± 0.15	1.00
	3	7.41 ± 1.03	7.45 ± 0.96	7.91 ± 0.67	8.26 ± 0.36A	7.03 ± 3.47	7.88 ± 0.85	6.89 ± 3.46	0.41
	F value	2.64	0.64	1.33	5.22*	0.54	1.09	1.04	
Yeast and mold	1	1.94 ± 2.28b	2.93 ± 1.72ab	3.95 ± 1.60a	4.06 ± 1.94a	4.06 ± 1.94a	3.85 ± 1.50a	2.99 ± 1.76a	0.78
	2	1.56 ± 2.07b	2.73 ± 1.67ab	2.27 ± 1.67a	2.89 ± 1.96a	2.89 ± 1.96a	2.67 ± 1.33a	2.20 ± 1.85a	0.81
	3	1.65 ± 2.16b	3.46 ± 2.48ab	2.75 ± 1.96a	3.11 ± 2.00a	3.11 ± 2.00a	3.02 ± 2.36a	2.47 ± 1.96a	0.92
	F value	0.46	0.02	0.19	0.01	0.27	0.51	0.00	
Lactococcus	1	5.60 ± 2.95	6.79 ± 0.36	7.08 ± 0.81	7.02 ± 0.35	7.02 ± 0.35	6.36 ± 0.57	6.81 ± 0.40	1.15
	2	6.56 ± 0.93	6.23 ± 0.37	6.80 ± 0.53	6.77 ± 0.08	6.77 ± 0.08	6.68 ± 0.07	6.38 ± 0.71	0.20
	3	5.46 ± 0.94	7.29 ± 0.80	6.94 ± 0.28	6.65 ± 0.37	6.65 ± 0.44	6.55 ± 0.55	5.58 ± 0.96	0.74
	F value	0.31	0.33	0.40	2.46	1.35	1.01	0.99	
Staphylococcus-Micrococcus	1	4.52 ± 1.07a	3.92 ± 1.99a	4.86 ± 0.49a	3.21 ± 2.51ab	3.21 ± 2.51ab	3.00 ± 2.58ab	1.40 ± 2.17b	1.87
	2	4.03 ± 2.00a	5.05 ± 0.92a	5.02 ± 0.86a	4.07 ± 0.56ab	4.07 ± 0.56ab	3.60 ± 2.30ab	2.72 ± 2.21b	1.32
	3	3.71 ± 3.14a	4.15 ± 2.07a	4.72 ± 0.71a	3.36 ± 2.62ab	3.33 ± 2.60ab	3.09 ± 2.52ab	3.22 ± 2.50b	0.34
	F value	0.17	0.70	0.44	0.50	0.29	0.06	0.63	
Psychrophilic	1	3.25 ± 2.52bA	2.26 ± 2.52ab	3.35 ± 2.60b	4.06 ± 2.00a	4.17 ± 2.06a	3.94 ± 2.11a	3.89 ± 2.08ab	0.51
	2	2.07 ± 1.75bB	3.34 ± 1.78ab	2.23 ± 1.88b	4.34 ± 0.51a	3.01 ± 2.47a	3.74 ± 2.06a	2.77 ± 2.17ab	3.95**
	3	2.79 ± 2.59bA	4.06 ± 1.95ab	3.12 ± 1.74b	4.64 ± 0.99a	4.33 ± 2.20a	3.66 ± 1.98a	3.05 ± 2.13ab	1.15
	F value	4.87*	0.97	1.25	0.80	0.52	0.04	0.51	

*:P < 0.05, **P: < 0.01.

a–b: Differences between the averages not marked with an identical letter code in the same column are statistically significant.

A, B: Differences between the groups not marked with an identical letter code in the same column are statistically significant.

1: Control–unpacked samples; 2: samples covered by wax; 3: vacuumed samples.

*P: < 0.05; **P: < 0.01.

a–g: Differences between the averages not marked with an identical letter code in the same column are statistically significant.

A, B: Differences between the groups not marked with an identical letter code in the same column are statistically significant.

wax-covered kaşar samples were higher than in the packed cheese samples, and fell between the values found by Yılmaz (21) (5.40%–8.12 %). The values of water-soluble nitrogen found in this study were lower than the values found by Tarakci and Kucukoner (27) (0.44%–0.88%). The value determined in the wax-covered cheese samples was lower than that of Ürkek (25) (11.44%). The lipolysis values fell between the values determined by Tarakci and Kucukoner (27) (1.91–3.20 ADV), although they were lower than the values obtained by Tunçtürk (24) (1.58–2.14 ADV).

The total number of aerobic mesophilic bacteria in the unpacked cheese samples was found higher than that of the packed cheese samples. In addition, the total number of aerobic mesophilic bacteria determined in the kaşar cheese samples was higher than the values obtained by Coşkun and Öztürk (23) (6.77 log CFU/g) and Atasever et al. (20) (2.3 × 107 – 3 × 107 CFU/g). The microbial load of the milk used in the cheese production, the heat treatment applied to the milk and the cheese production, storage conditions, and the characteristics of the starter culture have effects on the general characteristics of the cheese and the microbial load, which may result in differences among research findings. The number of *Lactobacillus* bacteria determined in the samples is close to the value determined by Fırat (28) (6.9 log CFU/g) and identical to the values (7.20–7.62 log CFU/g) obtained by Yılmaz (21) in the vacuum-packed kaşar cheese samples. At the same time, they are similar to the lower limits but higher than

Table 4. Some chemical analysis results for the cheeses produced by different packing methods (mean ± SD).

Characteristic	Sample	Day 1	Day 7	Day 15	Day 30	Day 60	Day 90	Day 120	F value
pH value	1	5.32 ± 0.05a	5.25 ± 0.06b	5.20 ± 0.05c	5.14 ± 0.04d	5.10 ± 0.04e	5.06 ± 0.04f	5.01 ± 0.04g	25.90**
	2	5.31 ± 0.13a	5.26 ± 0.11b	5.20 ± 0.09c	5.14 ± 0.07d	5.10 ± 0.06e	5.06 ± 0.06f	5.03 ± 0.04g	7.88**
	3	5.29 ± 0.09a	5.25 ± 0.10b	5.20 ± 0.08c	5.17 ± 0.07d	5.13 ± 0.07e	5.10 ± 0.07f	5.05 ± 0.05g	7.02**
	F value	0.02	0.01	0.03	0.25	0.42	0.67	079	
Titratable acidity (% l.a.)	1	0.20 ± 0.05g	0.29 ± 0.06f	0.40 ± 0.08e	0.49 ± 0.09d	0.55 ± 0.09c	0.65 ± 0.11b	0.85 ± 0.08aA	38.25**
	2	0.21 ± 0.03g	0.27 ± 0.04f	0.39 ± 0.03e	0.46 ± 0.06d	0.54 ± 0.07c	0.60 ± 0.07b	0.68 ± 0.09aB	41.09**
	3	0.21 ± 0.03g	0.32 ± 0.07f	0.42 ± 0.06e	0.49 ± 0.08d	0.54 ± 0.08c	0.63 ± 0.08b	0.69 ± 0.06aB	32.01**
	F value	0.07	0.82	0.21	0.25	0.02	0.42	7.74**	
Dry matter (%)	1	56.36 ± 3.25d	57.11 ± 3.25d	58.75 ± 4.37cd	60.67 ± 4.21c	63.47 ± 3.53b	65.30 ± 2.97b	67.64 ± 3.10a	8.30**
	2	55.63 ± 2.70d	56.07 ± 3.04d	57.47 ± 3.12cd	59.01 ± 2.54c	60.94 ± 2.47b	62.71 ± 2.69b	65.22 ± 2.66a	10.00**
	3	54.72 ± 3.64d	55.25 ± 3.74d	56.54 ± 4.08cd	57.74 ± 4.07c	59.76 ± 2.87b	61.52 ± 3.02b	64.36 ± 1.82a	4.44**
	F value	0.41	0.44	0.48	0.96	2.49	2.81	2.35	
Dry matter in fat (%)	1	45.44 ± 2.95	45.75 ± 3.11	46.24 ± 3.53	46.70 ± 3.24	46.72 ± 2.92	47.18 ± 2.69	47.45 ± 2.50	0.35
	2	43.36 ± 2.15	43.92 ± 2.68	42.28 ± 2.93	44.56 ± 2.72	46.96 ± 2.97	45.34 ± 2.95	46.59 ± 2.85	0.48
	3	44.47 ± 2.84	45.19 ± 3.18	45.55 ± 3.38	45.98 ± 3.23	46.31 ± 3.23	46.50 ± 3.16	46.87 ± 3.46	0.33
	F value	0.05	0.17	0.08	0.04	0.23	0.24	0.26	
Protein (%)	1	26.82 ± 0.66d	27.58 ± 0.65c	28.73 ± 1.9bc	29.60 ± 1.70ab	30.53 ± 2.05a	28.51 ± 1.56bc	27.68 ± 1.54c	4.06**
	2	26.48 ± 2.02d	27.64 ± 1.34c	28.27 ± 0.96bc	29.79 ± 1.50ab	30.75 ± 1.87a	29.44 ± 1.23bc	27.99 ± 1.51c	5.37**
	3	26.15 ± 1.72d	27.65 ± 1.52c	28.55 ± 1.58bc	29.19 ± 1.54ab	30.13 ± 1.77a	28.15 ± 1.35bc	27.47 ± 1.63c	3.87**
	F value	0.26	0.01	0.13	0.20	0.16	1.23	0.34	
Dry matter in protein (%)	1	47.69 ± 2.20ab	48.445 ± 2.97a	49.17 ± 5.45a	49.09 ± 5.73a	48.36 ± 5.87a	43.79 ± 3.97b	41.04 ± 3.83c	2.92*
	2	47.05 ± 4.06ab	48.80 ± 3.02a	49.05 ± 3.34a	50.99 ± 4.56a	50.76 ± 4.99a	47.03 ± 3.34b	43.96 ± 3.37c	3.00**
	3	47.87 ± 3.39ab	50.07 ± 3.63a	50.87 ± 4.80a	50.78 ± 4.90a	50.54 ± 4.27a	45.82 ± 3.11b	42.27 ± 2.83c	3.75**
	F value	0.10	0.42	029	0.25	0. 40	1.32	0.58	
Dry matter in salt (%)	1	5.25 ± 0.59gA	5.66 ± 0.32fA	5.99 ± 0.16eA	6.36 ± 0.15dA	6.56 ± 0.26c	6.67 ± 0.20b	6.83 ± 0.12a	23.93**
	2	4.73 ± 0.39gAB	5.19 ± 0.41fB	5.62 ± 0.28eB	5.94 ± 0.20dB	6.34 ± 0.26c	6.51 ± 0.27b	6.68 ± 0.17a	34.47**
	3	4.56 ± 0.27gB	5.03 ± 0.35fB	5.51 ± 0.22eB	6.01 ± 0.21dB	6.29 ± 0.16c	6.55 ± 0.24b	6.71 ± 0.14a	67.66**
	F value	4.03*	4.75*	7.07**	7.57**	2.12	1.18	1.99	
Dry matter in ash (%)	1	7.83 ± 0.36g	8.34 ± 0.27f	8.92 ± 0.51e	9.34 ± 0.39d	9.55 ± 0.19c	9.78 ± 0.10b	10.05 ± 0.24a	36.15**
	2	7.46 ± 0.41g	8.00 ± 0.27f	8.49 ± 0.48e	8.92 ± 0.36d	9.49 ± 0.08c	9.64 ± 0.07b	9.91 ± 0.15a	38.44**
	3	7.66 ± 0.26g	8.20 ± 0.42f	8.63 ± 0.42e	9.00 ± 0.33d	9.46 ± 0.23c	9.71 ± 0.23b	9.88 ± 0.26a	49.86**
	F value	1.34	2.78	0.63	1.80	0.48	1.85	1.01	
Total nitrogen	1	4.22 ± 0.05d	4.31 ± 0.10c	4.55 ± 0.33bc	4.63 ± 0.26ab	4.78 ± 0.32a	4.46 ± 0.24bc	4.33 ± 0.23c	3.89**
	2	4.18 ± 0.31d	4.32 ± 0.20c	4.42 ± 0.15bc	4.66 ± 0.23ab	4.81 ± 0.29a	4.61 ± 0.19bc	4.38 ± 0.23c	5.32**
	3	4.09 ± 0.26d	4.33 ± 0.23c	4.47 ± 0.24bc	4.57 ± 0.24ab	4.72 ± 0.28a	4.40 ± 0.2bc1	4.28 ± 0.28c	3.75**
	F value	0.43	0.01	0.38	0.25	0.07	0.97	0.16	
Water-soluble nitrogen (%)	1	0.08 ± 0.03b	0.15 ± 0.08b	0.23 ± 0.10b	0.26 ± 0.13b	0.29 ± 0.12b	0.32 ± 0.12b	0.35 ± 0.13a	4.43**
	2	0.14 ± 0.09b	0.19 ± 0.09b	0.26 ± 0.07b	0.29 ± 0.05b	0.30 ± 0.05b	0.33 ± 0.05b	0.40 ± 0.12a	1.50
	3	0.18 ± 0.09b	0.20 ± 0.09b	0.21 ± 0.09b	0.27 ± 0.10b	0.27 ± 0.10b	0.29 ± 0.11b	0.38 ± 0.11a	1.26
	F value	2.07	0.47	0.31	0.32	0.21	0.33	0.96	
Ripening degree (%)	1	2.08 ± 0.89e	3.66 ± 1.91de	5.11 ± 1.97cd	5.71 ± 2.59bc	6.25 ± 2.24bc	7.26 ± 2.59ab	8.25 ± 2.96a	5.20**
	2	3.41 ± 2.25e	4.56 ± 2.10de	5.93 ± 1.61cd	6.47 ± 1.13bc	6.57 ± 1.07bc	7.41 ± 1.31ab	8.12 ± 1.73a	5.18**
	3	4.37 ± 1.88e	4.76 ± 1.89de	4.91 ± 2.00cd	6.04 ± 2.09bc	6.03 ± 1.94bc	6.78 ± 2.42ab	7.17 ± 2.59a	1.80
	F value	2.52	0.52	0.49	0.43	0.13	0.23	0.30	
Water activity	1	0.93 ± 0.03	0.93 ± 0.05	0.92 ± 0.02	0.92 ± 0.02	0.91 ± 0.02	0.90 ± 0.03	0.88 ± 0.02	1.36
	2	0.94 ± 0.01	0.94 ± 0.01	0.93 ± 0.01	0.93 ± 0.01	0.91 ± 0.04	0.91 ± 0.04	0.88 ± 0.02	0.96
	3	0.92 ± 0.06	0.92 ± 0.06	091 ± 0.08	0.91 ± 0.07	0.90 ± 0.05	0.90 ± 0.05	0.90 ± 0.06	0.78
	F value	0.31	0.01	1.41	0.32	0.14	0.51	1.03	
Lipolysis value (ADV)	1	0.54 ± 0.30d	0.64 ± 0.33cd	0.85 ± 0.32cd	0.97 ± 0.27bc	1.20 ± 0.44b	1.84 ± 0.57a	2.05 ± 0.74a	4.71**
	2	0.91 ± 0.25d	0.99 ± 0.23cd	1.08 ± 0.36cd	1.20 ± 0.36bc	1.54 ± 0.23b	1.85 ± 0.36a	1.88 ± 0.35a	5.41**
	3	0.70 ± 0.36d	0.84 ± 0.36cd	1.08 ± 0.47cd	1.29 ± 0.38bc	1.67 ± 0.38b	1.99 ± 0.49a	2.38 ± 0.55a	16.55**
	F value	2.08	1.86	0.71	1.51	2.67	0.05	0.29	

*P: < 0.05; **P: < 0.01.

a–g: Differences between the averages not marked with an identical letter code in the same column are statistically significant.

A, B: Differences between the groups not marked with an identical letter code in the same column are statistically significant.

the upper limits of the values obtained in the wax-coated kaşar cheese samples (7.06–7.98 log CFU/g). The effect of maturation time on the yeast-mold numbers in the cheese samples was found statistically significant ($P < 0.05$). The yeast and mold number obtained at the end of the study is lower than the values (3.41–3.91 log CFU/g) determined by Coşkun and Öztürk (23) (3.61 log CFU/g) and Çetinkaya and Soyutemiz (29) (3.41–3.91 log CFU/g). Factors such as moisture content, storage conditions, packaging material, etc. in the cheese samples could result in a different yeast-mold number. The number of *Lactococcus* bacteria determined in the kaşar cheese samples is lower than the values obtained by Fırat (28) (6.36–6.89 log CFU/g). The difference in *Lactococcus* number may be attributed to the bacteria load in cheese samples, the starter culture, packing material, storage conditions, and other similar factors. The values obtained at the end of the study are higher than the values (1.39 × 102 CFU/g) found by Öksüztepe et al. (22). Coliform bacteria and *Staphylococcus aureus* bacteria were not found in any of the kaşar cheese samples. The psychrophilic bacteria values obtained in the kaşar cheese samples were found lower than the value determined by Çetinkaya and Soyutemiz (29) in the kaşar cheese (5.04–5.59 log CFU/g). The difference in the number of psychrophilic bacteria in cheese samples may be attributed to moisture, salt contents, and storage conditions of the cheese.

The sensory evaluations of the kaşar cheese samples revealed higher taste and smell points than the smell points determined by Ürkek (25) and Yılmaz (21). The texture points are higher than those determined by Gürsoy (19) (3.76–4.82).

It is concluded that the vacuum packaging and cheese wax covering did not have any adverse effect on cheese quality, nor did it delay cheese maturation. Hence, it could be recommended that cheese wax be used as a packaging material alternative to vacuum packaging in the storage of kaşar cheese. It could also be indicated that the brine salting method could be used as an alternative to boiler salting in kaşar cheese production.

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