ISSN 0101-2061 (Print)
ISSN 1678-457X (Online)
Food Science and Technology

DOI: https://doi.org/10.1590/fst.31019

The effects of adding garlic (*Allium sativum* L.) on the volatile composition and quality properties of yogurt

Ayla ARSLANER[1]*

Abstract

In this study, the effects of adding garlic (*Allium sativum* L.) of different origins on the volatile composition and quality properties of yogurt were investigated on day 1, 7 and 14 of storage. The addition of garlic did not cause a decrease in the total specific microorganism count ($>10^7$) in yogurt samples, and it led to a significant decrease in the yeast–mould count compared to the control. Seventy-four volatile compounds were identified in the samples, consisting of 15 carbonyl compounds, 9 aliphatic hydrocarbons, 8 acids, 3 alcohols, 6 esters, 12 sulfur-containing compounds, 12 terpenes and 9 heterocyclic compounds. Acetaldehyde, 2,3-butanedione, acetoin, hexanoic acid, tetramethylthiourea and 1,2-dihydro-2,2,4-trimethyl-quinoline were the major volatile compounds found in all yogurt samples. Although they were poor in terms of terpenes compared to the control, strong sulfurous components were detected in yogurt samples with garlic. It has been determined that the addition of garlic of different origins significantly changed the aromatic profile of the yogurt. In the sensory analyses, 1.0% domestic garlic was the sample most preferred by the panelists.

Keywords: yogurt; domestic garlic; imported garlic; volatile; aromatic.

Practical Application: Convenient garlic varieties and ratio for garlic yogurt, which is a functional fermented product.

1 Introduction

Yogurt is a fermented dairy product that is obtained as a result of lactic acid fermentation under the effect of *Streptococcus salivarius* ssp. *thermophilus* and *Lactobacillus delbrueckii* ssp. *bulgaricus* (Tamime & Robinson, 1999; Turkey, 2009) and which contains live yogurt cultures (Turkish Standards Institution, 2006; Food and Agriculture Organization of the United Nations, 2003). In addition to carrying the valuable nutritional elements of milk, yogurt products and yogurt-like products are more easily digestible due to lactose hydrolysis as a result of lactic acid fermentation. Furthermore, the fact that microorganisms synthesize some vitamins via their metabolic activity, increase the absorption of calcium in the optimum pH environment of the intestines, and with the high biological value of yogurt proteins and the high digestibility rate of milk fat, the value of yogurt in terms of healthy nutrition is increased (McKinley, 2005; Arslaner, 2016).

Flavour perception is one of the most important criteria in the evaluation of yogurt quality due to its effect on consumer acceptance and preference (Alonso & Fraga, 2001). Yogurt flavour is the sum of the components formed by the fermentation of lactic acid bacteria in addition to the natural aromatic components of the milk (Ott et al., 1997). More than 100 volatiles, including carbonyl compounds, alcohols, acids, esters, hydrocarbons, aromatic compounds, sulfur-containing compounds, and heterocyclic compounds, are found in yogurt at low to trace concentrations. Besides lactic acid, acetaldehyde, diacetyl, acetoin, acetone, and 2-butanone contribute most to the typical aroma and flavor of yogurt. (Cheng, 2010; Chen et al., 2017).

Natural products obtained from animals, plants and microbial sources have been widely used by humans in the treatment of diseases for thousands of years. Garlic, one of the vegetable that has been applied for centuries in the treatment of infectious diseases, and has been studied in depth in recent years, is reported to have been used by the Egyptians, Babylonians, Greeks and Romans (Ayaz & Alpsoy, 2007; Gebreyohannes & Gebreyohannes, 2013). Garlic is an important vegetable that is generally used with yogurt in Turkish cuisine (Kayserili, 2018) and mid-Asian cuisine, and it is also considered to be one of the top ten foods of the Mediterranean basin (Puga & Urquiaga, 2010). It is thought that garlic was one of the first cultivated plants starting in the Middle East approximately 5000 years ago (Ayaz & Alpsoy, 2007).

External factors such as environmental conditions and agricultural factors in the region where plants are grown, and internal factors such as genetic factors have an impact on the chemical contents of plants (Tomás-Barberán & Espin, 2001). Bioactive ingredient content of garlic; was highly dependent on both pre-harvest conditions such as genetics and various cultivation practices, and post-harvest conditions such as storage and process operations (Martins et al., 2016). In recent years, studies have been recorded that the chemical composition, bioactive components, mineral and heavy metal contents of imported and domestic garlic may differ significantly (Yıldız et al., 2016; Arslaner et al., 2017).

The volatile compounds of yogurt have been thoroughly investigated in recent years, but there is no comparative research

Received 05 Dec., 2019
Accepted 19 Feb., 2020
[1] *Department of Food Engineering, Engineering Faculty, Bayburt University, Bayburt, Turkey*
*Corresponding author: aylaarslaner@bayburt.edu.tr

concerning the effect of the addition of garlic of different origins on the volatile compounds of yogurt. Thus, the effect of adding garlic (0.5%, 1.0%) of different origins (imported, domestic) on the volatile composition and on some physicochemical, microbiological and sensory properties of yogurt were investigated on day 1, 7 and 14 of storage.

2 Materials and methods

Raw cow's milk was obtained from the Peykar Dairy and Agricultural Foods Co. Ltd. of Bayburt, Turkey. Commercial lyophilized direct vat set (DVS) starter cultures containing *Streptococcus salivarius* ssp. *thermophilus* and *Lactobacillus delbrueckii* ssp. *bulgaricus* species were obtained from Chr. Hansen Food, Industry and Trade Inc. Turkey; skimmed milk powder was obtained from the Pınar Dairy Products Ind. Inc., Turkey; imported garlic and Geographical Indication registered domestic garlic samples were obtained from Metro Cash & Carry, Turkey.

2.1 Yogurt production

The production of yogurt was duplicated. Raw cow's milk was standardized with skimmed milk powder in such a way that the amount of dry matter was at least 16%, and it was then subjected to heat treatment at 90 °C for 15 minutes. The DVS culture inoculation (*Str. salivarius* ssp. *thermophilus* and *Lb. delbrueckii* ssp. *bulgaricus*) was performed at the rate recommended by the supplier at 43 ± 1 °C. The milk was divided into 5 equal portions. One part of the milk was used as the control (sample C). The imported (I) and domestic (D) garlic paste was added into the milk in two different proportions (1.0%, 0.5%), and the samples were denoted by the letters C (control, 0% garlic, I1.0 (1.0% imported garlic), I0.5 (0.5% imported garlic), D1.0 (1.0% domestic garlic) and D0.5 (0.5% domestic garlic). The samples were incubated at the inoculation temperature until the pH reached 4.7 ± 0.1, and then they were stored at 4 °C for 14 days and analyzed on day 1, 7 and 14 of storage.

2.2 Physicochemical analyses

The total solids, protein contents, pH, titratable acidity (anhydrous citric acid, %), water soluble dry matter and water activity (aw) of the garlic samples were measured according to the method described by Cemeroğlu (2010). The dry matter, fat, protein, pH and titratable acidity of the experimental yogurts were measured on day 1 of storage. The total protein content of the yogurt samples was determined by the micro-Kjeldahl method (International Dairy Federation, 1993), and pH was measured using a pH meter (Mettler Toledo Seven Compact S220; Mettler-Toledo International Inc. Im Langacher Greifensee, Switzerland), while the dry matter was determined by a gravimetric method, and titratable acidity was determined by colorimetric titration (Cemeroğlu, 2010). The fat content of the yogurt samples was quantified using the Gerber method (Turkish Standards Institution, 1978).

2.3 Microbiological analyses

For microbiological analyses, 10 g of yogurt samples were weighed into jars under sterile conditions and transferred into stomacher bags, and 90 mL of sterile physiological saline (0.85% NaCl) was added. Then, the samples were homogenized in the stomacher (Interscience Bag Mixer® 400 France) for 2 minutes.

The following counts were made during storage: Standard Plate Count (SPC) on PCA (Harrigan, 1998), yeast and mould on Dichloran-Rose Bengal Chloramphenicol Agar (DRBCA, Merck) (Beuchat et al., 2007), *Lb. delbrueckii* ssp. *bulgaricus* on MRS agar, *Str. salivarius* ssp. *thermophilus* on M17 agar (Dave & Shah, 1996) and coliform group bacteria numbers on VRB agar (Harrigan, 1998).

2.4 Determination of volatile compounds

A duplicate 5.0 g sample of each yogurt was weighed into a 40 mL headspace vial (Supelco, Bellefonte PA, USA) and sealed using a PTFE-faced silicone septum (Supelco). Extraction of headspace volatiles from the yogurt samples was carried out using a solid phase micro extraction (SPME) device (Model 57330-U; Supelco, Bellefonte, PA, USA), with CAR/PDMS fibers (75 µm, carboxen/polydimethylsiloxane) that were conditioned once they were in the injection port of the gas chromatograph (GC). The vial was left at 40 °C in a thermo block (Supelco) for 30 minutes for the headspace temperature to reach equilibrium. The fiber was exposed to the headspace with the yogurt sample at 85 °C for 1 hour. Volatile compounds adsorbed by the fibers were identified using mass spectrometry (MS) detectors. Compounds adsorbed by the fibers were desorbed in the injection port of a gas chromatograph (6890N; Agilent Technologies, Santa Clara, CA, USA) in splitless mode for 6 minutes at 250 °C. Volatile compounds were separated using a capillary column (DB-624, 30 m × 0.25 mm i.d., 1.4 µm film) – from J&W Scientific inc., Folsom, CA, USA – using helium as the carrier gas. The helium flow rate was 1.0 mL·min^{-1}. The temperature program was started when the fibers were inserted and held at 40 °C for 5 minutes, with subsequent programming from 40 °C to 110 °C at 3 °C·min^{-1}, 4 °C·min^{-1} from 150 °C, then at a rate of 10 °C·min^{-1} from 210 °C, followed by a holding stage of another 12 minutes. The total run time was 56.33 minutes. The GC-MS interface was kept at 240 °C. The results were compared to the library of mass spectrometry (NIST, WILEY, FLAVOUR) and standard items were also used for identification (Marco et al., 2004; Kavaz Yüksel & Bakırcı, 2015).

2.5 Sensory analyses

To determine the sensory parameters, the score card described by Bodyfelt et al. (1988) and TS 1330 (Turkish Standards Institution, 2006) was modified (Bakırcı & Arslaner, 2007). For this purpose, the sensory properties of the yogurt samples, such as the appearance, consistency using a spoon, consistency in the mouth, and smell and taste were evaluated using a scale ranging from 1 (extremely poor) to 5 (very good) by ten trained panellists from the Department of Food Engineering of Bayburt University on day 1, 7 and 14 of storage.

2.6 Statistical analyses

Analysis of variance (ANOVA) was employed to establish statistical differences between volatile compounds, and the microbiological analysis results and the sensory analysis scores were evaluated using Minitab® 17.3.1 (Minitab Inc. USA) statistical software. Different groups were analysed with Fisher Pairwise Comparison.

3 Results and discussion

3.1 General properties of raw milk and garlic

In the study, the average values of dry matter, fat, protein, specific weight, titratable acidity and the pH of the raw cow's milk used in the yogurt production were determined to be 12.16 ± 0.50%, 3.55 ± 0.07%, 3.46 ± 0.20%, 1.032 $g \cdot cm^{-3}$, 0.18 ± 0.00% and 6.75 ± 0.01, respectively. In this way, the raw milk analysis results were in accordance with the predicted values of the TS-1018 raw milk standard (Turkish Standards Institution, 1981).

Total dry matter, water soluble dry matter (Brix°), pH, anhydrous citric acid (ACA %), total protein and water activity (aw) of the garlic samples used in the yogurt production ranged from 32.70 to 38.42%, 29.03 to 35.95%, 6.12 to 6.30, 0.455 to 0.618%, 5.53 to 8.88%, 0.90 to 0.92, respectively. Total dry matter, water soluble dry matter (Brix°), protein and the titratable acidity values of domestic garlic were higher than the imported garlic; pH and water activity values were found to be lower. Tomás-Barberán & Espin (2001) reported that genetic factors and external factors, such as the environmental conditions and agricultural factors in the regions where the plants grew, were highly influential on the chemical contents of the plants.

3.2 Physicochemical properties of yogurt

The dry matter, fat, protein, titratable acidity and pH of yogurt samples ranged from 16.54 to 16.96%, 4.20 to 4.50%, 4.63 to 4.72%, 1.15 to 1.31% and 4.40 to 4.59, respectively. Yogurt samples with garlic had a higher dry matter ratio, protein and pH value compared to the C sample (control). It is thought that the differences in dry matter, fat and protein ratios of the samples were due to the change in the garlic content. Similar results were reported by Gündoğdu et al. (2009) and Pagthinathan & Tharmiga (2016). The values determined in the samples are in accordance with the values stated in the Turkish Food Codex (Turkey, 2009).

3.3 Microbiological properties of yogurt

Although lower counts for *Lb. delbrueckii* ssp. *bulgaricus* and *Str. salivarius* ssp. *thermophilus* were detected in the yogurts with 1.0% garlic during storage compared to the control samples (Table 1), the bacterial counts in D0.5 were not significantly different from the C sample (control) at day 14 of storage ($P > 0.05$). In terms of the total specific microorganism count ($>10^7$), which is one of the qualities that yogurt and fermented dairy products should have, all yogurt samples conformed to the Turkish Food Codex Communique on Fermented Milk Products (Turkey, 2009). This is similar to the results of the study conducted by Rees et al. (1993), which measured the inhibitory effect of freeze-dried garlic samples on various microorganisms. Researchers have emphasized that the most resistant group to the inhibitory effect of garlic is lactic acid bacteria. The standard plate count (SPC) remained at a lower level in samples with garlic compared to the control group ($P < 0.05$). In addition, higher counts were detected in the I1.0 sample compared to the D1.0 at all storage times. Coliform group microorganisms were not detected in the yogurt test samples during storage. While yeast–mould was observed in all samples on day 1 of storage, it was not found in the samples with garlic on days 7and 14 of storage. The antifungal effect of garlic and its various forms has also been reported by many other researchers (Rees et al., 1993; Kutawa et al., 2018).

3.4 Volatile compound profiles of the yogurt

Seventy-four compounds were identified in the yogurt samples (Table 2), including 15 carbonyl compounds, 9 aliphatic hydrocarbons, 8 acids, 3 alcohols, 6 esters, 12 sulfur-containing

Table 1. Microbiological analysis results of the yogurt samples (log $CFU \cdot g^{-1}$)*.

Microorganisms	Storage (day)	Yogurt samples				
		C (control)	I1.0	I0.5	D1.0	D0.5
Lb. delbrueckii ssp. *bulgaricus*	1	9.699 a, A	9.176 a, B	9.778 a A	8.602 a, C	8.476 b, C
	7	9.398 ab, A	8.544 b, B	9.301 ab, A	8.532 a, B	8.903 ab, AB
	14	9.092 b, A	8.176 c, B	8.857 b, A	8.362 a, B	9.079 a, A
Str. salivarius ssp. *thermophilus*	1	9.704 a, A	9.172 a, B	9.146 a, B	8,563 a, C	9.560 a, AB
	7	9.316 a, A	8.646 ab, AB	9.453 a, A	8.491 a, AB	8.965 b, A
	14	9.638 a, A	8.446 b, C	8.931 a, B	8.511 a, C	9.447 a, A
Standard Plate Count	1	9.190 a, A	8.385 a, B	8.439 b, B	6.929 c, D	7.338 a, C
	7	9.543 a, A	7.712 b, BC	7.970 c, BC	7.253 b, C	8.092 ab, B
	14	9.908 a, A	8.518 a, BC	8.912 a, B	8.041 a, C	8.621 a, BC
Yeast-Mould	1	2.082	2.518	2.602	2.380	2.845
	7	2.041	<1	<1	<1	<1
	14	2.180	<1	<1	<1	<1
Coliform Group	1	<1	<1	<1	<1	<1
	7	<1	<1	<1	<1	<1
	14	<1	<1	<1	<1	<1

*Different lower letters (during storage days) in the same column and different capital letters (between samples at the same storage day) in the same line indicate significant differences ($P < 0.05$).

Table 2. Mean peak area Volatile compounds of in yogurt samples*.

RT	Volatile compounds	Yogurt Samples**					Days of Storage***		
		C (control)	I1.0	I0.5	D1.0	D0.5	1	7	14
	Carbonyl compounds								
5.24	2-Propanone	0.04 ± 0.03 c	0.55 ± 0.39 a	0.34 ± 0.19 b	0.47 ± 0.42 ab	0.16 ± 0.06 c	0.35 ± 0.26	0.28 ± 0.41	0.32 ± 0.33
6.23	Acetaldehyde	26.10 ± 2.04 a	13.67 ± 2.65 b	13.85 ± 2.83 b	11.4 ± 2.55 c	13.18 ± 1.26 b	16.13 ± 5.51 a	14.87 ± 5.80 b	16.24 ± 6.92 a
14.70	3-Pentanone	ND	ND	ND	0.16 ± 0.13 b	0.19 ± 0.00 a	0.15 ± 0.21 a	0.04 ± 0.08 b	ND
14.79	2,3-Butanedione	0.91 ± 0.23 a	0.62 ± 0.18 b	0.69 ± 0.26 b	0.54 ± 0.12 b	0.68 ± 0.57 b	0.77 ± 0.33 a	0.56 ± 0.38 b	0.52 ± 0.39 b
21.47	2,3-Pentanedione	0.58 ± 0.34 a	0.35 ± 0.13 b	0.36 ± 0.29 b	0.34 ± 0.16 b	0.40 ± 0.20 b	0.57 ± 0.26 a	0.38 ± 0.11 b	0.26 ± 0.22 c
24.27	Acetoin	3.57 ± 0.49 a	1.83 ± 0.51 c	3.00 ± 0.92 b	1.67 ± 0.66 c	3.01 ± 0.31 b	3.03 ± 0.68 a	2.48 ± 1.24 b	2.26 ± 0.73 b
28.29	Hexanal	0.44 ± 0.20 a	0.15 ± 0.04 c	0.33 ± 0.15 b	0.09 ± 0.05 d	0.19 ± 0.08 c	0.16 ± 0.06 c	0.34 ± 0.23 a	0.23 ± 0.15 b
31.99	n-Nonane	0.53 ± 0.12 a	0.06 ± 0.07 c	0.26 ± 0.06 b	0.06 ± 0.06 c	0.31 ± 0.08 b	0.23 ± 0.11	0.24 ± 0.21	0.25 ± 0.26
34.12	2-Heptanone	0.64 ± 0.15 a	0.41 ± 0.16 b	0.63 ± 0.03 a	0.26 ± 0.06 c	0.60 ± 0.11 a	0.52 ± 0.13 ab	0.45 ± 0.21 b	0.55 ± 0.21 a
35.55	Heptanal	0.32 ± 0.22 a	ND	0.31 ± 0.04 ab	ND	0.26 ± 0.09 b	0.13 ± 0.13 c	0.22 ± 0.23 a	0.18 ± 0.18 b
38.97	Benzaldehyde	ND	0.21 ± 0.05 a	0.22 ± 0.16 a	0.28 ± 0.08 a	0.05 ± 0.07 b	0.15 ± 0.16	0.14 ± 0.14	0.17 ± 0.11
39.26	Octanal	ND	0.08 ± 0.05 a	0.12 ± 0.11 ab	0.07 ± 0.05 ab	0.06 ± 0.01 ab	0.10 ± 0.10 a	0.04 ± 0.03 b	0.05 ± 0.04 ab
43.10	2-Nonanone	0.17 ± 0.05 a	ND	ND	ND	ND	0.03 ± 0.05	0.04 ± 0.08	0.04 ± 0.09
43.41	Nonanal	0.13 ± 0.11 a	ND	ND	ND	ND	ND	0.03 ± 0.07 b	0.05 ± 0.10 a
48.35	Benzaldehyde4-(1-methylethyl)-	0.04 ± 0.05 c	0.42 ± 0.11 b	0.28 ± 0.07 bc	0.71 ± 0.68 a	0.36 ± 0.27 b	0.45 ± 0.60	0.31 ± 0.16	0.32 ± 0.25
	Alcohols								
8.63	Ethyl alcohol	0.83 ± 0.90 a	0.32 ± 0.13 b	0.28 ± 0.19 b	0.13 ± 0.07 c	0.23 ± 0.15 b	0.27 ± 0.08 b	0.23 ± 0.13 b	0.61 ± 0.80 a
25.81	Dimethyl silanediol	ND	1.02 ± 0.17 a	0.27 ± 0.17 c	0.85 ± 0.32 b	0.12 ± 0.04 d	0.34 ± 0.32 b	0.50 ± 0.42 a	0.56 ± 0.59 a
41.34	2-Ethyl-1 hexanol	0.19 ± 0.17 c	1.45 ± 1.17 a	1.13 ± 0.30 ab	0.92 ± 0.28 b	0.25 ± 0.16 c	0.77 ± 0.75 ab	1.05 ± 0.91 a	0.57 ± 0.41 b
RT	Volatile compounds	Yogurt Samples**					Days of Storage***		
		C (control)	I1.0	I0.5	D1.0	D0.5	1	7	14
	Sulphur-containing compounds								
13.79	Allyl mercaptan	ND	1.86 ± 2.41 a	0.41 ± 0.49 b	0.55 ± 0.12 b	0.40 ± 0.12 b	1.43 ± 1.90 a	0.25 ± 0.22 b	0.25 ± 0.20 b
20.34	Allyl methyl sulfide	ND	1.26 ± 0.49 b	0.61 ± 0.18 c	1.71 ± 0.57 a	1.29 ± 0.27 b	1.19 ± 0.89 a	0.71 ± 0.46 c	0.98 ± 0.69 b
31.34	Diallyl sulfide	ND	3.02 ± 1.44 a	2.00 ± 0.52 b	3.33 ± 0.78 a	2.47 ± 0.60 b	1.75 ± 1.25 b	2.11 ± 1.18 b	2.55 ± 1.81 a
32.78	Allyl n-propyl sulfide	ND	0.04 ± 0.04 b	0.01 ± 0.02 c	0.08 ± 0.02 a	0.01 ± 0.03 c	0.02 ± 0.05 b	0.02 ± 0.03 b	0.04 ± 0.04 a
35.34	Allyl methyl disulfide	0.29 ± 0.11 d	7.58 ± 1.39 b	4.38 ± 0.49 c	10.31 ± 3.04 a	8.75 ± 3.89 b	7.83 ± 5.33 a	4.93 ± 3.07 b	5.56 ± 3.55 b
35.89	1,3-Dithiane	ND	0.18 ± 0.03 b	0.20 ± 0.13 b	0.46 ± 0.13 a	0.19 ± 0.04 b	0.19 ± 0.19 b	0.17 ± 0.11 b	0.26 ± 0.20 a
38.59	Dimethyl trisulfide	ND	0.38 ± 0.17 b	0.20 ± 0.12 c	1.41 ± 0.23 a	0.25 ± 0.10 c	0.41 ± 0.54 b	0.40 ± 0.45 b	0.56 ± 0.63 a
42.84	Allyl disulfide	ND	23.03 ± 6.57 a	16.46 ± 6.93 c	24.60 ± 2.13 a	19.48 ± 2.63 b	14.42 ± 9.69 c	16.68 ± 9.97 b	18.98 ± 11.10 a
43.16	Allyl cis 1-propenyl di sulfide	ND	9.63 ± 2.01 a	3.98 ± 2.48 b	9.32 ± 1.58 a	2.87 ± 1.12 b	4.04 ± 3.67 c	5.53 ± 4.70 a	6.24 ± 4.21 a
44.84	Allyl methyl trisulfide	ND	0.89 ± 0.43 c	0.59 ± 0.31 c	3.19 ± 0.54 a	1.68 ± 0.29 b	0.87 ± 1.07 b	1.15 ± 1.27 ab	1.24 ± 1.32 a
44.96	2, 4-dimethyl-thiophene	ND	0.55 ± 0.29 a	0.37 ± 0.04 b	0.56 ± 0.22 a	0.21 ± 0.09 c	0.25 ± 0.18 c	0.35 ± 0.31 b	0.44 ± 0.29 a
48.65	Tetramethyl thiourea	2.26 ± 0.22	1.98 ± 0.57	1.81 ± 1.37	1.37 ± 0.29	1.36 ± 0.39	1.98 ± 0.97	1.67 ± 0.40	1.64 ± 0.80
	Esters								
15.31	Ethyl acetate	ND	0.14 ± 0.22 d	0.15 ± 0.11 c	0.29 ± 0.19 a	0.18 ± 0.24 b	0.03 ± 0.07 c	0.24 ± 0.23 a	0.17 ± 0.16 b
34.01	Propanoic acid, butyl ester	0.04 ± 0.07 b	0.08 ± 0.08 b	0.09 ± 0.08 b	0.21 ± 0.18 a	0.08 ± 0.14 b	0.07 ± 0.09 b	0.15 ± 0.16 a	0.07 ± 0.09 b

RT: Retention Time, ND: Not Detected; *Mean values indicated by different exponential letters in the same line are significantly different from each other ($P < 0.05$); **The average of values found at the three sampling times (1, 7, 14 days); ***The average of values obtained from all samples at a sampling time.

Table 2. Continued...

RT	Volatile compounds	Yogurt Samples**					Days of Storage***		
		C (control)	I1.0	I0.5	D1.0	D0.5	1	7	14
45.24	Butanoic acid hexyl ester	0.30 ± 0.08 bc	0.69 ± 0.21 a	0.39 ± 0.21 b	0.71 ± 0.37 a	0.21 ± 0.03 c	0.31 ± 0.13 c	0.63 ± 0.38 a	0.47 ± 0.22 b
50.28	Arsenous acid, tris (trimethylsilyl) ester	0.12 ± 0.19 c	0.29 ± 0.14 a	0.16 ± 0.15 bc	0.22 ± 0.15 ab	0.24 ± 0.31 ab	0.04 ± 0.06 c	0.25 ± 0.15 b	0.34 ± 0.19 a
51.43	Silicic acid, diethyl bis(trimethylsilyl) ester	0.25 ± 0.08 c	0.54 ± 0.18 a	0.40 ± 0.45 b	0.28 ± 0.17 c	0.16 ± 0.07 d	0.38 ± 0.33 a	0.32 ± 0.19 b	0.29 ± 0.25 b
53.25	Trimethylsilyl 3-methyl-4-[(trimethylsilyl)oxy]benzoate	ND	0.49 ± 0.09 a	0.25 ± 0.18 b	0.22 ± 0.11 b	ND	0.21 ± 0.27	0.18 ± 0.17	0.20 ± 0.19
RT	Volatile compounds	Yogurt Samples**					Days of Storage***		
		C (control)	I1.0	I0.5	D1.0	D0.5	1	7	14
	Acids								
18.39	Acetic acid	0.33 ± 0.26 d	1.78 ± 0.44 a	0.79 ± 0.30 c	1.42 ± 0.87 b	0.97 ± 0.60 c	0.60 ± 0.44 b	1.36 ± 0.57 a	1.24 ± 0.91 a
30.00	Butanoic acid	0.38 ± 0.18 b	0.44 ± 0.12 b	0.69 ± 0.11 a	0.33 ± 0.09 b	0.73 ± 0.19 a	0.45 ± 0.15	0.55 ± 0.21	0.53 ± 0.27
31.59	Propanoic acid	ND	0.34 ± 0.09 a	0.20 ± 0.05 b	0.38 ± 0.10 a	0.17 ± 0.11 b	0.25 ± 0.17 a	0.19 ± 0.15 b	0.19 ± 0.16 b
33.22	3-Methyl pentanoic acid	ND	ND	ND	0.06 ± 0.06 a	ND	0.02 ± 0.05	0.02 ± 0.04	ND
40.13	Hexanoic (caproic) acid	41.31 ± 3.28 a	3.84 ± 2.72 c	20.64 ± 4.72 b	3.23 ± 1.83 c	24.04 ± 6.42 b	20.28 ± 15.18 a	19.27 ± 15.58 a	15.43 ± 15.79 b
42.50	Hexadecanoic acid	ND	0.97 ± 0.12 a	ND	0.78 ± 0.15 b	ND	0.32 ± 0.41 b	0.38 ± 0.49 a	0.40 ± 0.50 a
45.94	Octanoic (caprilic) acid	0.03 ± 0.06 c	0.86 ± 0.34 a	0.31 ± 0.21 b	0.98 ± 0.32 a	0.18 ± 0.08 bc	0.37 ± 0.29 b	0.63 ± 0.58 a	0.44 ± 0.41 b
49.53	Gibberellic acid	ND	0.26 ± 0.21 a	0.19 ± 0.23 ab	0.14 ± 0.09 b	0.13 ± 0.08 b	0.07 ± 0.07 b	0.20 ± 0.17 a	0.18 ± 0.21 a
	Aliphatic hydrocarbons								
18.92	Heptane	0.55 ± 0.05 a	ND	0.23 ± 0.06 c	ND	0.28 ± 0.08 b	0.24 ± 0.23 a	0.22 ± 0.22 a	0.17 ± 0.21 b
36.51	Methyl propenyl disulfane	ND	0.90 ± 0.09 b	0.75 ± 0.35 c	1.34 ± 0.17 a	0.76 ± 0.15 c	0.68 ± 0.49 b	0.72 ± 0.42 b	0.86 ± 0.56 a
37.53	n-Decane	1.41 ± 0.52 a	0.59 ± 0.31 c	0.83 ± 0.38 b	0.41 ± 0.26 d	0.65 ± 0.33 c	0.69 ± 0.19 b	0.65 ± 0.65 b	1.03 ± 0.48 a
38.72	Dodecane 4-methyl	0.19 ± 0.09 a	ND	ND	ND	ND	0.02 ± 0.04 c	0.06 ± 0.12 a	0.04 ± 0.07 b
40.31	Dodecane. 2,6,10 trimethyl	0.28 ± 0.13 a	0.26 ± 0.15 a	0.22 ± 0.17 ab	0.31 ± 0.15 a	0.13 ± 0.18 b	0.17 ± 0.19 b	0.26 ± 0.12 a	0.32 ± 0.11 a
41.77	n-Undecane	0.14 ± 0.21 b	0.14 ± 0.05 b	0.17 ± 0.09 b	0.23 ± 0.08 a	0.07 ± 0.07 c	0.11 ± 0.12 b	0.18 ± 0.15 a	0.14 ± 0.10 b
42.16	Nonadecane	0.66 ± 0.52 a	0.07 ± 0.06 d	0.41 ± 0.32 b	0.11 ± 0.10 d	0.22 ± 0.18 c	0.28 ± 0.42 b	0.34 ± 0.38 a	0.28 ± 0.25 b
44.69	Dodecane	0.22 ± 0.23 bc	0.49 ± 0.13 a	0.20 ± 0.09 bc	0.34 ± 0.12 ab	0.08 ± 0.05 c	0.22 ± 0.21	0.29 ± 0.16	0.32 ± 0.21
55.60	Eicosane	1.32 ± 1.56 a	0.13 ± 0.11 d	0.51 ± 0.87 c	0.01 ± 0.02 d	0.93 ± 0.27 b	0.88 ± 1.33 a	0.69 ± 0.67 a	0.17 ± 0.33 b
RT	Volatile compounds	Yogurt Samples**					Days of Storage***		
		C (control)	I1.0	I0.5	D1.0	D0.5	1	7	14
	Terpenes								
25.17	Methylbenzene	0.31 ± 0.02 a	0.12 ± 0.14 c	0.25 ± 0.05 ab	0.20 ± 0.09 b	0.27 ± 0.05 ab	0.19 ± 0.11 b	0.26 ± 0.09 a	0.24 ± 0.09 ab
31.39	Ethylbenzene	1.03 ± 0.19 a	ND	ND	ND	ND	0.16 ± 0.33 b	0.24 ± 0.50 a	0.25 ± 0.49 a
31.88	1.3-dimethylbenzene	0.49 ± 0.11 a	0.12 ± 0.05 d	0.23 ± 0.07 c	0.16 ± 0.01 d	0.31 ± 0.10 b	0.22 ± 0.12 b	0.23 ± 0.19 b	0.28 ± 0.21 a
33.61	Ethenylbenzen	1.48 ± 0.48 a	0.27 ± 0.22 d	0.56 ± 0.26 c	0.21 ± 0.03 d	0.92 ± 0.39 b	0.54 ± 0.41	0.66 ± 0.50	0.86 ± 0.75
34.37	3-carene	0.28 ± 0.09 a	ND	0.10 ± 0.04 c	ND	0.14 ± 0.03 b	0.10 ± 0.11 b	0.13 ± 0.14 a	0.08 ± 0.09 b
39.05	α-pinene	0.43 ± 0.17 a	ND	0.20 ± 0.16 b	0.09 ± 0.01 c	0.31 ± 0.12 b	0.14 ± 0.16 b	0.23 ± 0.19 a	0.24 ± 0.25 a
37.66	β-pinene	0.19 ± 0.09 a	ND	ND	ND	ND	0.02 ± 0.05	0.05 ± 0.11	0.05 ± 0.10
39.93	d-Limonene	1.54 ± 0.43 a	0.08 ± 0.04 b	1.29 ± 0.95 a	0.07 ± 0.12 b	1.34 ± 0.17 a	0.98 ± 1.07	0.55 ± 0.66	0.48 ± 0.45

RT: Retention Time, ND: Not Detected; *Mean values indicated by different exponential letters in the same line are significantly different from each other ($P < 0.05$); **The average of values found at the three sampling times (1, 7, 14 days); ***The average of values obtained from all samples at a sampling time.

Table 2. Continued...

RT	Volatile compounds	Yogurt Samples**					Days of Storage***		
		C (control)	I1.0	I0.5	D1.0	D0.5	1	7	14
40.12	1-methyl-2-(1-methylethyl) benzene	0.95 ± 0.22 a	0.01 ± 0.03 b	1.03 ± 0.36 a	0.02 ± 0.06 b	0.93 ± 0.18 a	0.61 ± 0.57	0.57 ± 0.50	0.56 ± 0.54
41.06	γ- terpinene	1.49 ± 0.57 a	ND	0.38 ± 0.59 c	0.16 ± 0.08 d	0.77 ± 0.26 b	0.38 ± 0.42 c	0.54 ± 0.77 b	0.76 ± 0.75 a
46.54	Azulene	ND	0.30 ± 0.15 a	0.08 ± 0.08 c	0.28 ± 0.15 a	0.07 ± 0.06 c	0.10 ± 0.09 b	0.14 ± 0.14 a	0.15 ± 0.19 a
54.16	1,2-bis(trimethylsilyl) benzene	ND	0.77 ± 0.29 b	0.14 ± 0.13 c	0.99 ± 0.34 a	0.19 ± 0.10 c	0.19 ± 0.27 b	0.39 ± 0.42 a	0.46 ± 0.52 a
	Heterocyclic compounds								
26.81	Hexamethyl cyclotrisiloxane	1.49 ± 0.30 d	8.98 ± 1.75 a	3.53 ± 3.28 c	5.03 ± 2.79 b	1.57 ± 0.23 d	4.55 ± 4.35	4.05 ± 3.00	4.00 ± 3.11
36.63	Octamethyl cyclotetrasiloxane	0.59 ± 0.13 c	3.11 ± 1.08 a	0.82 ± 0.28 c	1.50 ± 0.83 b	0.89 ± 0.48 c	1.24 ± 1.51	1.61 ± 1.08	1.39 ± 0.68
37.91	4- methyl-2-(1-propenyl)-1,3 oxathiane	ND	0.74 ± 1.07 a	0.06 ± 0.07 ab	0.34 ± 0.27 ab	0.14 ± 0.06 ab	0.12 ± 0.13	0.21 ± 0.26	0.47 ± 0.93
43.01	Decamethyl cyclopentasiloxane	ND	1.15 ± 0.18 a	0.24 ± 0.19 c	0.79 ± 0.54 b	0.14 ± 0.04 c	0.43 ± 0.5 b	0.58 ± 0.51 a	0.55 ± 0.54 a
46.39	1-methyl-4-[4,5-dihydroxyphenyl]-hexahydropyridine	ND	0.40 ± 0.13 a	0.29 ± 0.22 ab	0.33 ± 0.12 ab	0.18 ± 0.08 b	0.21 ± 0.19	0.31 ± 0.21	0.20 ± 0.15
46.73	5-methyl-2-phenyl-1H-Indole	0.12 ± 0.10 c	0.65 ± 0.59 b	0.18 ± 0.09 c	1.56 ± 0.51 a	0.13 ± 0.07 c	0.26 ± 0.39 c	0.74 ± 0.85 a	0.55 ± 0.68 b
47.62	Dodecamethyl cyclohexasiloxane	ND	1.17 ± 0.63 a	0.22 ± 0.09 b	0.94 ± 0.28 a	0.15 ± 0.07 b	0.38 ± 0.30 b	0.57 ± 0.48 ab	0.69 ± 0.76 a
52.00	1,1,1,3,5,5,5-Heptamethyltrisiloxane	ND	0.31 ± 0.22 a	0.25 ± 0.42 ab	0.15 ± 0.05 ab	ND	0.17 ± 0.34	0.18 ± 0.23	0.09 ± 0.09
56.23	1,2-dihydro-2,2,4-trimethylquinoline	1.15 ± 1.91	0.14 ± 0.18	0.79 ± 1.13	0.29 ± 0.39	0.93 ± 0.62	0.72 ± 1.54	1.06 ± 0.85	0.21 ± 0.13

RT: Retention Time, ND: Not Detected; *Mean values indicated by different exponential letters in the same line are significantly different from each other ($P < 0.05$); **The average of values found at the three sampling times (1, 7, 14 days); ***The average of values obtained from all samples at a sampling time.

compounds, 12 terpenes and 9 heterocyclic compounds. The flavour, which is the sum of these components – formed as a result of a series of chemical and biochemical reactions – is an important attribute determining consumer choice (Cheng, 2010).

The widest occurring volatile compound group was carbonyl compounds. Acetaldehyde, acetoin and 2,3-butanedione were the most abundant ones in all the yogurt samples during the storage period. The highest mean concentration of these three compounds was detected in yogurt sample C (control). The addition of garlic paste significantly affected the acetaldehyde, acetoin and 2,3-butanedione contents in the yogurt samples ($P < 0.05$) the type of garlic was not effective on concentration of these volatiles. Acetaldehyde, acetoin and diacetyl are accepted as the main components contributing to yogurt flavour, and generally, acetaldehyde is a source of the characteristic fresh and fruity flavour of yogurt (Bakırcı & Arslaner, 2007; Tamime & Deeth, 1980). Yogurt sample D1.0 had the lowest mean concentration of acetaldehyde, but no significant differences were determined between other garlic yogurt samples. There was no significant difference in terms of acetaldehyde concentration between 1 and 14 days of storage. The highest mean concentration of acetoin and 2,3-butanedione were detected in the control (C) sample. The mean concentration of acetoin and 2,3-butanedione decreased after day 1 of storage ($P < 0.05$), and 2-nonanone and nonanal were only detected in yogurt sample C. In contrast, benzaldehyde and octanal were only found in yogurt samples with garlic.

Alcohols have a high flavour threshold, so have little effect on the yogurt flavour (Su et al., 2017). Ethyl alcohol and 2-ethyl-1 hexanol were detected in all yogurt samples, but dimethylsilanediol was only identified in yogurt samples with added garlic paste. The addition of garlic paste significantly affected the level of alcohol concentration in the yogurt samples ($P < 0.05$). The highest mean concentration of ethyl alcohol was detected in the control (C) sample. The D1.0 sample had a lower concentration of ethyl alcohol compared to the others. However, the use of different garlic varieties created significant ($P < 0.05$) differences in the 2-ethyl-1 hexanol concentration. The I1.0 and I0.5 samples containing imported garlic paste had higher levels of this compound compared to samples D1.0 and D0.5. In addition, the proportions of dimethylsilanediol, which is an onion genus, *Allium* based volatile (Cheng et al., 2014), also increased due to the increased garlic paste content. The highest concentration of this alcohol was detected in yogurt sample I1.0. The effect of storage on alcohol concentrations was significant ($P < 0.05$). Ethyl alcohol and dimethylsilanediol concentrations increased towards day 14 of storage, but 2-ethyl-1 hexanol decreased.

A total of twelve sulfur-containing compounds were detected in the yogurt samples. Only two sulfuric compounds, allyl methyl sulfide and thiourea, were identified in the C (control) sample. The addition of garlic paste significantly increased the concentration of these compounds ($P < 0.05$). Furthermore, the garlic variety and amount significantly affected the concentrations of sulfur-containing compounds in the yogurt samples. Significant differences ($P < 0.05$) were detected between the samples with added imported garlic and added domestic garlic. The highest level of allyl methyl sulfide, allyl n-propyl sulfide, allyl methyl disulfide, 1,3-dithiane, dimethyl trisulfide and allyl methyl trisulfide were detected in yogurt sample D1.0, also the high concentration of allyl methyl disulfide and allyl methyl trisulfide was remarkable in the D1.0 and D0.5 samples containing domestic garlic compared I1.0 and I0.5 samples containing imported garlic. Some researchers have suggested that these volatiles in garlic oil may protect the body against the injury caused by radical molecules encountered in daily life (Park et al., 2017). Zhang et al. (2016) reported that allyl methyl disulfide may become a supplementary drug used in the selective treatment and prevention of liver injury.

There was no significant difference between I1.0 and D1.0 in terms of diallyl sulfide, allyl disulfide, allyl cis 1-propenyl disulfide and 2, 4-dimethyl thiophene concentrations. The storage time significantly ($P < 0.05$) affected the mean concentration of sulfur-containing compounds, except for tetramethylthiourea. The allyl mercaptan, allyl methyl sulfide and allyl methyl disulfide concentrations decreased during storage.

Esters related to the presence of acid and alcohol, although at low concentrations, make a positive contribution to the flavour of yogurt (Cheng, 2010). In this study, a total of 6 esters were detected in the yogurt samples. The ratio of added garlic paste and variety of garlic significantly affected ($P < 0.05$) the level of esters in the yogurt samples. The highest concentrations of ethyl acetate and propanoic acid butyl ester were identified in yogurt sample D1.0. No ethyl acetate or trimethylsilyl 3-methyl-4-[(trimethylsilyl)oxy] benzoate was detected in sample C (control). The highest concentrations of arsenous acid, tris (trimethylsilyl) ester, silicic acid, diethyl bis(trimethylsilyl) ester and trimethylsilyl 3-methyl-4-[(trimethylsilyl)oxy] benzoate were detected in sample I1.0. The concentrations of esters fluctuated during storage.

Yogurt is typically characterized by a sharp acid and fruity flavour (Bodyfelt et al., 1988; Cheng, 2010; Chen et al., 2017). The volatile and non-volatile acids produced by bacterial fermentation and lipolysis, especially lactic acid, affect the formation of the typical acidic flavour of yogurt (Cheng, 2010). Eight different volatile acids were isolated from the yogurt samples during storage. Acetic acid, butanoic acid, hexanoic acid and octanoic acid were identified in all yogurt samples, but propanoic acid and gibberellic acid were only detected in samples with garlic paste. Acetic acid, propanoic acid and hexadecanoic acid were previously detected in 74% and 100% ethanol garlic extract by Park et al. (2017). It has been reported that gibberellins, produced by plants and necessary for their growth and development, are also produced by various bacteria living with plants (Tien et al., 1979). Significant differences were observed between the samples in terms of mean volatile acid concentrations ($P < 0.05$). Also, 3-methyl pentanoic acid was only found in yogurt samples containing 1.0% domestic garlic paste (D1.0), and hexadecanoic acid was only found in yogurt samples I1.0 and D1.0. Hexanoic acid was the most abundant volatile acid in all the samples. Similar results have been reported by other researchers (Kavaz Yüksel & Bakırcı, 2015; Dan et al., 2017).

Control sample (C) had the the highest mean concentration of hexanoic acid (41.31%). Use of garlic paste resulted in a decrease in its concentration. The hexanoic acid concentration of yogurt samples decreased significantly ($P < 0.05$) after day 7 of storage. Acetic acid is one of the major components in the breakdown of lactose by *Str. salivarius* ssp. *thermophilus* and *Lb. delbrueckii* ssp. *bulgaricus* (Tamime & Robinson, 1999). The formation of acetic acid at high concentrations causes an undesirable vinegar-like taste (Tamime & Robinson, 1999; Ott et al., 1997; Chen et al., 2017). Samples containing garlic paste had a higher acetic acid concentration compared to the control sample (C). The highest value peak area of acetic acid was detected in the I1.0 sample containing 1.0% imported garlic paste, and the lowest one was in the C sample ($P < 0.05$). Butanoic acid, which is responsible for the characteristic cheese-like taste, was found to be higher in the yogurt samples containing 0.5% imported and 0.5% domestic garlic paste compared to the other samples. Nine aliphatic hydrocarbon compounds were detected in the volatile fraction of the yogurt samples. The ratio of added garlic paste and variety of garlic significantly affected the level of these compounds in the samples ($P < 0.05$). Heptane, n-decane, nonadecane and eicosane concentrations were significantly higher in the control sample (C) compared to other samples ($P < 0.05$). Methyl propenyl disulfane was only detected in yogurt samples with garlic paste, and the highest mean concentration was detected in yogurt sample D1.0 ($P < 0.05$), followed in descending order by samples I1.0, D0.5 and I0.5. The compound 4-methyl dodecane was only present in yogurt sample C.

Terpenes, one of the volatile constituents of plant origin, are important aromatic components of dairy products especially those produced from mountainous regions (Curioni & Bosset, 2002). In the current study, a total of twelve terpenes were detected in the yogurt samples. It can be said that the rich terpene content of the control yogurt samples is due to the use of milk from cows grazing in spring pasture. The highest concentrations of methyl benzene, ethyl benzene, 1.3 dimethyl benzene, ethenyl benzene, 3-carene, α-pinene, β-pinene and γ-terpinene were found in sample C. In addition, the use of garlic paste significantly ($P < 0.05$) affected the terpene concentrations of the yogurt samples. Ethyl benzene and β-pinene were only detected in sample C, while azulene and 1,2 bis (trimethylsilyl) benzene were only present in the samples with added garlic. There was no significant difference between samples I0.5, D0.5 and C in terms of d-limonene and 1-methyl-2-(1-methylethyl) benzene. The mean ethyl benzene, 1,3 dimethyl benzene, α-pinene, γ-terpinene, azulene and 1,2 bis (trimethylsilyl) benzene concentration in the yogurt samples significantly ($P < 0.05$) increased until day 14 of storage, but there was no significant change in ethenyl benzene, β-pinene, d-limonene and 1-methyl-2-(1-methylethyl) benzene concentrations.

A total of nine heterocyclic compounds were identified in the yogurt samples. As shown in Table 2, significant ($P < 0.05$) differences were observed in the concentrations of heterocyclic compounds in the yogurt samples. The variety in garlic and content significantly affected the concentration of these components in the samples. The four compounds, hexamethylcyclotrisiloxane, octamethylcyclotetrasiloxane, 5-methyl-2-phenyl-1H-indole and 1,2-dihydro-2,2,4-trimethylquinoline were only detected in sample C (control). The highest mean concentrations of hexamethylcyclotrisiloxane, octamethylcyclotetrasiloxane, 4-methyl-2- (1-propenyl)-1,3 oxathiane, decamethylcyclopentasiloxane, 1-methyl-4-[4,5 dihydroxyphenyl]-hexahydropyridine, dodecamethylcyclohexasiloxane and 1,1,1,3,5,5,5-heptamethyltrisiloxane were observed in sample I1.0 containing 1.0% imported garlic paste. The effect of storage on decamethylcyclopentasiloxane, and 5-methyl-2-phenyl-1H-indoleconcentrations produced significant differences ($P < 0.05$) between yogurt samples.

3.5 Sensory properties of yogurt

It was observed that the addition of garlic did not cause a significant change in the appearance of the samples (Table 3). When the average values for the storage day increments were examined, it was observed that the scores for the lowest consistency

Table 3. Sensory analysis results of the yogurt samples*.

Sensory parameters	Storage (day)	Yogurt samples				
		C (control)	I1.0	I0.5	D1.0	D0.5
Appearance	1	4.71 ± 0.49 a, AB	4.71 ± 0.49 a, AB	4.43 ± 0.79 a, AB	4.86 ± 0.38 a, A	4.14 ± 0.69 a, B
	7	4.57 ± 0.53 a, A	4.57 ± 0.79 a, A	4.86 ± 0.38 a, A	4,86 ± 0.38 a, A	4.71 ± 0.49 a, A
	14	4.43 ± 0.53 a, A	4.43 ± 0.53 a, A	4.43 ± 0.53 a, A	4.71 ± 0.49 a, A	4.43 ± 0.53 a, A
Consistency (by spoon)	1	4.86 ± 0.38 a, A	4.00 ± 0.58 a, B	4.57 ± 0.53 a, AB	4.86 ± 0.38 a, A	4.29 ± 0.76 a, AB
	7	4.29 ± 0.49 ab, A	4.14 ± 0.90 a, A	3.86 ± 0.69 ab, A	4.43 ± 0.53 a, A	4.00 ± 0.81 a, A
	14	3.71 ± 0.76 b, A	3.57 ± 0.79 a, A	3.71 ± 0.76 b, A	4.29 ± 0.76 a, A	3.71 ± 0.76 a, A
Consistency (by mouth)	1	4.43 ± 0.53 a, AB	3.86 ± 0.90 a, B	4.57 ± 0.53 a, AB	4.71 ± 0.49 a, A	4.29 ± 0.49 a, AB
	7	4.43 ± 0.53 a, A	4.14 ± 0.69 a, A	4.00 ± 0.82 a, A	4.42 ± 0.53 a, A	4.14 ± 0.69 a, A
	14	4.14 ± 0.69 a, A	3.71 ± 0.76 a, A	4.14 ± 0.69 a, A	3.71 ± 0.76 b, A	4.00 ± 0.82 a, A
Odour	1	4.86 ± 0.38 a, A	4.43 ± 0.53 a, A	4.86 ± 0.38 a, A	4.71 ± 0.49 a, A	4.71 ± 0.76 a, A
	7	4.43 ± 0.53 ab, AB	4.00 ± 0.58 a, B	4.29 ± 0.49 b, AB	4.57 ± 0.53 a, AB	4.86 ± 0.38 a, A
	14	4.29 ± 0.49 b, A	4.14 ± 0.69 a, A	3.43 ± 0.53 c, B	3.71 ± 0.49 b, AB	3.71 ± 0.49 b, AB
Taste	1	4.71 ± 0.49 a, A	4.43 ± 0.79 a, A	4.71 ± 0.49 a, A	4.86 ± 0.38 a, A	4.71 ± 0.49 a, A
	7	4.14 ± 0.69 ab, A	3.86 ± 0.38 a, A	3.71 ± 0.49 b, A	4.29 ± 0.49 ab, A	4.29 ± 0.49 a, A
	14	3.85 ± 0.69 b, A	3.86 ± 0.69 a A	3.71 ± 0.95 b, A	3.86 ± 0.69 b, A	3.71 ± 0.62 b, A

*Different lower letters (during storage days) in the same column and different capital letters (between samples at the same storage day) in the same row indicate significant differences ($P < 0,05$).

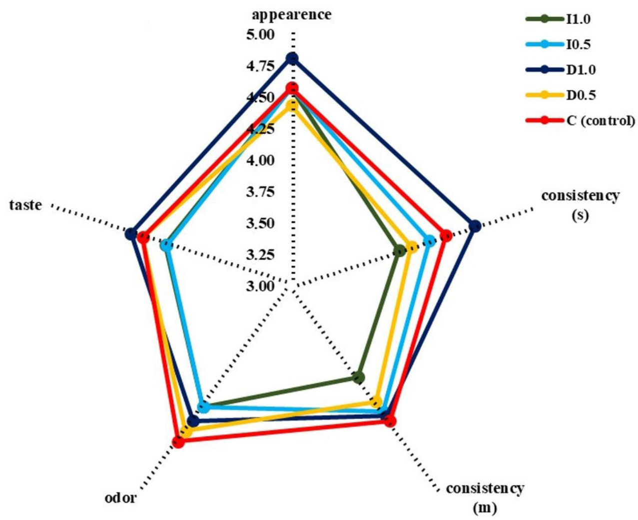

Figure 1. Total average sensory scores of yogurt samples C (control): 0% garlic; I1.0: 1.0% imported garlic; I0.5: 0.5% imported garlic; D1.0: 1.0% domestic garlic; D0.5: 0.5% domestic garlic.

using a spoon and consistency by mouth belonged to the I1.0 sample (Figure 1). The I0.5 and C (Control) samples received the highest average odour score on the first day of storage, and the D0.5 sample received it on day 14 of storage. Although the odour and taste scores of the yogurt samples decreased during storage, it was observed that the addition of garlic did not cause a negative change in these properties. The highest taste score (4.86) belonged to the D1.0 sample on the first day of storage.

4 Conclusion

Yogurt samples with garlic had a higher dry matter ratio, protein and pH value than the C (control) sample. The addition of garlic in different amounts in yogurt production did not cause a decrease in the total specific microorganism count (>10^7) during storage, but it led to a significant decrease in the yeast–mould count compared to the control samples.

The addition of garlic paste significantly decreased the level of carbonyl compounds, aliphatic hydrocarbons (except heptane), terpenes (except azulene 1,2-bis(trimethylsilyl) benzene), heterocyclic compounds (except 1,2-dihydro-2,2,4-trimethylquinoline) concentrations in the yogurt samples. In addition, sulphur-containing compounds (except tetramethyl thiourea), esters, acids (except hexanoic acid) and heterocyclic compounds (except 1,2-dihydro-2,2,4-trimethylquinoline) concentrations increased with the addition of garlic. Propanoic acid and gibberellic acid were only detected in samples with garlic paste. Samples with imported garlic paste were found to be richer in terms of alcohol content than samples with domestic garlic paste. It was thought that the rich terpene content of the control yogurt samples is due to the use of milk from cows grazing in spring pasture. The variety of garlic and content significantly affected the concentration of the heterocyclic components in the yogurt samples. It was determined that the addition of 1.0% garlic had a significant effect on the characteristic volatile compound profiles of the yogurt but did not cause any negative effect on consumer taste. In the sensory analyses, the yogurt samples produced with the addition of 1.0% domestic garlic were the samples most preferred by the panelists in terms of appearance, consistency (m), and taste scores.

References

Alonso, L., & Fraga, M. J. (2001). Simple and rapid analysis for quantitation of the most important volatile flavour compounds in yogurt by headspace gas chromatography-mass spectrometry. *Journal of Chromatographic Science*, 39(7), 297-300. http://dx.doi.org/10.1093/chromsci/39.7.297. PMid:11471993.

Arslaner, A. (2016). Yoğurt ve sağlıklı beslenme. *Bilinçli Sağlıklı Yaşam Dergisi*, 12, 563-574.

Arslaner, A., Çakır, Ö., Yıldız, H., & Aksehir, K. (2017). Mineral Content and Antioxıdant Activity of Taşköprü Garlic (*Allium sativum* L.). In *Proceedings International Taşköprü Pompeiopolis Science Culture Research Symposium*. Kastamonu, Turkey: Kastamonu University Taşköprü Vocational School.

Ayaz, E., & Alpsoy, H. C. (2007). Garlic (*Allium sativum*) and traditional medicine. *Turkish Journal Parasitology*, 31(2), 145-149. PMid:17594659.

Bakırcı, I., & Arslaner, A. (2007). The effects of partially skim milk powder with whey powder in set type yogurt manufacture. *Milk Science International-Milchwissenschaft*, 62, 434-438.

Beuchat, L. R., Mann, D. A., & Gurtler, J. B. (2007). Comparison of dry sheet media and conventional agar media methods for enumerating yeasts and moulds in food. *Journal of Food Protection*, 70(11), 2661-2664. http://dx.doi.org/10.4315/0362-028X-70.11.2661. PMid:18044453.

Bodyfelt, F. W., Tobias, J., & Trout, G. M. (1988). Sensory evaluation of cultured milk products. In F. W. Bodyfelt, J. Tobias & G. M. Trout (Eds.), *The sensory evaluation of dairy products*. New York: Van Nostrand Reinhold.

Cemeroğlu, B. (2010). General methods in food analysis. In B. Cemeroğlu (Ed.), *Food analysis* (2nd ed.). Ankara: Food Technology Association Publications.

Chen, C., Zhao, S., Hao, G., Yu, H., Tian, H., & Zhao, G. (2017). Role of lactic acid bacteria on the yogurt flavour: a review. *International Journal of Food Properties*, 20(1), 316-330. http://dx.doi.org/10.1080/10942912.2017.1295988.

Cheng, H. (2010). Volatile flavour compounds in yogurt: a review. *Critical Reviews in Food Science and Nutrition*, 50(10), 938-950. http://dx.doi.org/10.1080/10408390903044081. PMid:21108074.

Cheng, L., Luo, J., Li, P., Yu, H., Huang, J., & Luo, L. (2014). Microbial diversity and flavor formation in onion fermentation. *Food & Function*, 5(9), 2338-2347. http://dx.doi.org/10.1039/C4FO00196F. PMid:25088041.

Curioni, P. M. G., & Bosset, J. O. (2002). Key odorants in various cheese types as determined by gas chromatography-olfactometry. *International Dairy Journal*, 12(12), 959-984. http://dx.doi.org/10.1016/S0958-6946(02)00124-3.

Dan, T., Wang, D., Wu, S., Jin, R., Ren, W., & Sun, T. (2017). Profiles of volatile flavor compounds in milk fermented with different proportional combinations of *Lactobacillus delbrueckii* ssp. *bulgaricus* and *Streptococcus thermophilus. Molecules*, 22(10), 1-14. http://dx.doi.org/10.3390/molecules22101633. PMid:28961194.

Dave, R. I., & Shah, N. P. (1996). Evaluation of media for selective enumeration of *Streptococcus thermophilus, Lactobacillus delbrueckii* ssp. *bulgaricus, Lactobacillus acidophilus,* and Bifidobacteria. *Journal of Dairy Science*, 79(9), 1529-1536. http://dx.doi.org/10.3168/jds.S0022-0302(96)76513-X. PMid:8899517.

Food and Agriculture Organization of the United Nations – FAO, Codex Alimentarius Commission – CAC. (2003). *Codex stan 243-2003: standard for fermented milks*. Rome: FAO/WHO.

Gebreyohannes, G., & Gebreyohannes, M. (2013). Medicinal values of garlic: a review. *International Journal of Medicine and Medical Science*, 5(9), 401-408. http://dx.doi.org/10.5897/IJMMS2013.0960.

Gündoğdu, E., Çakmakçı, S., & Dağdemir, E. (2009). The effect of garlic (*Allium sativum* L.) on some quality properties and shelf-life of set and stirred yoghurt. *Turkish Journal of Veterinary and Animal Sciences*, 33(1), 27-35. http://dx.doi.org/10.3906/vet-0704-26.

Harrigan, W. F. (1998). *Laboratory methods in food microbiology* (3rd ed.). San Diego: Academic Press.

International Dairy Federation – IDF. (1993). *IDF standard method 20: milk determination of nitrogen content*. Brussels: IDF.

Kavaz Yüksel, A., & Bakırcı, I. (2015). An investigation of the volatile compound profiles of probiotic yogurts produced using different inulin and demineralized whey powder combinations. *Food Science and Biotechnology*, 24(3), 807-816. http://dx.doi.org/10.1007/s10068-015-0105-0.

Kayserili, A. (2018). An essay on cultural geography: gastronomy in Turkish culture. In A. Kırkkılıç, E. E. Başar & Y. Söylemez (Eds.), *Selected studies on social science* (Chap. 4, pp. 294-297). Newcastle upon Tyne: Cambridge Scholars Publishing.

Kutawa, A. B., Danladi, M. D., & Haruna, A. (2018). Antifungal activity of garlic (*Allium sativum*) extract on some selected fungi. *Journal of Medicinal Herbs and Ethnomedicine*, 4, 12-14. http://dx.doi.org/10.25081/jmhe.2018.v4.3383.

Marco, A., Navarro, J. L., & Flores, M. (2004). Volatile compounds of dry- fermented sausages as affected by solid-phase micro extraction (SPME). *Food Chemistry*, 84(4), 633-641. http://dx.doi.org/10.1016/S0308-8146(03)00288-7.

Martins, N., Petropoulos, S., & Ferreira, I. C. F. R. (2016). Chemical composition and bioactive compounds of garlic (*Allium sativum* L.) as affected by pre- and post-harvest conditions: a review. *Food Chemistry*, 211, 41-50. http://dx.doi.org/10.1016/j.foodchem.2016.05.029. PMid:27283605.

McKinley, M. C. (2005). The nutrition and health benefits of yoghurt. *International Journal of Dairy Technology*, 58(1), 1-12. http://dx.doi.org/10.1111/j.1471-0307.2005.00180.x.

Ott, A., Fay, L. B., & Chaintreau, A. (1997). Determination and origin of the aroma impact compounds of yogurt flavor. *Journal of Agricultural and Food Chemistry*, 45(3), 850-858. http://dx.doi.org/10.1021/jf960508e.

Pagthinathan, M., & Tharmiga, R. (2016). Effect of garlic paste added to yoghurt of cow milk. *Journal of Agricultural Science and Technology B*, 6(6), 411-417. http://dx.doi.org/10.17265/2161-6264/2016.06.006.

Park, N. H., Jang, H. R., Lee, S. J., Boby, N., & Park, S. C. (2017). Gas chromatographic-mass spectrometric analysis, antimicrobial and antioxidant effects of ethanolic garlic extract. *International Journal of Phytomedicine*, 9(2), 324-331. http://dx.doi.org/10.5138/09750185.2087.

Puga, F. L., & Urquiaga, I. (2010). The Mediterranean diets: nutrition and gastronomy. In J. Smith & E. Charter (Eds.), *Functional food product development* (Chap. 15, pp. 322-343). West Sussex: Blackwell Publishing.

Rees, L. P., Minney, S. F., Plummer, N. T., Slater, J. H., & Skyrme, D. A. (1993). A quantitative assessment of the antimicrobial activity of garlic (*Allium sativum*). *World Journal of Microbiology & Biotechnology*, 9(3), 303-307. http://dx.doi.org/10.1007/BF00383068. PMid:24420031.

Su, N., Ren, L., Ye, H., Sui, Y., Li, J., & Ye, M. (2017). Antioxidant activity and flavor compounds of hickory yogurt. *International Journal of Food Properties*, 20(8), 1894-1903. http://dx.doi.org/10.1080/10942912.2016.1223126.

Tamime, A. Y., & Deeth, H. C. (1980). Yogurt: technology and biochemistry. *Journal of Food Protection*, 43(12), 939-977. http://dx.doi.org/10.4315/0362-028X-43.12.939. PMid:30836467.

Tamime, A. Y., & Robinson, R. K. (1999). *Historical background: yogurt science and technology* (2nd ed.). Cambridge: Woodhead Publishing.

Tien, T. M., Gaskins, M. H., & Hubbell, D. H. (1979). Plant growth substances produced by *Azospirillum brasilense* and their effect on the growth of pearl millet (*Pennisetum americanum* L.). *Applied and Environmental Microbiology*, 37(5), 1016-1024. http://dx.doi.org/10.1128/AEM.37.5.1016-1024.1979. PMid:16345372.

Tomás-Barberán, F. A., & Espin, J. C. (2001). Phenolic compounds and related enzymes as determinants of quality in fruits and vegetables. *Journal of the Science of Food and Agriculture*, 81(9), 853-876. http://dx.doi.org/10.1002/jsfa.885.

Turkey, Ministry of Agriculture and Forestry. (2009, February 16). Turkish food codex, fermented dairy products communique (nº 2009/25). *Official Gazette of the Republic of Turkey*.

Turkish Standards Institution – TSE. (1978). *Van gulik methods: official methods of analysis*. Ankara: TSE.

Turkish Standards Institution – TSE. (1981). *TSE-TS 1018: raw milk standard*. Ankara: TSE.

Turkish Standards Institution – TSE. (2006). *TSE-TS 1330: yoghurt standard*. Ankara: TSE.

Yıldız, H., Arslaner, A., & Çakır, Ö. (2016). Mineral and heavy metal content of China and Taşköprü Garlic (*Allium sativum* L.). In *Proceedings of the 2nd International Congress of Forensic Toxicology*. Ankara: Ankara University.

Zhang, Y., Zhang, F., Wang, K., Liu, G., Yang, M., Luan, Y., & Zhao, Z. (2016). Protective effect of allyl methyl disulfide on acetaminophen-induced hepatotoxicity in mice. *Chemico-Biological Interactions*, 249, 71-77. http://dx.doi.org/10.1016/j.cbi.2016.03.008. PMid:26969520.