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Korrespondenzadresse:
murat.terzioglu@atauni.edu.tr

[1]) Atatürk University, Faculty of Agriculture, Department of Food Engineering, 25240, Erzurum, Turkey

Fatty acid composition, cholesterol content, volatile compounds, antioxidant activity, phenolic compounds, and microstructure of sheep yoghurt enriched with the addition of kiwi and banana

Fettsäurezusammensetzung, Cholesteringehalt, flüchtige Verbindungen, antioxidative Aktivität, phenolische Verbindungen und Mikrostruktur von mit Kiwi und Banane angereichertem Schafsjoghurt

Murat Emre Terzioğlu[1]), İhsan Bakirci[1])

Summary

In this study, physicochemical, biochemical, microstructure, and sensory properties of sheep yoghurts with kiwi and banana added at different rates were investigated. It was determined that the addition of kiwi and banana at different rates increased the amount of ∑MUFA (monounsaturated fatty acids), ∑PUFA (polyunsaturated fatty acids), conjugated linoleic acid (CLA), DPPH (2,2-diphenyl-1-picrylhydrazyl) free radical scavenging activity and the total phenolic compounds (TPC), while decreasing the value of ∑SFA (saturated fatty acids), cholesterol content, acetaldehyde, diacetyl, acetoin, and ACE (angiotensin converting enzyme) inhibitory activities. In addition, the addition of fruit was effective on the homogeneous structure in the microstructure and the amount and depth of the serum pores. As a result of the current research, the production of yoghurt enriched with kiwi and banana at different proportions from sheep milk has shown many positive effects in terms of both nutrition and health.

Keywords: Conjugated linoleic acid, cholesterol, antioxidant activity, ACE inhibitory activity, microstructure

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Introduction

Sheep milk is a very rich source of protein, fat, vitamins, and mineral substances due to its high total solids content compared to cow's milk, which is the most preferred. In addition, due to its high viscosity feature, it is relatively easy to process dairy products with the desired consistency and texture (Balthazar et al., 2017). The proteins and fats it contains are the main compounds that contribute to the functional properties of sheep milk. The fact that sheep milk triglycerides have different structures than those of cow milk makes them superior in terms of digestibility (De Barros et al., 2020). Its easy digestibility can be explained by the fact that it has smaller (<3 µm) fat globules compared to cow and goat milk, and that short and medium-chain fatty acids such as butyric, caproic, caprylic, and capric acids are directly included in the blood circulation (Balthazar et al., 2017). On average, sheep milk fat contains 60% saturated fatty acids, 30% monounsaturated fatty acids, and 10% polyunsaturated fatty acids. It is known that the CLA content, which is associated with the superiority of sheep milk to other kinds of milk, plays an important role in the prevention of diseases with high mortality rates such as cardiovascular diseases, cancer, and diabetes (Kahraman and Yüceer Özkul, 2020). Acetaldehyde, diacetyl, and acetoin volatile compounds are responsible for the characteristic aroma of yoghurt, which is a product obtained by fermenting milk using *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus salivarius* subsp. *thermophilus* bacteria. These compounds are formed as a result of yoghurt bacteria use precursors such as lactose, threonine, methionine, and pyruvate. The amount of volatile compounds in yoghurts is significantly affected by the milk type and additives such as fruit included in the production process (Zhao et al., 2018). On the other hand, while sheep milk has antioxidant activity due to the bioactive peptides it contains, this activity increases significantly with the addition of fruit. Today, the intake of antioxidant substances has an effective mechanism in scavenging free radicals and preventing oxidation, which is associated with many diseases in the body. Although various factors are effective on the oxidation reaction, it is not possible to completely prevent these factors. The addition or use of antioxidant substances to reduce or prevent oxidation is a general practice that will cover all factors. On the other hand, fruits, which are one of the natural antioxidant substances, draw attention as an alternative source due to the possible side effects of synthetic antioxidant substances (El Azab and Mostafa, 2021). Kiwi and bananas, which are among these fruits, are rich sources of phenolic compounds, polyphenols, flavonoids, organic acids, food fiber, vitamins, and mineral substances they contain (Falcomer et al., 2019). Another important property provided by bioactive peptides is ACE inhibitory activity. ACE inhibitors are used in the treatment of hypertension, which is one of the cardiovascular diseases. Due to some of the observed side effects of synthetic ACE inhibitors (aptopril, fosinopril, and lisinopril) used in the treatment of hypertension, the search for natural ACE inhibitors has accelerated. In this context, the fact that sheep milk and its products have significant ACE inhibitory activity has directed attention to this area. Whey proteins and caseins are both natural and rich sources for the formation of ACE inhibitory peptides. Bioactive peptides with ACE inhibitory activity are formed by proteolytic activity that occurs during heat treatment, fermentation, and storage in yoghurt production (Wulandani et al., 2018; Tsevdou et al., 2020).

In line with all this information, the consumption of sheep milk should be expanded due to the nutritional elements it contains and its functional properties. On the other hand, consumers' lack of easy access to sheep milk, its dominant taste/aroma, and narrow product range limit consumption. In addition, fruit-added yoghurts contribute significantly to the increase in consumer demands and yoghurt consumption. Although fruit cow yoghurts are offered for consumption, it is an important shortcoming that fruit yoghurts produced from sheep milk are not included in consumption and there is not enough study on fruit sheep yoghurts.

For this purpose, in the present study, different proportions of kiwi and banana were added to the yoghurt samples produced from sheep milk, and the fatty acid composition, CLA content, cholesterol content, volatile compound amount, DPPH free radical scavenging activity, TPC amount, ACE inhibitory activity, and microstructure were investigated as well as physicochemical, and sensory analyses during the storage period.

Materials and methods

Material

In the present study, experimental sheep yoghurt was produced using sheep milk, sugar, kiwi, and banana (obtained from local markets in Erzurum), and *L. bulgaricus* and *S. thermophilus* cultures (obtained from CHR Hansen/Süt-Sa Süt Sanayii İht. Malz. Tic.).

Method

Preparation of kiwi and banana puree

After adding 7.5% sugar to the peeled kiwi and banana fruits, they were pureed and homogenized with a kitchen-type blender. Then, it was subjected to pasteurization at 90±1ºC for 5–10 minutes. After cooling to room temperature, it was added to the experimental sheep yoghurt samples.

Experimental sheep yoghurt production

The production flow chart of the experimental sheep yoghurt samples is given in Figure 1.

Physicochemical analyses of raw sheep milk

In the current study, physicochemical analyses of raw sheep milk used as raw material were carried out with reference to Kavaz (2012).

Physicochemical analyses

Physicochemical analyses of the experimental sheep yoghurt samples, were carried out with reference to Kavaz (2012).

Fatty acid composition and CLA content

Gas chromatography (Shimadzu, GC-QP2010) was used to determine the fatty acid composition and CLA content of the experimental sheep yoghurt samples, and the method given by Satchithanandam et al. (2001) was taken as a basis. Fatty acid composition and CLA analysis were performed in gas chromatography using Restek RTX-2330 capillary column (60 m x 0.25 mm x 0.1 µm) and flame ionization detector.

Cholesterol content
Cholesterol content of experimental sheep yoghurt samples was determined by making some modifications the method introduced by Fletouris et al. (1998). In this context, after adding methanolic KOH solution on the yoghurt sample, it was mixed and kept in a water bath at 80°C for 15 minutes. After cooling to room temperature, it was centrifuged by adding 5 mL of n-hexane and 1 mL of water and analyzed in gas chromatography (Shimadzu, GC-MS-QP2010).

Volatile compounds
Gas chromatography-mass spectrometry (Shimadzu, GC-MS-QP2010) was used to determine the volatile compounds of the experimental sheep yoghurt samples, and headspace injection mode and DB-WAX Ultra Inert (Agilent, 30 m, 0.25 mm, 0.25 µm) column were used. For this purpose, 5 g of sheep yoghurt sample was weighed into the headspace vial and shaken for 30 minutes. Then, the volatile compounds were collected by incubating at 80°C. After the column oven of GC-MS was kept at 40°C for 2 minutes, it was increased to 200°C at a rate of 5°C/min. Helium was used as the carrier gas in GC-MS with a flow rate of 1.70 mL/min (Kavaz, 2012).

DPPH free radical scavenging activity
The antioxidant activity of the experimental sheep yoghurt samples was determined using the DPPH free radical scavenging activity method introduced by Arslaner et al. (2021). In this direction, 50 µL of sheep yoghurt sample was weighed, mixed with 0.004% DPPH solution with 5 mL of methanol, and kept at room temperature for 30 minutes. Then, absorbance measurement was performed by using a spectrophotometer at 517 nm. In the determination of DPPH free radical scavenging activity, a curve was drawn with reference to Trolox and the results were given as mg TE/100 g.

TPC amount
In order to determine the TPC amount, 1 mL of Folin-Ciocalteu reagent, and 46 mL of distilled water were added to the 0.1 mL of sheep yoghurt sample and mixed for 3 minutes. Then, 3 mL of 2% Na_2CO_3 solution was added to the mixture and left for 2 hours. These processes were also applied to the gallic acid solution and the absorbance of all samples was measured at 760 nm in the spectrophotometer (Arslaner et al., 2021).

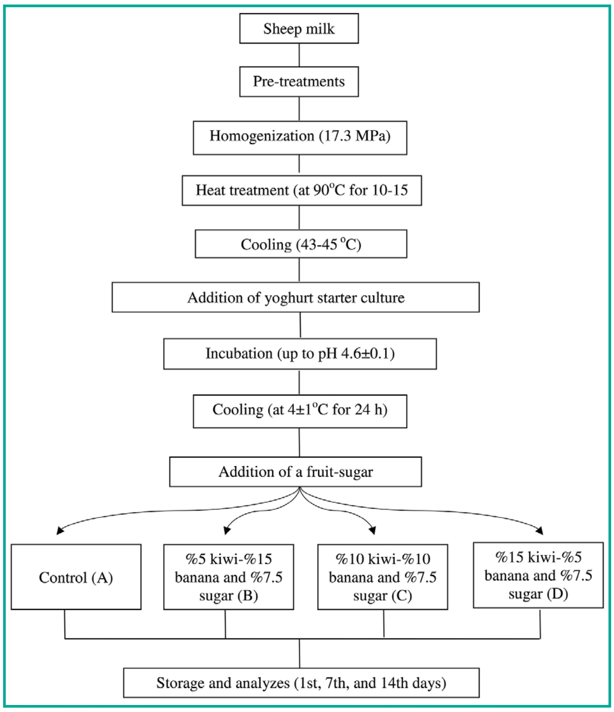

FIGURE 1: *Flow chart of the production of the experimental sheep yoghurt samples.*

ACE inhibitory activity
The ACE inhibitory activity of the experimental yoghurt samples was determined by modifying the method introduced by Cushman and Cheung (1971) and Nakamura et al. (1995). For this purpose, 50 µL of yoghurt sample and 20 µL of ACE solution were added onto 180 µL of HHL solution. After the obtained mixture was incubated at 37°C for 90 minutes, 250 µL of 1 M HCl was added to the mixture and the incubation was terminated. After 1.7 mL of ethyl acetate was added to the mixture and extraction was performed, a 15-minute evaporation process was performed at 100°C. 1 mL of distilled water was added to the hippuric acid solution obtained and absorbance was measured in the UV spectrophotometer at a wavelength of 228 nm.

Microstructure
The method given by Akalın et al. (2012) was taken as reference in determining the microstructure of the experimental sheep yoghurt samples. For this purpose, microstructure images were obtained by scanning electron microscope (SEM; Quanta-Feg 250 FEI) using 1000x magnification.

Sensory analyses
The sensory analyses of the experimental sheep yoghurt samples were carried out by 8 laboratory staff panelists familiar with yoghurt by evaluating the parameters of appearance, consistency, odor, taste, fruit-sugar ratio, and general acceptability (Anonymous, 2006).

Statistical analysis
The research was carried out according to the Completely Randomized Block Designs on the experimental sheep yoghurt samples produced with four different fruit-sugar combinations (together with the control group, samples which consists of 5% kiwi, 15% banana, 7.5% sugar; 10% kiwi, 10% banana, 7.5% sugar, and 15% kiwi, 5% banana, 7.5% sugar), during three different storage periods (1st, 7th and 14th days), and in two repetitions. Statistical analyses were interpreted by using the SPSS 20 package program and Duncan multiple comparison test.

Results and Discussion

Physicochemical analyses results of raw sheep milk
Physicochemical analyses results of sheep milk used in the production of experimental yoghurt are given in Table 1.

The composition of raw sheep's milk is influenced by various factors such as animal type, breed, gender, feeding, and milking method, but it is in harmony with the literature (Balthazar et al., 2017; Tripaldi et al., 2018).

Physicochemical analyses results of sheep yoghurt samples
The physicochemical analyses results of the experimental yoghurt samples are given in Table 2.

While it was determined that the pH value of the experimental yoghurt samples was statistically significant

TABLE 1: *Physicochemical analysis of sheep milk.*

	Total Solids (%)	Fat (%)	Solids Nonfat (%)	Protein (%)	Ash (%)	Density (g/mL)	Titratable Acidity (% Lactic Acid)	pH	Freezing Point (°C)	Apparent Viscosity (cP)
Sheep Milk	18.61±0.04	6.93±0.03	11.68±0.01	5.77±0.01	0.96±0.03	1.038±0.00	0.25±0.01	6.64±0.04	-0.57±0.00	3.14±0.04

TABLE 2: *Physicochemical analysis of the experimental yoghurts.*

		Total Solids (%)	Fat (%)	Solids Nonfat (%)	Protein (%)	Ash (%)	pH	Titratable Acidity (Lactic Acid %)	Apparent Viscosity (cP)	Syneresis (mL/25 g)
Experimental Yoghurts	A	19.89±0.08^{d}	7.08±0.07^{a}	12.81±0.09^{d}	6.07±0.08^{a}	1.04±0.03^{c}	4.32±0.10^{a}	1.00±0.08^{c}	9242.50±525.20^{c}	0.74±0.15^{c}
	B	27.69±0.14^{a}	4.86±0.08^{d}	22.83±0.08^{a}	5.52±0.11^{b}	1.11±0.03^{b}	4.24±0.10^{a}	1.07±0.06^{bc}	14718.33±2079.47^{a}	1.42±0.27^{b}
	C	26.37±0.15^{b}	5.09±0.06^{c}	21.28±0.14^{b}	5.50±0.10^{b}	1.12±0.03^{ab}	4.15±0.11^{ab}	1.12±0.07^{ab}	12067.00±1259.86^{b}	1.89±0.32^{b}
	D	24.81±0.15^{c}	5.29±0.07^{b}	19.53±0.11^{c}	5.48±0.13^{b}	1.16±0.02^{a}	4.06±0.14^{b}	1.19±0.08^{a}	10515.17±896.83^{bc}	2.71±0.50^{a}
	Sig.	**	**	**	**	**	*	**	**	**
Storage Period (days)	1.	24.68±3.18^{a}	5.57±0.96^{a}	9.11±4.13^{a}	5.65±0.28^{a}	1.11±0.04^{a}	4.25±0.12^{a}	1.06±0.09^{a}	12305.25±2693.23^{a}	1.54±0.69^{a}
	7.	24.69±3.12^{a}	5.58±0.96^{a}	9.11±4.05^{a}	5.66±0.28^{a}	1.11±0.05^{a}	4.20±0.14^{a}	1.09±0.10^{a}	11612.00±2500.90^{a}	1.74±0.96^{a}
	14.	24.69±3.18^{a}	5.58±0.96^{a}	9.10±4.07^{a}	5.63±0.29^{a}	1.11±0.06^{a}	4.13±0.15^{a}	1.13±0.09^{a}	10990.00±2187.81^{a}	1.79±0.81^{a}
	Sig.	ns	ns	ns	ns	ns	ns	ns	ns	ns

$^{a-d}$: Different letters indicate significant differences in column. *: p<0.05, **: p<0.01, ns: p>0.05. A sample: control group, B sample: 5% kiwi puree+15% banana puree+7.5% sugar, C sample: 10% kiwi puree+10% banana puree+7.5% sugar, D sample: 15% kiwi puree+5% banana puree+7.5% sugar

($p<0.05$), it was determined that all other physicochemical analyses results were statistically very significant ($p<0.01$). On the other hand, the storage period was found to be statistically insignificant ($p>0.05$) on the results of physicochemical analysis in the experimental yoghurt samples. With the addition of kiwi and banana to the experimental yoghurt samples, as expected, an increase was observed in total solids, solids nonfat, ash, titratable acidity, viscosity, and syneresis values, while a decrease occurred in fat, protein, and pH values. In the yoghurt samples, it was determined that the banana ratio was more effective on the increase in total solids, solids nonfat and viscosity values compared to kiwi, while the kiwi ratio was found to be more effective on the increase in ash, titratable acidity, and syneresis values. Tarakçı (2010) reported that the addition of kiwi marmalade at different ratio to yoghurt samples caused an increase in total solids, solids nonfat and titratable acidity values, while it led to a decrease in fat and pH values. As a matter of fact, there are similar results in the literature (Ban et al., 2020; Diep et al., 2022).

Fatty acid composition and CLA results

The fact that milk fat contains high levels of saturated fatty acids has raised the issue that it may be risky for health. On the other hand, it has been reported that starter cultures used in fermented milk products such as yoghurt, as well as fructooligosaccharides and isomaltooligosaccharides, added to them, contribute to the production of short-chain fatty acids (Ahmad et al., 2021). The most dominant fatty acids in animal products are palmitic acid, stearic acid, oleic acid, and linoleic acid, while other fatty acids are expressed as minor fatty acids. While palmitic and stearic fatty acids are associated with various diseases such as obesity, cholesterol, inflammation, and diabetes, unsaturated fatty acids provide positive contributions such as preventing cardiovascular diseases and supporting the immune system and nervous system (Balthazar et al., 2016). The fatty acid composition and CLA content of the experimental yoghurt samples are given in Table 3.

It was determined that the experimental yoghurt samples had a statistically very significant effect ($p<0.01$) on myristic acid, palmitic acid, stearic acid, ∑SFA, oleic acid, ∑MUFA, linoleic acid, ∑PUFA, and CLA. As expected, the main fatty acids were determined to be palmitic acid and stearic acid in SFAs, oleic acid in MUFAs, and linoleic acid in PUFAs. With the addition of kiwi and banana to the experimental yoghurt samples, a decrease was determined in myristic acid, palmitic acid, stearic acid, and ∑SFA contents, while an increase was detected in oleic acid, ∑MUFA, linoleic acid, and ∑PUFA contents. The fact that kiwi and

TABLE 3: *Fatty acid composition (%) and conjugated linoleic acid (%) and cholesterol content (mg/100g) of the experimental yoghurts.*

	Experimental Yoghurt Samples				
	A	B	C	D	Sign.
Myristic acid (C14:0)	10.62±0.03^{a}	7.21±0.01^{d}	7.42±0.04^{c}	7.55±0.02^{b}	**
Palmitic acid (C16:0)	24.73±0.03^{a}	18.27±0.02^{d}	18.35±0.02^{c}	18.64±0.01^{b}	**
Stearic acid (C18:0)	12.24±0.01^{a}	8.16±0.02^{d}	8.25±0.02^{c}	8.38±0.01^{b}	**
Other SFA	16.57±0.02	26.83±0.04	26.80±0.04	26.78±0.01	-
∑SFA	64.16±0.05^{a}	60.47±0.01^{d}	60.82±0.04^{c}	61.35±0.04^{b}	**
Oleic acid (C18:1)	20.07±0.01^{d}	21.33±0.01^{c}	21.52±0.03^{b}	21.72±0.04^{a}	**
Other MUFA	11.78±0.05	13.43±0.01	12.93±0.01	11.88±0.01	-
∑MUFA	31.85±0.06^{d}	34.76±0.01^{a}	34.45±0.04^{b}	33.60±0.04^{c}	**
Linoleic acid (C18:2)	2.44±0.02^{c}	3.36±0.03^{b}	3.68±0.01^{a}	3.75±0.05^{a}	**
Other PUFA	1.55±0.13	1.40±0.06	1.05±0.08	1.30±0.13	-
∑PUFA	3.99±0.11^{c}	4.76±0.03^{b}	4.73±0.07^{b}	5.05±0.08^{a}	**
CLA	0.56±0.04^{c}	0.62±0.03^{bc}	0.68±0.02^{b}	0.80±0.03^{a}	**
Cholesterol	17.53±1.36^{a}	12.93±1.15^{b}	13.47±0.54^{b}	14.72±0.78^{b}	*

$^{a-d}$: Different letters indicate significant differences in column. **: p< 0.01; *: p<0.05. A sample: control group, B sample: 5% kiwi puree+15% banana puree+7.5% sugar, C sample: 10% kiwi puree+10% banana puree+7.5% sugar, D sample: 15% kiwi puree+5% banana puree+7.5% sugar. SFA: Saturated Fatty Acid; MUFA: Monounsaturated Fatty Acid; PUFA: Polyunsaturated Fatty Acid; CLA: Conjugated Linoleic Acid bananas had lower SFAs and higher MUFAs and especially PUFAs in their fatty acid composition (Dias et al., 2020) caused a decrease in SFAs and an increase in MUFA and PUFAs in yoghurt samples with added fruit compared to the control group.

In recent years, CLA has attracted attention with its various benefits such as anticancer, antiatherogenic, immunomodulatory, antidiabetes, and antiobesity. In addition to the fact that sheep milk is a CLA-rich source, the ability of yoghurt bacteria to produce CLA from linoleic acid makes sheep yoghurt an even more important source of CLA (Balthazar et al., 2016). In the current study, CLA, which was determined as 0.56% in the control group yoghurts, increased with the addition of kiwi and banana and varied between 0.62–0.80%. The fact that the D sample has the highest CLA content is thought to be due to the fact that the proportion of kiwi is high compared to the proportion of bananas and that kiwi contains a high percentage of PUFA (Dias et al., 2020). The current results are in line with the literature (Kowaleski et al., 2020).

Cholesterol content results

High cholesterol level is associated with cardiovascular diseases, one of the leading causes of death worldwide. On the other hand, it is reported that dairy products such as kefir and yoghurt, which are considered as functional foods, play a role as important potential sources in the prevention and/or treatment of these diseases (Kumar et al., 2022).

The cholesterol content results of the experimental yoghurt samples are given in Table 3. It was determined that the experimental yoghurt samples had a statistically significant effect ($p<0.05$) on cholesterol content. While the cholesterol content of the experimental yoghurt samples was determined as 17.53 mg/100g in the control group, it decreased with the addition of kiwi and banana and changed between 12.93–14.72 mg/100g. As expected, the reducing effect of kiwi and banana addition on cholesterol content was observed.

Volatile compounds results

The volatile compounds result of the experimental yoghurt samples are given in Table 4. It was determined that the experimental yoghurt samples had a statistically very significant effect ($p<0.01$) on acetaldehyde, diacetyl, and acetoin. Compared to the control group, the addition of kiwi and banana resulted in a decrease in the content of acetaldehyde, diacetyl, and acetoin in yoghurt samples. On the other hand, in yoghurt samples where kiwi and banana were added equally, it was found that the decrease in aroma components was less compared to other fruit yoghurts. Lactose, protein, and fat are the main precursors in the formation of volatile compounds in fermented dairy products such as yoghurt, and the most important among them are proteins. It is thought that there is a decrease in the amount of volatile compounds due to the decrease of these components with the addition of fruit (Çelik, 2007). Similar results are available in the literature (Sahingil and Hayaloglu, 2022).

DPPH free radical scavenging activity and TPC results

The DPPH free radical scavenging activity and TPC results of the experimental yoghurt samples are given in Table 4.

It was determined that the experimental yoghurt samples had a statistically very significant effect ($p<0.01$) on the DPPH free radical scavenging activity and TPC. Bioactive peptides formed during fermentation play a major role in the antioxidant activity of sheep milk. In addition, another factor contributing to the antioxidant activity is the use of fruits rich in phenolic compounds such as kiwi and banana in the products such as yoghurt (El Azab and Mostafa, 2021). As a matter of fact, DPPH free radical scavenging activity and TPC amount were found to be higher in the samples with kiwi and banana compared to the control group samples. The use of a higher proportion of kiwi than banana in yoghurt samples resulted in higher DPPH free radical scavenging activity and the amount of TPC. Indeed, Park et al. (2015) reported the phenolic compound amount of kiwi to be approximately 7.7 mg/kg FW and the phenolic compound amount of banana to be approximately 3.0 mg/kg FW.

ACE inhibitory activity results

The ACE inhibitory activity results of the experimental yoghurt samples are given in Table 4. It was determined that the experimental yoghurt samples had a statistically very significant effect ($p<0.01$) on ACE inhibitory activity. It was determined that the ACE inhibitory activity value in fruit yoghurt samples decreased compared to the control group samples. The fact that ACE inhibitory activity was high in control group yoghurt samples and was low in fruit yoghurt samples was linked to the effect of the formation of bioactive peptides in fermentation due to the decrease in protein content with the addition of fruit (Kim et al., 2021). When the kiwifruit and banana added to the yoghurt samples were compared, it was observed that the ACE inhibitory activity value decreased more with the increase in the kiwi ratio. The present results are in line with the literature (Rezaei et al., 2019).

Microstructure

The microstructure images of the experimental yoghurt samples are given in Figure 2.

When the images of the microstructures of the experimental yoghurt samples are examined, it is seen that the control group sample has a more homogeneous structure and smaller serum pores. In the samples where kiwi and banana were added, it was determined that the homogeneous structure was disturbed and deeper serum pores prevailed. In addition, the observation of high serum separation in samples with a high kiwi ratio was associated with more and deeper serum pores in these samples. On the other hand, milk type, yoghurt production method (set type/stirred type), homogenization process, culture type used, and

TABLE 4: *Volatile compounds, DPPH free radical scavenging activity, TPC and ACE inhibitory activity analyses of the experimental yoghurts.*

		Acetaldehyde (µg/mL)	Diacetyl (µg/mL)	Acetoin (µg/mL)	DPPH (mg TE/100 g)	TPC (mg GAE/100 g)	ACE Inhibitory Activity (%)
Experimental Yoghurts	A	9.15±0.03[a]	1.67±0.02[a]	37.41±0.03[a]	9.47±0.30[d]	8.66±0.15[d]	39.11±0.66[a]
	B	8.25±0.11[b]	1.36±0.04[b]	34.76±0.05[b]	33.54±0.25[c]	31.63±0.33[c]	25.44±0.45[b]
	C	8.43±0.08[b]	1.43±0.02[b]	34.84±0.03[b]	38.15±0.43[b]	34.94±0.36[b]	26.15±0.48[b]
	D	8.19±0.09[b]	1.25±0.03[c]	34.55±0.05[c]	40.74±0.22[a]	39.18±0.13[a]	24.93±0.57[b]
	Sig.	**	**	**	**	**	**

[a–d]: Different letters indicate significant differences in column. **: $p<0.01$. A sample: control group, B sample: 5% kiwi puree+15% banana puree+7.5% sugar, C sample: 10% kiwi puree+10% banana puree+7.5% sugar, D sample: 15% kiwi puree+5% banana puree+7.5% sugar.

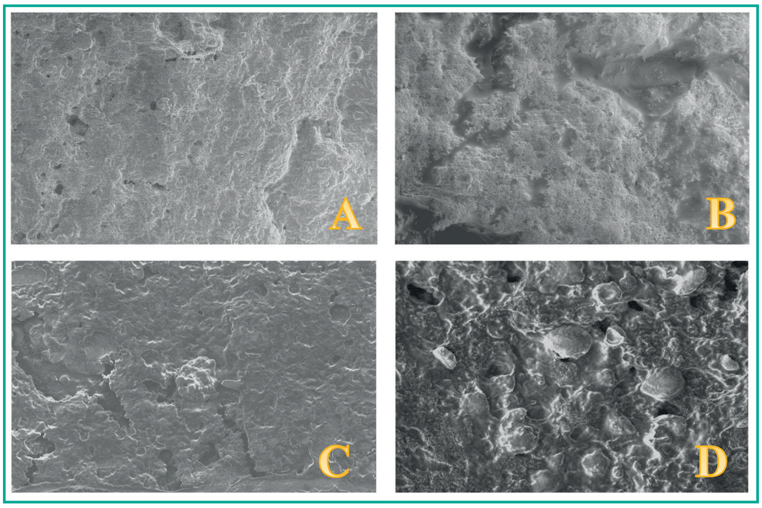

FIGURE 2: *SEM micrographs of the experimental yoghurts.*

added additives such as fruit play an important role in the formation of different microstructures in yoghurts (Prasanna et al., 2018). Studies on microstructure in the literature are similar to the current study (Akalın et al., 2012).

Sensory analysis results

The sensory analysis results of the experimental yoghurt samples are given in Table 5.

It was determined that the experimental yoghurt samples had a very significant effect ($p<0.01$) on appearance, consistency, odor, taste, fruit-sugar ratio, and general acceptability values, while the storage period was found to be statistically insignificant ($p>0.05$). Compared to the control group, it was seen that the addition of kiwi and banana increased all sensory parameter values, while the Sample C with kiwi and banana fruit added in equal proportion received the highest score. The present results are in line with the studies investigating the effect of fruit addition on sensory analyses (Khatoon et al., 2021).

Conclusion

In the present study, yoghurts produced from sheep's milk were enriched with kiwi and banana, and these samples were evaluated in terms of physicochemical properties, fatty acid composition, CLA, cholesterol content, volatile compounds, DPPH free radical scavenging activity, TPC, ACE inhibitory activity, microstructure, and sensory parameters. While the addition of fruit improved the fatty acid composition, CLA content, antioxidant activity, and sensory properties of the yoghurt samples, it caused decreases in various physicochemical properties, cholesterol content and ACE inhibitor activity values. On the other hand, despite these decreases, it is seen that fruit sheep yoghurt still has superior properties in terms of these properties compared to yoghurts produced from other kinds of milk. In addition, it was observed that the addition of fruit supported the growth of yoghurt starter cultures. As a result of this research, it was revealed that sheep yoghurt with the addition of kiwi and banana can be used both in nutrition as a functional food and in pharmaceutical and therapeutic applications when considering the quality parameters and the properties studied in terms of health.

Author Contributions

Murat Emre Terzioğlu: Conceptualization, Methodology, Investigation, Formal analysis, Writing-original draft, Writing-review & editing. **İhsan Bakirci:** Conceptualization, Methodology, Investigation, Writing-original draft, Writing-review & editing, Supervision.

Conflict of interest

The authors have declared no conflict of interest.

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TABLE 5: *Sensory analysis of the experimental yoghurts.*

		Appearance	Consistency	Smell	Taste Intensity	Fruit-Sugar Ratio	Overall acceptability
Experimental yoghurts	A	3.14 ± 0.08^{d}	3.07 ± 0.11^{d}	2.97 ± 0.14^{d}	3.11 ± 0.08^{d}	-	12.29 ± 0.37^{d}
	B	3.37 ± 0.08^{c}	3.32 ± 0.09^{c}	3.30 ± 0.09^{c}	3.40 ± 0.11^{c}	3.13 ± 0.18^{c}	16.52 ± 0.39^{c}
	C	4.33 ± 0.15^{a}	4.26 ± 0.14^{a}	4.09 ± 0.09^{a}	4.25 ± 0.14^{a}	4.02 ± 0.15^{a}	20.95 ± 0.54^{a}
	D	3.71 ± 0.12^{b}	3.76 ± 0.16^{b}	3.64 ± 0.14^{b}	3.78 ± 0.13^{b}	3.58 ± 0.12^{b}	18.47 ± 0.50^{b}
	Sig.	**	**	**	**	**	**
Storage Period (days)	1.	3.64 ± 0.50^{a}	3.59 ± 0.52^{a}	3.46 ± 0.45^{a}	3.64 ± 0.49^{a}	2.64 ± 1.67^{a}	16.96 ± 3.45^{a}
	7.	3.61 ± 0.48^{a}	3.60 ± 0.49^{a}	3.50 ± 0.49^{a}	3.64 ± 0.47^{a}	2.70 ± 1.70^{a}	17.05 ± 3.44^{a}
	14.	3.66 ± 0.50^{a}	3.62 ± 0.50^{a}	3.54 ± 0.43^{a}	3.63 ± 0.44^{a}	2.71 ± 1.70^{a}	17.06 ± 3.35^{a}
	Sig.	ns	ns	ns	ns	ns	ns

[a-d]: Different letters indicate significant differences in column. **: $p<0.01$, ns: $p>0.05$. A sample: control group, B sample: 5% kiwi puree+15% banana puree+7.5% sugar, C sample: 10% kiwi puree+10% banana puree+7.5% sugar, D sample: 15% kiwi puree+5% banana puree+7.5% sugar.

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Address of corresponding author:
Murat Emre Terzioğlu
Atatürk University
Faculty of Agriculture
Department of Food Engineering
25240, Erzurum
Turkey
murat.terzioglu@atauni.edu.tr