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Determination of the effect of Turmeric (*Curcuma longa* L.) on selected quality parameters of Bez Sucuk, a traditional fermented sausage

Bestimmung der Wirkung von Kurkuma (Curcuma longa L.) auf ausgewählte Qualitätsparameter von Bez Sucuk, einer traditionellen fermentierten Wurst

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Summary

In this research, the effects of turmeric (*Curcuma longa* L.) added to Bez sucuk on some quality parameters were investigated. For this purpose, Bez sucuk groups were formed as 1% (T1), 3% (T2), and 5% (T3) according to their turmeric levels and control without turmeric. Sodium nitrite was not added to the groups to which turmeric was added. Chemical, microbiological, sensory, and histological analyzes were performed after 14 days of maturation of the Bez sucuk groups in natural conditions. As a result of the analysis, it was observed that the pH values ranged from 4.95-5.16, the percent titratable acidity values (lactic acid %) ranged from 0.85 to 1.39, and there was no statistical difference between the groups. It was observed that the moisture, protein, and ash values varied between 31.55-33.35%, 24.55-26.37%, and 4.73-4.98%, respectively, and there was no difference between. the groups. The highest saturated fatty acid level in sucukpaste was 16:0, and the unsaturated fatty acid level was 18:1n9c. Total mesophilic bacteria, lactic acid bacteria, and yeast-mold counts varied between 7.60-7.11, 6.09-6.61, and 5.25-5.63 CFU/g, respectively. Also, *E. coli* was not detected in any group. As a result of the sensory analysis, it was seen that adding different amounts of turmeric to the Bez sucuk did not make any difference in sensory features (P>0.05). In histological analysis, it was observed that there was no difference between the groups. As a result, we concluded that, turmeric has a positive effect on the chemical, sensorial. and microbiological quality of the Bez sucuk but there was no difference between the groups.

Keywords: Bez sucuk, microbiological quality, physicochemical quality, sausage, turmeric

Introduction

Sucuk is a meat product made by fermentation by adding spices and other additives to minced meat and animal fat, which is packed natural or synthetic casings Çiçek and Köse, 2005). Bez sucuk is a kind of traditional fermented sucukwith a history of 200-300 years. It is a regional sucukvariety produced by Türkiye Tokat province and surrounding areas. There is no standard formulation or production method for the production of Bez sucuk (Çiçek and Köse, 2005; Çiçek and Polat, 2016). It is generally produced by butchers in the autumn season using the traditional method. After the meat and fat have been processed through the meat grinder, salt, garlic, and spices are added, and the sucukpaste is mixed for a certain period. Then it is filled with special cloth casings, suspended in the air, and subjected to maturation. During the ripening process, sucuk are flattened by rolling, suspended again, and matured. The production process varies depending on weather conditions. Bez sucuk has its unique taste and aroma compared to classical sausages. The most important feature that distinguishes Bez sucuk from other sausages is the use of unpainted white fabric called mermerşahi as packaging (Çiçek and Polat, 2016; Kaval et al., 2020).

The demand for foods that do not contain any additives has increased (Göncü and Serdar 2017). Therefore, studies on natural substances that can replace synthetic additives have started in recent years (Han and Rhee, 2005; İncili et al., 2020). Curing meat products with additives containing natural nitrate instead of synthetic nitrate has also been the subject of previous research. Research on the use of plant-derived additives as alternatives to synthetic nitrate, especially in meat products, has become increasingly important (Babaoğlu, 2020). Additionally, removing undesirable additives from meat products using natural antioxidants and antimicrobial components has become a significant research area (Özer, 2017). The source of these components are natural ingredients used as herbs and spices with high bioactivity properties. While spices are used to give more flavor to foods, they have been used in recent years to increase shelf life, especially by protecting foods (Özer, 2017; Ibáñez and Blázquez 2021).

Turmeric (*Curcuma longa* L.) is a tuberous herbaceous perennial plant belonging to the ginger family, with large leaves and yellow flowers. It is a plant widely grown in China and India. It is also known as saffron root, castor saffron, and turmeric. Turmeric, a polyphenolic compound, has a bitter taste and is generally used as a spice and dye. It is widely used in foods to extend the color, aroma, and shelf life. Studies have also reported that turmeric has a strong antioxidant and antimicrobial effect in meat and meat products, extending shelf life (Arshad et al., 2019; Ibáñez and Blázquez, 2021)

This study aimed to determine the effects of turmeric (*Curcuma longa* L.) added to Bez sucuk on probiotics and some quality parameters which matured by natural methods using different levels of turmeric in the production.

Materials and method

A total of four groups of Bez sucuks were produced with varying levels of turmeric added to the prepared sucukpaste plus control as follows: control group with no added turmeric (C), 1% turmeric (T1), 3% turmeric (T2), and 5% turmeric (T3). Sodium nitrite ($NaNO_2$) was not added to the groups to which turmeric was added.

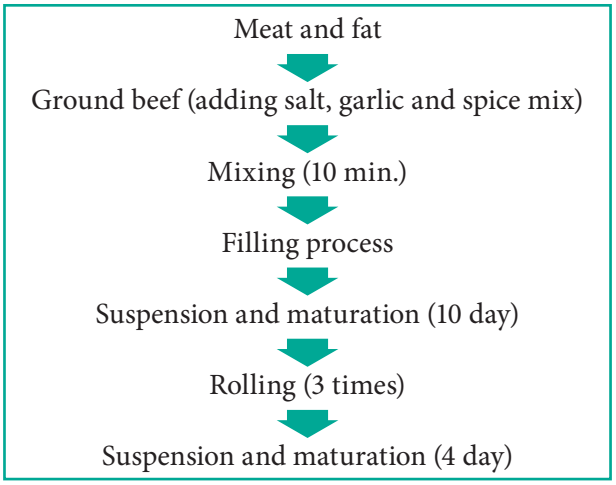

FIGURE 1: *Production stages of Bez sucuk.*

Raw material supply

Lean beef and tail fat were used in the production of the Bez sucuk. Meat and fat were produced in a cold chain and kept at +4°C until production. The turmeric, hot red pepper, sweet red pepper, cumin, black pepper, allspice (Bağdat Baharat, Türkiye), salt (table salt) (Billur Tuz, Türkiye) and garlic used in the production of the sucukwere supplied from local markets in packaged form. For the casing filling process, a fabric called "mermerşah" made of 100% cotton with dimensions of 25 cm x 8 cm, was used. Sodium nitrite (NaNO2) (106549, Merck, Darmstadt, Germany) was used as a curing agent. Lactobacillus plantarum + Staphylococcus carnosus (Alfasol®, Türkiye) was used as a starter culture.

Bez sucuk formulation and production

In this study, Bez sucuk samples were produced experimentally (Figure 1). While producing the sucuk, the formulation in Table 1 was taken into consideration. The maturation conditions are given in Table 2. An example of ripened gland sausage is given in Figure 2. Following the maturation process, chemical analyzes, microbiological analyzes, sensory analyzes, and histological analyzes were performed on the Bez sucuk samples. Analyses were carried out immediately after the sucuk ripening period (14 days). Furthermore, a fatty acid analysis was conducted on the sucuk paste during the production of acid analysis was made of the sucukpaste.

Chemical analysis

Protein, dry matter, ash and pH analyzes of the sausage samples were performed according to the AOAC method

FIGURE 2: *Ripe and sliced Bez sucuk.*

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TABLE 1: *Formulations of Bez sucuk samples with different proportions of turmeric (%).*

Raw materials and additives	C	T1	T2	T3
Meat	80	80	80	80
Fat	20	20	20	20
Salt	1.6	1.6	1.6	1.6
Garlic	2	2	2	2
Red pepper (bitter)	0.8	0.8	0.8	0.8
Red pepper (sweet)	0.6	0.6	0.6	0.6
Black pepper	0.4	0.4	0.4	0.4
Cumin	0.8	0.8	0.8	0.8
Allspice	0.2	0.2	0.2	0.2
Sucrose	0.5	0.5	0.5	0.5
Sodium nitrite ($NaNO_2$)	150 ppm	–	–	–
Ascorbic acid	450 ppm	450 ppm	450 ppm	450 ppm
Starter culture	2.5	2.5	2.5	2.5
Turmeric	–	1	3	5

C: Control, T1: %1 turmeric added sausage, T2: %3 turmeric added sausage, T3: %5 turmeric added sucuk

TABLE 2: *The ripening conditions of Bez sucuk.*

Temperature (°C)	Time (day)	Relative humidity (%)
22	2	90
22	2	85
20	3	80
18	3	75
18	4	60

(AOAC, 1990) and the results are given in percentages. The percent titration acidity (TA) (lactic acid%) of the cloth sucuk samples was made according to the method used by Çiçek and Polat (2016). All analyzes were performed in two parallel and two replicates.

Fatty acid analysis

A sample was taken from the prepared sucuk paste (2 g) and homogenized in a mixture of chloroform/methanol (Merck, Darmstadt, Germany) (3:2) (v/v) (21). Lipid extracts were centrifuged at 10000 rpm for 10 minutes. The supernatant was removed, and the solvent was evaporated under vacuum. The remaining part was dissolved in 10 mL of hexane (Merck, Darmstadt, Germany), and 0.5 mL of 2 N KOH-methanol (Merck, Darmstadt, Germany), solution was added, shaken in the vortex, and kept in the dark for 1 hour. Then, analyzes were performed on the GC-FID device [FID detector and the Teknochroma TR882192 TR-CN 100 (100mx0.25mmx0.20µm)]. The peaks obtained from the samples were identified by comparison. With the standard peaks, as the fatty acids were calculated as percentages in the sum of the concentrations of the identified peaks (Anonymous, 1987).

Microbiological analysis

For the microbiological analysis, Bez sucuk sample were weighed at 10 g in a special bag of a sterile disintegrant bag (Stomacher 400), and 90 mL of sterile 1/4 peptone water (Merck, Darmstadt, Germany) solution was added to it and homogenized in the stomacher (Nüve, Ankara, Türkiye). Thus, a 1/10 dilution of the sample was prepared. Other dilutions were made from this dilution up to 10^6 using the same diluent. Sowing was done in double series with the cast plate method using 1 mL of each dilution of the samples, and at the end of the incubation period, plates containing 30–300 colonies were evaluated (Harrigan, 1998). All analyzes were performed in duplicate and two replicates. Total Mesophilic Aerobe Bacteria Count (TMAB) Plate Count Agar (Oxoid CM 325, Basingstoke, UK) medium was used. Petri dishes were evaluated after 3 days of incubation at 30±1 ºC (FDA, 2021), Enumeration of *Escherichia coli:* Tryptone Bile X – Glucuronide Medium (TBX) (Oxoid CM 945, Basingstoke, UK) medium was used for the isolation of the agent. Petri dishes were evaluated after 4 hours of incubation at 30±1 ºC, then at 44±1 ºC for 18 hours (FAO, 1992). Enumeration of Lactic Acid Bacteria (LAB): Man Rogosa Sharpe Agar (MRS-Oxoid, CM361, Basingstoke, UK) medium was used for the enumeration of lactic acid bacteria. Plates were evaluated after 48 hours of incubation at 37 ºC (Harrigan, 1998). Yeast-mold Count: Dichloran Rose Bengal Chloramphenicol Agar (DRBC) (Biokar, Beauvais, France) was used. Plates were evaluated after five days of incubation at 25±1°C 125 (ISO, 2008).

Histological analysis

For the histological preparations, samples of 150 g were taken from each Bez sucuk sample and prepared according to the method used by Ayaz et al., (2002). The stained preparations were examined and photographed with an Olympus DP71 (Japan) brand research microscope.

Sensory analysis

Bez sucuk of each group were cut in 3 mm thickness and cooked separately in a Teflon pan. Later, they were tasted by 10 panelists (five men and five women) between the ages of 20–40. The panelists were trained on the production technology and sensory properties of the product, and then the tasting process was carried out. Cooked Bez sucuk were evaluated in terms of appearance, color, odor, taste, texture, and general appearance parameters. For each of the sensory characteristics, they were scored on a continuous scale from 1 to 5 (1: Very bad, 2: Bad, 3: Normal, 4: Good, 5: Very good) (Kurtcan and Gönül 1987).

Statistical analysis

For the statistical analysis of the study data, the SPSS package program (24.0 for Windows software SPSS Inc., NY, USA) was analyzed by one-way analysis of variance (one-way ANOVA) at a 95% confidence interval. The Duncan multiple comparison test was used to determine the difference between the means of the experimental groups after analysis of variance. Values were given as mean±standard deviation (SPSS, 2017).

Results

In this study, the results of chemical, microbiological, sensory, and histological analyzes of Bez sucuk produced by adding turmeric in different proportions were examined separately. The moisture, protein, fat, and ash contents of the Bez sucuk are given in Table 3, the fatty acid content of the Bez sucuk paste is given in Table 4, and the fatty acid chromatogram is given in Figure 3. Microbiological analysis results are given in Table 5. The scores given by the panelists for all Bez sucuk groups in the sensory analysis are shown in Table 6. The histological. results of the Bez sucuk evaluations are shown in Figure 4.

Discussion

The pH, titratable acidity (lactic acid%), moisture, protein, and ash values of the Bez sucuk samples examined in this study are presented in Table 3. The pH values, which have a significant effect on the color, texture, taste, and durability of the Bez sucuk samples, did not show a significant difference between the control and turmeric-added groups. As stated in the sucuk standard, the pH value of a quality sucuk should be in the range of 4.7–5.4 (TSE, 2002). In this study, it was seen that the pH value in all groups was in accordance with the standards (Table 3). Lactic acid bacteria have a significant effect on the texture and sharp taste of fermented sucuks (Montel et al., 1998). In our study, no difference was found between the groups in terms of percentage of TA (lactic acid%) (Table 3). Köse (2010) reported that the pH values of the fermented sucuks were in the range of 5.08–5.66, and the TA (lactic acid%), values were between 1.02–2.25% in his study which he conducted on Bez sucuks purchased from 12 different manufacturers.

Ensoy et al. (2010) reported that the pH and TA (lactic acid%) values in Bez sucuks were in the range of 5.66–5.08, and 2.25–1.02, respectively. Kaval et al. (2020) reported that the pH value of 30 Bez sucuk samples was between 4.69-6.94. Çiçek and Tokatlı (2018) reported in their study that the pH value of the Bez sucuks they produced using different meat and fat ratios varied between 4.72–4.94 after 14 days of maturation. Turhan et al. (2010) stated that the pH values of Bez sucuks were between 5.16–5.68. Kaval et al. (2010) reported that the pH values of Bez sucuks were in the range of 4.69–6.96. Karakuş (2011) reported that the pH values of Bez sucuks were 5.18–6.48.

The results demonstrated that there was no significant difference between the control and turmeric-added groups in terms of moisture, and ash content. Köse (2010) reported that the moisture, protein, and ash content of Bez sucuks ranged from 35.20–49.96%, 15.6427.83%, and 3.28–6.81%, respectively. On the other hand, Turhan et. al. (2010) similar results were reported. In a study by Ciçek and Polat (2016) in which the effects of different meat and fat ratios on the. sensory and physicochemical properties of Bez sucuks were investigated, moisture, protein, and ash contents were 36.04%±2.76-38.88±2.98%, 32.88±0.80-25.48±1.34%, 3.17±0.10-4.20±0.25%, respectively. In a study conducted by Çevik (2012). some chemical and physical properties of Bez sucuks produced using commercial starter culture were examined and moisture, protein, and ash contents of Bez sucuks were reported as 35.18–42.42%, 20.87–26.05%, 3.55–3.92%, respectively. Karakuş (2011) reported that the moisture, protein, and ash contents of 20 Bez sucuks collected from 10 different producers were in the range of 42.91–43.28%, 15.83–23.88%, and 4.41–4.47%, respectively. Helvacıoğlu (2020) reported that the moisture, protein, and ash contents of. sucuk were in the range of 36.24–38.22%, 23.42–24.68%, and 5.48–6.62%, respectively in a study examining the effect of turmeric added to fermented sucuk in different proportions on some physicochemical and microbiological quality of sucuk. De Carvalho et al. (2020) reported that adding different amounts of turmeric to sucuks did not make any difference in terms of the physicochemical properties of the sausages. The results reported in the studies in the literature are similar to the results we found. We think that the small differences seen are related to the quality of the. meat used, the spice levels, and the fat content of the product. As a result, it was concluded that the use of turmeric as a component in the production of sucuk will not cause any problems in terms of some physicochemical properties (protein, moisture, ash) of sucuks.

According to our results, the fatty acids and their amounts determined in the prepared Bez sucuk paste are

TABLE 3: *Chemical analysis of Bez sucuk samples.*

	pH	TA (lactic acid %)	Moisture (%)	Protein (%)	Ash (%)
C	4.95±0.02	1.39±0.19	31.55±0.09	24.55±0.67	4.80±0.03
T1	5.09±0.07	0.85±0.62	33.35±0.07	26.37±0.55	4.98±0.03
T2	5.36±0.19	0.95±0.63	32.70±0.14	26.20±0.62	4.78±0.08
T3	5.16±0.33	1.12±0.41	31.60±0.42	26.08±0.01	4.73±0.35

C: Control, T1: 1% turmeric added, T2: 3% turmeric added , T3: 5% turmeric added

TABLE 4: *Fatty acid analysis of Bez sucuk.*

No.	Fatty acid	Average (%)
1	butyric acid (4:0)	0.072 ±0.002
2	capric acid (10:0)	0.098±0.003
3	lauric acid (12:0)	0.093±0.003
4	myristic acid (14:0)	4.921±0.094
5	myristoleic acid (14:1)	1.331±0.045
6	pentadecanoic acid (15:0)	0.589±0.007
7	cis-10-pentadecanoic acid (15:1)	0.242±0.009
8	palmitic acid (16:0)	38.724±0.565
9	palmitoleic acid (16:1)	4.295±0.136
10	heptadecanoic acid (17:0)	0.794±0.029
11	cis-10-heptadecanoic acid (17:1)	0.352±0.009
12	stearic acid (18:0)	9.060±1.120
13	cis-oleic acid (18:1n9c)	37.747±1.850
14	cis-linoleic acid (18:2n6c)	1.506±0.045
15	linolenic acid (18:3n6)	0.107±0.007
16	heneicosanoic acid (21:0)	0.070±0.002

TABLE 5: *Microbiological analysis of Bez sucuk samples (CFU/g).*

	TMAB	LAB	Yeast-Mold	*E. coli*
C	7.11±0.12^{b}	6.09±0.07^{b}	5.28±0.04	–
T1	7.60±0.07^{a}	6.61±0.08^{a}	5.25±0.75	–
T2	7.58±0.04^{a}	6.35±0.04^{ab}	5.63±0.69	–
T3	7.45±0.03^{a}	6.48±0.05^{a}	5.36±0.42	–

C: Control, T1: 1% turmeric added sucuk, T2: 3% turmeric added sucuk, T3: 5% turmeric added sucuk; a–b: The mean values with different letters in the same column are significantly different (P<0.05).

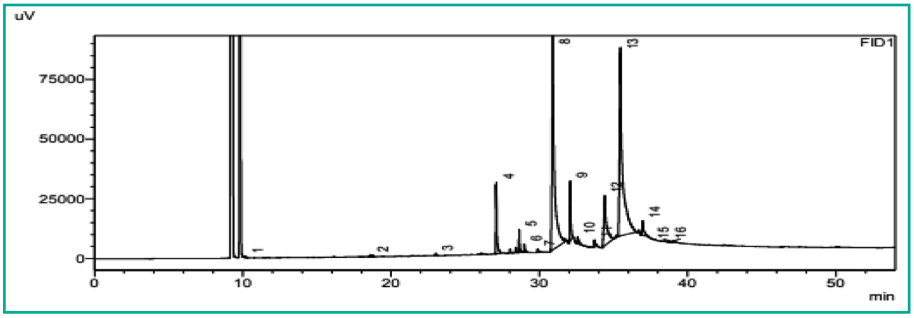

FIGURE 3: *GC-MS chromatogram obtained in fatty acid analysis of sucuk paste*

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TABLE 6: *Sensory analysis of Bez sucuk samples.*

	Smell	Color	Taste	Texture	Appearance	General view
C	4.1±0.87	3.5±0.52	4.0±0.94^{ab}	4.3±0.67	4.2±0.63	3.9±0.73
T1	3.4±0.69	3.8±0.63	3.7±0.94^{ab}	3.6±1.17	4.3±0.82	3.7±0.82
T2	4.0±0.81	4.1±0.73	4.2±1.03^{a}	4.0±0.94	4.4±0.51	4.1±0.73
T3	3.8±1.03	3.9±0.56	3.0±1.44^{b}	3.9±1.19	3.9±0.73	3.5±0.84

C: Control, T1: 1% turmeric added sucuk, T2: 3% turmeric added sucuk, T3: 5% turmeric added sucuk; a–b: The mean values with different letters in the same column are significantly different (P<0.05). A: Control group B: 1% turmeric added C: 2% tumeric added D: 3% turmeric added; m: Muscle tissue a: Adipose tissue n: Nerve tissue v: Arterial vessel

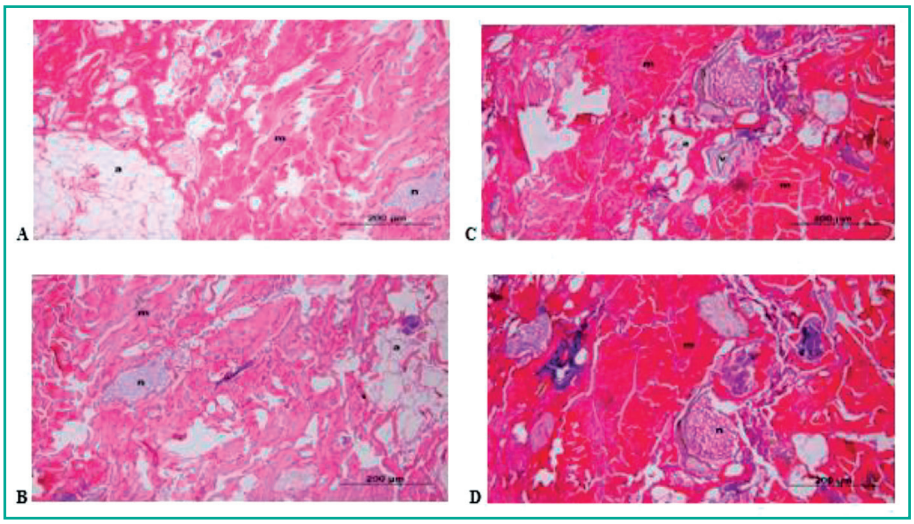

FIGURE 4: *Histological results of Bez sucuk. A: Control group; B: 1% turmeric added; C: 2% tumeric added; D: 3% turmeric added; m: Muscle tissue a: Adipose tissue n: Nerve tissue v: Arterial vessel*

given in Table 4 and Figure 3. Saturated fatty acids detected at high levels in 194 sucuk paste were 16:0 (38.724±0.565%), 18:0 (9.060±1.120%), 14:0 (4.921±0.094%) and 195 unsaturated fatty acids 18:1n9c (37.747±1.850%) was 16:1 (4.295±0.136%). Since animal- origin fat is used in sucuk paste, the levels of stearic acid and palmitic acid, which are saturated fatty acids, were expected to be high. It has been determined that oleic acids constitute a large part of the unsaturated fatty acids contained in sucuk paste. The most common fatty acid in nature and more than half of the fatty acids found in most oils are oleic acids (Ünal and Karakaya, 2017). No studies related to the fatty acid content of Bez sucuks have been found, but the amounts of fatty acids have been reported at different levels in studies conducted on fermented Turkish sucuks. Özkaya (2020) reported that the level of saturated fatty acids was found to be high in sucuk samples 203 (14:0% 3.080, 16:0% 26.216, and 18:0% 24.052). Ünal and Karakaya (2017) reported the fatty. 204 acid levels of sucuks as 14:0 2.99%, 16:0 24.72%, 18:0 15.92% and 18:1 41.92%. Kayardı and Gök (1999) reported that they detected fatty acids at the levels of 14:0 2.46%, 16:0 21.32%, 18: 0 18.04%, and 18:1n9c 46.24% in sucuks. Gök (2006) reported that he detected major fatty 207 acids at the level of 14:0 2.81–2.86%, 16:0% 24.22–24.55, 18:0% 20.9–21.3, and 18:1n9c 42.63–43.20%. In our study, we concluded that there were differences between the high levels of fatty acids we detected in the sucuk paste and the results reported in the studies mentioned due to the processes applied to the Bez sucuks, the additives in the content of the Bez sucuks, and the type and levels of fat used.

The results of this study show that there is statistically significant difference between the turmeric added groups (P<0.05). It was observed that the TMAB count of the control group was slightly lower than that of the turmeric added groups. It was concluded that this was due to the passage of bacteria from the turmeric spice to the sucuk paste. In a study examining the physical, chemical, and microbiological properties of 20 Bez sucuks collected from 10 different manufacturers, Karakuş (2011) reported that the number of TMAB was in the range of 8.93–8.99 log10CFU/g in a study where they examined the physical, chemical, and microbiological properties of 20 Bez sucuks collected from 10 different manufacturers. Helvacıoğlu (2020) reported that the effect of turmeric added to fermented sucuk in different proportions on some physicochemical and microbiological quality of sucuks was examined, and the number of TMAB changed between 3.90±0.01–4.38±0.04 log10CFU/g after 21 days of maturation. They also reported that there was no difference between the control group and the turmeric-added groups. In a study by Yun et al. (2013) which investigated the effect of turmeric powder added to chicken sucuks on the quality characteristics, it was reported that the TMAB number of the control group was 6.60 and the TMAB number of the turmeric sucuk group was 4.67 after 20 days of storage. The results we found in this study were lower than the results reported in some studies on Bez sucuk, higher than in other studies, and agreement with some studies. We think that the reason for the differences between the results of the studies is that the starter culture is used to improve the quality of fermented sucuks and to obtain standard sucuks because starter culture has been reported to affect the number of TMAB (Nazlı et al., 1986). In addition, we think that this difference may be due to the lack of production in sucuks, the quality of the raw material used, and the insufficient maturation of the sucuks.

The mean LAB numbers for the Bez sucuk groups are presented in Table 5. The results of this study show that there is a statistically significant difference between the turmeric supplement groups (P<0.05). The lowest LAB count was found in the control group. This is thought to be due to the beneficial effect of turmeric on LAB counts as a result of the suppression of pathogenic or spoilage bacteria. A study by Helvacıoğlu (2020) investigating the effect of turmeric added to fermented sucuk in different proportions showed that the LAB number varied between 4.58±0.01–5.19±0.01 log10CFU/g after 21 days of ripening, and the LAB value during the ripening period was statistically significant in all samples. Karakuş (2011) reported a range of 6.87–7.02 log CFU/g in his study examining the physical, chemical and microbiological properties of 20 Bez sucuks collected from 10 different manufacturers. Kaval et al. (2020) reported. that the. number of LABs of 30 Bez. sucuks they collected in the market ranged from 5.55×10^{5} to 2.45×10^{9} CFU/g. Tosati et al. (2017) reported that the LAB number was between 6.32 and 7.81 log CFU/g after 30 days of storage in a study in which the microbial and physicochemical properties of frankfurter

sucuks were coated with a mixture of turmeric, starch, and gelatin with a renewable coating. In addition, it has been reported that LAB results were lower in Frankfurter sucuks that were coated after storage compared to samples without coating. The results we found are in harmony with the results reported in the studies on Bez sucuk. The sucuk studies with turmeric added by Tosati et al (2017) were compatible with the results reported but higher than the results reported by Helvacıoğlu (2020). This difference may be due to the difference in sucukproduction stages and the starter culture used.

Table 5 shows the average yeast and mold numbers in the Bez sucuk groups. In our study, it was observed that there was no statistically significant difference between the groups (P> 0.05). Karakuş (2011) reported that the yeast-mold count was in the range of 4.11-4.20. log CFU/log. in a study where they examined the physical, chemical, and microbiological properties of 20 Bez sucuk collected from 10 different manufacturers. Kaval et al. (2020). reported that the yeast-mold count of 30 Bez sucuks. that they collected. in the market varied between 2.50×10^{3}–6.90×10^{9} CFU/g. Helvacıoğlu (2020) reported that the yeast-mold numbers varied between 2.76±0.01–3.65±0.06 log10CFU/g after 21 days of maturation in a study examining the effect of turmeric added to fermented sucukat different rates on some physicochemical and microbiological quality of sucuks. It was reported that the yeast-mold values were statistically different in all samples during the ripening period, and the yeast-mold numbers of the samples decreased on the last day of ripening compared to the other days. Our results are consistent with the studies on Bez sucuk but higher than the results reported in the sucuk study with turmeric added. We think that this difference is due to the hygienic quality of the spices used.

The presence of *E. coli* in all sucuktypes is an important indicator of the lack of hygiene of the product. According to TS 1070 (2002) sucukstandard, *E. coli* should not be found in sucuk. *E. coli* was not detected in any group in our study (Table 5). Our results have been found to comply with the sucukstandard. Karakuş (2011) reported that *E. coli* was detected in three samples in a study in which they examined the physical, chemical, and microbiological properties of 20 Bez sucuks collected from 10 different manufacturers. Kaval et al. (2020) in a study found in samples they collected in a market, as a result of identification. and verification tests, *E. coli* biotype 1 in 10 samples (33.33%), *E. coli* biotype 2 in two samples (6.67%), and *E. coli* O157: H7 serotype in 16 samples (53.33%). Öksüztepe et. al. (2011) reported that they detected *E. coli* in 15% of a total of 100 fermented sucuks they examined. The absence of *E. coli* in the Bez sucuks analyzed in this study is quite positive in terms of hygienic quality.

The scores given by the panelists for all Bez sucuk groups are shown in Table 6. As a result of the sensory analysis, it was seen that adding different amounts of turmeric to the sucukdid not make a difference in terms of color, odor, texture, appearance, and general taste in Bez sucuk (P>0.05). However, it is observed that there is a difference between the groups in terms of taste (P<0.05). T3 group exhibited group a significantly lower rating in terms of taste compared to the other groups. The reason for this is thought to be due to the bitter flavor that turmeric gives when the ratio of turmeric is increased. Normally, a difference in color angle would be expected. Because the color of turmeric is yellow, when the rate of turmeric is increased, a yellow color is expected to be dominant in sucuks. In addition, it was expected that there would be a difference in color angle in the control group due to the addition of $NaNO_2$ to the other groups. However, there was no statistically significant difference between the groups in terms of color. De Carvalho et al. (2020) reported that adding different amounts of turmeric to sucuks did not make a difference in sensory aspects; the only negative points obtained were in terms of color due to the yellow color of the turmeric. In a study conducted by Helvacıoğlu (2020), it was seen that turmeric added to fermented sucukin different proportions was appreciated in the sensory evaluation. The most liked group was reported to be a 3.50% turmeric-added group. These studies are similar to our results in terms of sensory analysis results. It is likely that the negative points of different sensory features are related to regional taste. As a result, it was concluded that using turmeric as an ingredient in the production of sucukwill not cause sensory distress.

Significant progress has been made in the methods applied to detect adulteration of foodstuffs. Chemical methods developed were used to analyze the rate of addition of plant- based substances to meat products such as fat, protein, moisture, and ash. However, it is not enough to reach a complete conclusion about the quality of sucukpaste using chemical methods. For this reason, other methods of detection have been sought to detect animal tissues and organs and herbal additives that are not allowed to be added to meat products. It has been stated that in stained preparations, it is possible to distinguish organ and tissue parts with low nutritional value and all tissues with or without regeneration by histological examination (İnal, 1992). In addition to determining the adulteration in sucuks with histological analysis, it can also be decided on the distribution, size, and the number of tissues added to the sucuk. In addition, the presence of plant-based structures can be determined in addition to animal tissues in the products. The histological images of all groups in our study are shown in Figure 4.

To the best of our knowledge, there are no studies on histological analysis of Bez sucuks in the literature. However, there are studies on fermented Turkish sucuks. Altun et al. (2015) reported that in a study where the histological examination of sucuks and fermented sucuks was carried out, they detected cartilage tissue in six samples (30%), lymph tissue in six samples (15%), and connective tissue in two samples (10%). In Sezer et al.'s study (2013), as a result of a histological analysis of fermented. sucukand sucuk-like products offered for sale in Kars, 13 (32.5%) of the samples had epithelial tissue, 11 (27.5%) had glandular epithelium, and five (12.5%) had smooth muscle tissue, cartilage they also reported that they encountered bone tissue. Ayaz et al. (2012) reported that they detected cartilage in 12.7% of sucuksamples, epithelium belonging to the skin and cellular structures belonging to internal organs, and 9.9% cartilage, bone, and epithelial tissue belonging to the digestive system in sucuksamples. Gürbüz et al. (2020) reported that the fermented sucuks which they examined had striated muscle, collagen fibers, connective tissue, fat, nerve, gland, cartilage, bone, lung, heart, spleen tissues, blood vessels, glandular epithelium, and various plant materials They also reported that all of their sucuksamples contain animal tissues that are not allowed to be included in sucukcontent. When the results reported in this study and studies were evaluated, it was concluded that sensory, chemical, physical and microbiological analyzes should be performed

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in addition to histological analyzes in order to determine the quality of Bez sucuk. We believe that it will lead the histological analysis to be made on Bez sucuks since ours was the first study in which a histological analysis of Bez sucuks was made.

Conclusion

As a result of our study, it was observed that adding turmeric in different proportions to the Bez sucuk samples instead of synthetic nitrate has a positive effect on the chemical, sensory, probiotics and microbiological quality of the sucuk. It was observed that there was no significant difference between the control group to which $NaNO_2$ was added and the other groups to which turmeric was added in terms of the criteria. It was concluded that using turmeric as a component in the production of Bez sucuk will increase the quality of Bez sucuks. However, we believe that these analyzes should be carried out throughout the shelf. life of Bez sucuks and detailed studies should be conducted to determine the effect on pathogenic bacteria in order to determine whether turmeric can be used as a total replacement for synthetic nitrate, which is currently used as a component in Bez sucukproduction. In addition, this study will lead the histological analysis to be made in Bez sucuks since it is the first study in which a histological analysis of Bez sucuks was made.

Ethics approval

The conducted research is not related to animals use. No ethical approval was obtained because this study did not involve laboratory animals and only involved non-invasive procedures (e.g. collection of waste tissue after surgery, fecal samples, voided urine etc).

Conflicts of interest

The authors declare no potential conflicts of interest.

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