FOOD and HEALTH

FOOD and HEALTH
E-ISSN 2602-2834

Food and Health 11(3), 231-239 (2025) • https://doi.org/10.3153/FH25019

Research Article

Evaluation of the quality and safety of Burdur şiş köfte: Physicochemical and microbiological perspective

Erdem ÖZMEN[1], **Birol KILIÇ**[1], **Azim ŞİMŞEK**[2]

Cite this article as:
Özmen, E., Kılıç, B., Şimşek, A. (2025). Evaluation of the quality and safety of Burdur şiş köfte: Physicochemical and microbiological perspective. Food and Health, 11(3), 231-239. https://doi.org/10.3153/FH25019

[1] Suleyman Demirel University, Faculty of Engineering and Natural Sciences, Department of Food Engineering, Isparta, Türkiye

[2] Isparta University of Applied Sciences, Egirdir Vocational School, Department of Food Processing, Isparta, Türkiye

ORCID IDs of the authors:
E.Ö. 0009-0001-6013-8007
B.K. 0000-0001-6575-4418
A.Ş. 0000-0002-7570-0832

Submitted: 18.02.2025
Revision requested: 15.03.2025
Last revision received: 18.03.2025
Accepted: 23.03.2025
Published online: 13.06.2025

Correspondence:
Azim ŞİMŞEK
E-mail: azimsimsek@isparta.edu.tr

Available online at
http://jfhs.scientificwebjournals.com

ABSTRACT

This research was conducted to evaluate the physicochemical characteristics and microbiological quality of raw and cooked Burdur şiş köfte collected from fast-food restaurants in Burdur, Türkiye. Results for physicochemical properties of raw Burdur şiş köfte samples were 5.84 pH, 58.53% moisture, 16.87% protein, 19.87% fat, 2.99% ash, 2.00% salt and 70.57 mg/100 g cholesterol, whereas, these values for cooked samples were 6.05, 61.85%, 22.88%, 11.10%, 3.13%, 2.11% and 72.65 mg/100 g, respectively. While the average counts (log CFU/g) of total mesophilic aerobic bacteria, total coliforms, yeasts-moulds, *Bacillus cereus* and *Staphylococcus aureus* in raw Burdur şiş köfte samples were 5.73, 3.83, 3.09, 2.31 and <1.00, respectively, these counts in cooked Burdur şiş köfte samples were 1.80, <1.00, <1.00, 1.40 and <1.00, respectively. Moreover, *Salmonella* spp. was not detected in any of the Burdur şiş köfte samples. In conclusion, the present research revealed that the cooked Burdur şiş köfte sold in Burdur had acceptable hygienic quality and nutritional value. On the other hand, some raw Burdur şiş köfte samples were found to have insufficient hygienic quality, which may create a potential health risk to consumers. Therefore, necessary precautions should be taken to ensure hygienic processing, especially during the manufacture of raw Burdur şiş köfte.

Keywords: Burdur şiş köfte, Consumer health, Microbiological quality, Physicochemical characteristics

Introduction

Burdur şiş köfte is a traditional grilled meat meal prepared with beef, goat or lamb, salt and back fat. It is commonly consumed in restaurants throughout the province of Burdur and in surrounding cities. This product was made from ground goat meat in the early 19th century when it first appeared. Currently, it is also made from fresh ground beef. Burdur şiş köfte is widely cooked on a charcoal grill and served with grilled pepper and pita bread. Burdur Şiş Köfte, which is confirmed to be a product specific to Burdur province, was officially documented by the Turkish Patent Institute in terms of geographical indication and announced in the Official Gazette on July 3, 2011 (Turkish Patent Institute, 2011).

Traditional foods play a crucial role in local identity, consumer behaviour, and the transfer of cultural heritage to future generations, while also influencing the interaction of this heritage with the rest of the world (Albayrak & Gunes, 2010). During the manufacturing of these products, microbial contamination may occur due to factors such as the use of low-quality raw materials, unsanitary processing, and inadequate storage conditions, which can have adverse impacts on consumer health. Moreover, the production of these products, often in small-scale or home-based environments, can also lead to inconsistent hygienic practices, thereby increasing safety risks (Rakha et al., 2022). Additionally, the perishable nature of these foods increases the risk of foodborne illnesses. Foodborne illnesses associated with these products typically result from contamination with pathogenic microorganisms such as *Salmonella* spp., *Escherichia coli,* and *Staphylococcus aureus* (Bintsis, 2017). Factors such as improper temperature control, inadequate cooking, and cross-contamination during preparation contribute significantly to these risks (Sunarti, 2024).

Burdur şiş köfte is a popular fast food sold in various restaurants and fast-food shops across Burdur and neighbouring cities. Since there is no previous study on the quality attributes and microbiological features of Burdur şiş köfte sold in fast food restaurants and supermarkets, consumers and meat processors have been demanding information regarding the quality and safety features of Burdur şiş köfte to meet their expectations. Therefore, it is crucial to research the composition, microbiological quality, and cooking effectiveness of Burdur şiş köfte to provide essential information to authorities regarding the public safety of this traditional meat product. Thus, the present research aimed to evaluate the physicochemical characteristics and microbiological quality of raw and cooked Burdur şiş köfte collected from fast-food restaurants in Burdur Province, Türkiye. This is the first study to provide an update on the current status of the quality and safety characteristics of Burdur şiş köfte.

Materials and Methods

In this research, a total of 60 Burdur şiş köfte (30 raw and 30 cooked samples) were purchased randomly from 30 different fast-food restaurants in Burdur, Türkiye. Burdur şiş köfte samples were aseptically placed in sterile polyethene bags and immediately transported to the Meat Sciences and Technology Laboratory at Suleyman Demirel University, Isparta, Türkiye, in a cooling box. Then, microbiological and physicochemical analyses were carried out on the samples.

Physicochemical Analyses

pH was measured using a glass electrode attached to a benchtop pH/ORP meter (HI 2211, Hanna Instruments, Germany) according to the method described by Şimşek and Kılıç (2020). Both raw and cooked Burdur şiş köfte samples were subjected to colour measurements using a Minolta Colourimeter (Model CR-200, Illuminant D65, Minolta Corp., Ramsey, NJ, U.S.A.). The instrument was standardised against a white calibration plate (D65, $L^* = 97.79$, $a^* = -0.11$, $b^* = 2.69$). The values of chroma (C^*_{ab}), hue angle (h_{ab}) and browning index (*BI*) were calculated using CIE L^*, a^* and b^* values according to equations given by Uysal et al. (2022). The protein (992.15), moisture (950.46), ash (920.153) and fat (991.36) analyses were conducted by the AOAC (1997) procedures. Salt contents were determined by the Mohr method, a titrimetric method for determining chloride ions (Papadima et al., 1999). The spectrophotometric procedure stated by Rudel and Morris (1973) was used to determine the cholesterol content. Cholesterol contents were calculated with the equation obtained from the standard curve prepared using 3β-Hydroxy-5-cholestene (C8667; Sigma-Aldrich, Germany) and presented as mg/100 g samples.

Microbiological Analyses

Total mesophilic aerobic bacteria (TMAB), total coliforms, yeasts-moulds, *Staphylococcus aureus* and *Bacillus cereus* counts of raw and cooked Burdur şiş köfte samples were detected and presented as log CFU/g samples. In addition, the presence of *Salmonella* spp. was investigated. For the detection of TMAB, total coliforms and yeast-moulds, each sample (10 g) was aseptically taken and placed into a sterile stomacher pouch, and then homogenised in 90 mL of 0.1% buffered peptone water (BPW) using a stomacher blender (Biobase BK-SHG04, China) for 2 min. 10-fold serial dilutions

were prepared using BPW. The counts for TMAB, total coliforms and yeasts-moulds were performed by using the spread-plate technique on plate count agar (PCA, Merck), eosin methylene blue agar (EMB, Merck) and potato dextrose agar (PDA, Merck), respectively (Şimşek, 2022). The plates for TMAB, total coliforms and yeasts-moulds were enumerated after incubating at 30 °C for 48 h, 37 °C for 48 h and 25 °C for 120 h, respectively. For *S. aureus* and *B. cereus* detection, 25 g of each sample was aseptically weighed into a sterile stomacher pouch containing 225 mL of 0.1% BPW and homogenised by a stomacher (Biobase BK-SHG04, China) for 2 min. 10-fold serial dilutions were prepared with 0.1% BPW from the homogenised samples. The plates containing Baird Parker Agar (BPA, Merck, 105406) with egg yolk tellurite (Merck, 103785) were used for the enumeration of *S. aureus*. 0.1 mL aliquots from appropriate 10-fold dilutions were transferred to the plates containing BPA, and the plates were incubated at 37 °C for 24 h. The suspected *S. aureus* colonies with a typical black appearance surrounded by a clear area on plates were enumerated. The presence of *S. aureus* was proven by the coagulase test (Burnham et al., 2008). The enumeration of *B. cereus* was performed using the spread-plate technique in the plates containing mannitol egg yolk polymyxin (MYP) agar (Merck, 105267). The plates were counted after incubating for 24 h at 30 °C. The tests of hemolysis, reduction of nitrate and Voges–Proskauer were performed to confirm typical *B. cereus* colonies (Güven et al., 2006). The method described by the International Organisation for Standardisation was used to detect the presence of *Salmonella* spp. (ISO, 2002). Each sample (25 g) was homogenised in 225 mL of BPW for 2 min using a stomacher, and then the diluted samples were incubated at 37 °C for 18 h. At the end of the incubation, 1 mL of pre-enrichment culture was transferred into sterile tubes containing 10 mL of Selenite Cystine Broth (SCB, Merck, 100212), and then the tubes were incubated for 24 h at 37 °C. A loopful from each SCB tube was subcultured on Brilliant-Green Phenol-Red Lactose Sucrose Agar (BPLSA, Merck, 100207) and incubated for 24 h at 37 °C. Triple Sugar Iron Agar (TSIA, Merck, 44940) was used to confirm typical *Salmonella* spp. colonies.

Statistical Analyses

Each analysis was performed in triplicate for raw and cooked samples purchased from each fast-food restaurant. The results were analysed by analysis of variance (ANOVA) using the SPSS 19.0.0 (SPSS Inc., Chicago, USA) software package. The differences among the means were assessed using the Independent-Samples T-test. Differences were considered significant at the $p<0.05$ level.

Results and Discussion

Physicochemical Characteristics of Burdur Şiş Köfte

Physicochemical results of raw and cooked Burdur şiş köfte samples are shown in Table 1. The average pH values (with range) of raw and cooked Burdur şiş köfte samples were 5.84 (5.47-6.36) and 6.05 (5.82-6.47), respectively. Sarıcaoğlu and Turhan (2013) reported that the pH values of raw beef meatballs were in the range of 5.30-5.63. Yılmaz and Dağlıoğlu (2003) reported that pH values of cooked beef meatballs ranged from 5.80 to 5.87, whereas Öğütcü et al. (2018) reported that pH values of cooked Tire meatballs were between 6.23 and 6.35. In addition, higher pH values (in the range of 6.24-6.99) were determined in the research results recorded by Çimen and Çiçek (2021) in meatballs. In studies, it has been observed that the pH values obtained in meatball samples varied over a wide range. These differences in pH values can be attributed to variations in initial meat pH and product formulations. Our study results showed that the average pH of cooked samples was higher than that of the raw samples ($p<0.05$). Nuray and Oz (2019) reported that the meat pH increases due to the release of imidazole, sulfhydryl and hydroxyl groups as a result of cooking. pH values of 22 (73.33%) raw Burdur şiş köfte samples ranged from 5.47 to 6.00, whereas pH values of 8 (26.67%) raw samples were between 6.01 and 6.36. On the other hand, pH values of 15 (50%) cooked Burdur şiş köfte samples ranged between 5.82 and 6.00, whereas pH values of 15 (50%) cooked samples were between 6.01 and 6.47.

Moisture, protein, fat, ash and salt levels ranged from 49.88% to 64.58%, 14.06% to 20.90%, 11.50% to 30.00%, 1.86% to 3.90%, 0.95% to 2.98% for raw samples, and 54.85% to 65.86%, 19.08% to 26.73%, 7.50% to 19.50%, 2.04% to 4.25%, 1.37% to 3.28% for cooked samples, respectively (Table 1). Similar moisture (52.09%-59.89%), protein (12.56%-25.26%), fat (9.15%-20.85%), ash (2.43%-3.75%) and salt (1.78%-3.22%) levels were reported by Çimen and Çiçek (2021) in ready-to-eat meatballs. Sarıcaoğlu and Turhan (2013) noted that the moisture, protein, fat, ash and salt contents of Akçaabat meatballs were in the ranges of 48.35%-54.53%, 14.14%-15.17%, 19.09%-22.27%, 1.91%-2.09% and 1.23%-1.51%, respectively. Yılmaz and Demirci (1995) indicated that moisture, protein, fat, ash and salt contents of Tekirdağ meatballs were 56.66%, 16.86%, 16.07%, 2.70% and 2.21% for ungrilled meatballs, 53.79%, 18.84%, 12.72%, 3.04% and 2.69% for grilled meatballs, respectively. Moreover, Öğütcü et al. (2018) reported that Tire meatball samples had moisture, protein, fat, ash and salt contents of 52.42%-54.83%, 17.57%-20.98%, 16.41%-18.05%, 2.58%-

2.91% and 1.59%-2.19%, respectively. There is a significant variation in terms of chemical composition among meatballs, as indicated by the results obtained in the present study and previous studies. These differences may be attributed to the variations in product formulations and final moisture levels. According to the Turkish Food Codex, meat products prepared with ground meat are allowed up to 25% fat and 2% salt content, and at least 12% protein content (TFC, 2016). Therefore, all of the raw and cooked Burdur şiş köfte samples were within legal limits in terms of protein level. However, the salt contents of 16 (53.33%) raw Burdur şiş köfte samples and 17 (56.67%) cooked Burdur şiş köfte samples were determined to be slightly higher than the acceptable upper salt limit value. The fat contents of 2 (6.67%) raw Burdur şiş köfte samples exceeded this upper limit value. The average moisture, protein, ash and salt levels were significantly higher in cooked Burdur şiş köfte samples than the raw counterparts ($p<0.05$). On the other hand, the average fat level of cooked Burdur şiş köfte samples was lower than that of raw samples ($p<0.05$). Protein levels of all Burdur şiş köfte samples increased, and fat levels decreased compared to raw counterparts after the cooking process ($p<0.05$). A lower fat content in the cooked Burdur şiş köfte samples was expected, as raw Burdur şiş köfte samples lost some fat through melting and draining during cooking. Moreover, the moisture levels of 6 (20%) samples, ash levels of 4 (13.33%) samples, and salt levels of 8 (26.67%) samples exhibited no significant changes as a result of the cooking process. Out of 30 cooked Burdur şiş köfte samples, 24 (80%), 16 (53.33%) and 12 (40%) had higher moisture, ash and salt levels compared to raw counterparts, respectively ($p<0.05$). The reduction in fat levels (Table 1) during cooking was considered the primary cause of the increase in moisture, protein, ash, and salt levels.

Table 1. Physicochemical characteristics of raw (n=30) and cooked (n=30) Burdur şiş köfte samples

	Raw			Cooked		
	Mean±SD	**Minimum**	**Maximum**	**Mean±SD**	**Minimum**	**Maximum**
pH	5.84^{b}±0.25	5.47	6.36	6.05^{a}±0.19	5.82	6.47
Moisture (%)	58.53^{b}±3.85	49.88	64.58	61.85^{a}±2.73	54.85	65.86
Protein (%)	16.87^{b}±1.88	14.06	20.90	22.88^{a}±2.24	19.08	26.73
Fat (%)	19.87^{a}±3.80	11.50	30.00	11.10^{b}±2.29	7.50	19.50
Ash (%)	2.99^{b}±0.48	1.86	3.90	3.13^{a}±0.61	2.04	4.25
Salt (%)	2.00^{b}±0.56	0.95	2.98	2.11^{a}±0.45	1.37	3.28
Cholesterol (mg/100 g)	70.57^{a}±15.20	42.16	104.27	72.65^{a}±19.72	38.34	114.58
*L**	52.87^{a}±5.46	47.06	63.93	49.56^{b}±2.91	45.26	55.14
*a**	15.10^{a}±6.96	6.19	26.97	10.21^{b}±1.66	7.30	12.56
*b**	4.48^{b}±1.90	2.01	8.99	8.45^{a}±1.27	5.62	11.87
h_{ab}	20.90^{b}±14.00	4.54	50.71	39.78^{a}±6.58	30.62	57.76
C^*_{ab}	16.16^{a}±5.72	8.29	27.35	13.35^{b}±1.12	10.11	15.72
BI	28.97^{b}±7.17	16.91	48.82	33.32^{a}±3.24	24.09	39.65

SD: standard deviation; h_{ab}: hue angle; C^*_{ab}: chroma; *BI:* browning index; Results are expressed as mean±SD; $^{a-b}$Means with different superscripts within a row are significantly different ($p<0.05$).

The cholesterol levels of Burdur şiş köfte samples ranged from 42.16 mg/100 g to 104.27 mg/100 g for raw samples and 38.34 mg/100 g to 114.58 mg/100 g for cooked samples, respectively. The cholesterol levels obtained in this study were similar to the results (in the ranges from 70.4% to 89.7% for raw samples and 67.0% to 76.5% for cooked samples) of previous studies on meatballs and hamburgers (Baggio & Bragagnolo, 2006). Study results showed no differences between raw and cooked Burdur şiş köfte samples in terms of average cholesterol level (Table 1). The cholesterol levels were higher in 15 (50%, out of 30) and lower in 12 (40%) cooked Burdur şiş köfte samples compared to raw counterparts ($p<0.05$). Previous studies have reported that the cholesterol levels of processed meat products vary significantly depending on factors such as the type of meat or muscle used, the cooking or heating processes applied, and product formulations (Bragagnolo, 2008; Dinh et al., 2011). Specifically, several studies in the literature have demonstrated the impact of cooking on cholesterol levels (Chizzolini et al., 1999; Dinh et al., 2011). Dinh et al. (2011) noted the migration of cholesterol from fat tissues to muscle tissues as the reason for the greater cholesterol level determined in cooked meats compared to raw ones. On the other hand, Chizzolini et al. (1999) stated that the cholesterol levels in meats do not significantly alter on cooking, because negligible amounts of cholesterol are lost from the membranes. The researchers also reported that cooking beef patties containing up to 25% fat resulted in a small decrease in cholesterol levels. Moreover, Kregel et al. (1986) noted that cholesterol retention during cooking varied between 96% and 74% in ground beef, depending on fat levels of 9.5% and 28.5%, respectively. In the present study, the increases or decreases in cholesterol levels of cooked Burdur şiş köfte samples may be attributed to differences in fat levels among the tested products.

The lightness (L^*), redness (a^*), yellowness (b^*), hue angle (h_{ab}), chroma (C^*_{ab}), and browning index (BI) values (Table 1) of the raw and cooked şiş köfte samples were in the ranges (average) of 47.06-63.93 (52.87), 6.19-26.97 (15.10), 2.01-8.99 (4.48), 4.54-50.71 (20.90), 8.29-27.35 (16.16) and 16.91-48.82 (28.97) for raw samples, and 45.26-55.14 (49.56), 7.30-12.56 (10.21), 5.62-11.87 (8.45), 30.62-57.76 (39.78), 10.11-15.72 (13.35) and 24.09-39.65 (33.32) for cooked samples, respectively. Sarıcaoğlu and Turhan (2013) stated that the L^*, a^* and b^* values of raw Akçaabat meatballs were in the ranges of 39.10-45.65, 6.19-10.35 and 10.22-12.60, respectively. Öğütcü et al. (2018) noted that the colour values of Tire meatballs ranged from 50.16 to 58.30 for L^* values, 4.72 to 6.70 for a^* values and 12.86 to 15.56 for b^* values. Çimen and Çiçek (2021) reported that L^*, a^* and b^* values of meatballs ranged from 32.99 to 48.63, 5.70 to 11.83 and 13.05 to 21.50, respectively. Moreover, Bozkurt (2009) demonstrated that L^*, a^*, b^* and h_{ab} values of İnegöl köfte samples were 40.75, 15.03, 18.22 and 50.48 for raw köfte samples and 37.71, 7.63, 15.77 and 64.22 for cooked köfte samples, respectively. There are significant variations in colour values among meatball samples, as determined by the results of the present study and previous studies. It has been noted that the colour values of meat products are influenced by various factors, including moisture and fat content, oxidation, and added ingredients (Lorenzo et al., 2017). The colour results revealed that the lower average L^*, a^* and C^*_{ab} values and the higher b^*, h_{ab} and BI values were determined in the cooked Burdur şiş köfte samples compared to raw Burdur şiş köfte samples ($p<0.05$).

Microbiological Quality of Burdur Şiş Köfte

The average microbial counts (log CFU/g) of TMAB, total coliforms, yeasts-moulds, *Salmonella* spp., *Bacillus cereus* and *Staphylococcus aureus* obtained from raw and cooked Burdur şiş köfte samples are shown in Table 2. The average counts of TMAB, total coliforms, yeasts-moulds, *B. cereus* and *S. aureus* for raw Burdur şiş köfte samples were 5.73 (3.48-8.25), 3.83 (2.43-5.46), 3.09 (1.48-4.58), 2.31 (1.30-3.08) and <1.00 (<1.00-2.56), respectively. In cooked Burdur şiş köfte samples, the average counts of TMAB, total coliforms, yeasts-moulds, *B. cereus* and *S. aureus* were 1.80 (<1.00-3.52), <1.00 (<1.00-2.79), <1.00 (<1.00-3.71), 1.40 (<1.00-2.96) and <1.00 (<1.00-2.32), respectively. Öğütcü et al. (2018) noted that the mesophilic and total coliform bacteria counts of raw Turkish Tire meatballs were in the ranges of 4.45-6.48 log CFU/g and 2.90-4.05 log CFU/g, respectively. Can et al. (2013) reported that TMAB and *S. aureus* counts of cooked Sivas köfte samples were in the ranges from 2.70 log CFU/g to 4.90 log CFU/g and <1.00 to 1.90 log CFU/g, respectively. It was noted that TMAB, yeasts, total coliforms and *S. aureus* counts in Tekirdağ meatballs were 5.38-7.34 log CFU/g, 4.00-5.85 log CFU/g, 2.00-5.63 log CFU/g and <1.00-2.39 log CFU/g for raw meatballs and 2.78-4.17 log CFU/g, 2.00-2.84 log CFU/g, <1.00-3.83 log CFU/g and <1.00-1.90 log CFU/g for cooked meatballs, respectively (Yilmaz et al., 2002). Variations in microbial counts observed in the present and previous studies could be attributed to differences in initial microbial loads, storage conditions, and the hygienic quality maintained during the processing period. In the present study, the results of microbiological analysis showed that lower counts of TMAB, total coliforms, yeasts-moulds, as well as *B. cereus*, were detected in cooked Burdur şiş köfte samples ($p < 0.05$). According to the Microbiological Criteria Legislation of the Turkish Food Codex (TFC, 2011), *Salmonella* should not be detected in 25 g of raw meat

mixtures and cooked meatballs. In the present study, *Salmonella* spp. was not detected in either raw or cooked Burdur şiş köfte samples. This finding complies with the criteria reported in the Turkish Food Codex (TFC, 2011). All tested raw Burdur şiş köfte samples were positive for TMAB, total coliforms, yeasts-moulds and *B. cereus* counts. Only 14 (46.67%) out of 30 tested raw samples showed *S. aureus* counts ≥ 1 log CFU/g (Table 2). Out of 30 tested cooked Burdur şiş köfte samples, 24 (72%), 2 (6.67%), 11 (36.67%), 19 (63.33%), and 2 (6.67%) were positive for TMAB, total coliforms, yeasts-moulds, *B. cereus* and *S. aureus* counts, respectively. According to the Microbiological Criteria Legislation of the Turkish Food Codex, the acceptable upper limit for the number of aerobic colonies in ground meat is reported to be 5×10^6 CFU/g (TFC, 2011). Considering this upper limit value, it can be stated that TMAB counts of 13 (43.33%) raw Burdur şiş köfte samples (6.19 to 8.20 log CFU/g) exceeded the upper limit value. On the other hand, the TMAB counts of all tested cooked Burdur şiş köfte samples were below the acceptable upper limit value (5×10^6 CFU/g). The Turkish Food Codex (TFC, 2011) has no acceptable upper limit for total coliform counts in raw or cooked meat products. However, the presence of total coliform bacteria is often used as an indicator of potential faecal contamination due to inadequate processing and/or post-processing recontamination. In the present study, total coliform counts in 28 (93.33%) out of 30 cooked Burdur şiş köfte samples were below the detection limit (1 log CFU/g). In contrast, total coliform counts of raw Burdur şiş köfte samples ranged between 2.43 log CFU/g and 5.46 log CFU/g. According to the Turkish Food Codex, there are no legal limits on yeast and mould counts in raw meat mixtures and cooked meatballs (TFC, 2011). On the other hand, it has been noted that yeast-mould counts should exceed 4 log CFU/g to indicate spoilage (Ahmad & Srivastava, 2007). Yeast-mould counts of 6 (20%) raw Burdur şiş köfte samples (4.01 to 4.31 log CFU/g) were detected to be slightly higher than the value reported by Ahmad and Srivastava (2007). Considering this upper limit value, it was seen that none of the yeast-mould counts in cooked Burdur şiş köfte samples exceeded the specified limit value. Regarding *B. cereus* and Coagulase-positive Staphylococci, the acceptable upper limit for *B. cereus* and Coagulase-positive Staphylococci counts in ready-to-eat and not ready-to-eat meat products is noted to be 3 log CFU/g and 4 log CFU/g, respectively (TFC, 2011). Considering this limit value for *B. cereus* and *S. aureus*, it was observed that *B. cereus* and *S. aureus* counts detected in all raw and cooked Burdur şiş köfte samples were below the specified limit values. Additionally, Yu et al. (2020) highlighted that *B. cereus* can lead to food poisoning even at lower numbers. Thus, a concentration of more than 3 log CFU/g is deemed unsafe for consumption. Moreover, Kadariya et al. (2014) pointed out that *S. aureus* enterotoxin typically does not reach levels that cause food poisoning until the pathogen's count reaches at least 5 log CFU/g.

Table 2. Microbiological analysis results (log CFU/g) of raw (n=30) and cooked (n=30) Burdur şiş köfte samples

Microorganism types	Raw					Cooked				
	Mean±SD	Minimum	Maximum	n^p	Rate of Positive Samples (%)	Mean±SD	Minimum	Maximum	n^p	Rate of Positive Samples (%)
TMAB	5.73^a±1.18	3.48	8.25	30	100	1.80^b±0.90	<1.00	3.52	24	72
Total coliform bacteria	3.83^a±0.76	2.43	5.46	30	100	$<1.00^b$	<1.00	2.79	2	6.67
Yeasts and moulds	3.09^a±0.81	1.48	4.58	30	100	$<1.00^b$	<1.00	3.71	11	36.67
Bacillus cereus	2.31^a±0.45	1.30	3.08	30	100	1.40^b±1.12	<1.00	2.96	19	63.33
Staphylococcus aureus	<1.00	<1.00	2.56	14	46.67	<1.00	<1.00	2.32	2	6.67
Salmonella spp.	N.D.	N.D.	N.D.	-	-	N.D.	N.D.	N.D.	-	-

*TMAB: Total mesophilic aerobic bacteria; N.D.: Not detected; n: number of analysed samples; n^p: number of positive analysed samples; SD: Standard deviation; Results are expressed as mean±SD; $^{a-b}$Means with different superscripts within a row are significantly different ($p<0.05$).

Conclusion

This research assessed the physicochemical properties and microbiological features of Burdur şiş köfte. Consequently, it was determined that Burdur şiş köfte samples mostly met the legal requirements specified in the Turkish Food Codex in terms of physicochemical properties, except for their salt and fat contents. On the other hand, Burdur şiş köfte samples collected from fast-food restaurants showed significant variation in terms of physicochemical properties. The microbiological attributes of cooked Burdur şiş köfte samples generally met the legal standards. However, some raw Burdur şiş köfte samples surpassed the limit values for TMAB, yeast-moulds, and total coliforms. On the other hand, *B. cereus* and *S. aureus* counts found in all raw and cooked Burdur şiş köfte samples were within the acceptable limit values. Moreover, *Salmonella* spp. was not found in any of the raw and cooked Burdur şiş köfte samples. Ultimately, this research revealed that the hygienic quality of specific raw Burdur şiş köfte samples was inferior to that of cooked ones. The cooking process plays a significant role in reducing the microbial load in Burdur şiş köfte. The present study results indicate the insufficient hygienic quality of raw Burdur şiş köfte; thus, necessary precautions should be taken during the preparation, processing, and storage of raw Burdur şiş köfte.

Compliance with Ethical Standards

Conflict of interest: The author(s) declare that they have no actual, potential, or perceived conflicts of interest related to this article.

Ethics committee approval: The authors declare that this study does not involve experiments with human or animal subjects, and therefore, ethics committee approval is not required.

Data availability: Data will be made available at the request of the author(s).

Funding: This study was supported by Süleyman Demirel University, the Department of Scientific Research Project (BAP, Project ID: 2309-YL-10).

Acknowledgements: -

Disclosure: This study was produced from the Master's Thesis of Erdem Özmen (Suleyman Demirel University, Graduate School of Natural and Applied Sciences, Department of Food Engineering).

References

Ahmad, S., & Srivastava, P. K. (2007). Quality and shelf life evaluation of fermented sausages of buffalo meat with different levels of heart and fat. *Meat Science*, *75*(4), 603-609. https://doi.org/10.1016/j.meatsci.2006.09.008

Albayrak, M., & Gunes, E. (2010). Traditional foods: Interaction between local and global foods in Turkey. *African Journal of Business Management*, *4*(4), 555.

AOAC (1997). Association of Official Analytical Chemists. In W. Horwitz (Eds.) Official methods of analysis (15th ed.). Washington, DC. ISBN: 0-935584-42-0

Baggio, S.R., & Bragagnolo, N. (2006). The effect of heat treatment on the cholesterol oxides, cholesterol, total lipid and fatty acid contents of processed meat products. *Food Chemistry*, *95*(4), 611-619. https://doi.org/10.1016/j.foodchem.2005.01.037

Bintsis, T. (2017). Foodborne pathogens. *AIMS Microbiology*, *3*(3), 529. https://doi.org/10.3934/microbiol.2017.3.529

Bozkurt, H. (2009). *The application, mathematical modelling and exergetic optimization of ohmic cooking in kofte production* (Doctoral dissertation, M. sc. Thesis, Ege University, Izmir).

Bragagnolo, N. (2008). Cholesterol and cholesterol oxides in meat and meat products. In *Handbook of muscle foods analysis* (pp. 207-240). CRC Press. https://doi.org/10.1201/9781420045307.ch12

Burnham, G.M., Hanson, D.J., Koshick, C.M., & Ingham, S.C. (2008). Death of *Salmonella* serovars, *Escherichia coli* O157:H7, *Staphylococcus aureus* and *Listeria monocytogenes* during the drying of meat: a case study using biltong and droëwors. *Journal of Food Safety*, *28*(2), 198-209. https://doi.org/10.1111/j.1745-4565.2008.00114.x

Can, O.P., Şahin, S., Erşan, M., & Harun, F. (2013). Sivas kofte and examination of microbiological quality. *Biotechnology in Animal Husbandry*, *29*(1), 133-143. https://doi.org/10.2298/BAH1301133C

Chizzolini, R., Zanardi, E., Dorigoni, V., & Ghidini, S. (1999). Calorific value and cholesterol content of normal and

low-fat meat and meat products. *Trends in Food Science & Technology*, *10*(4-5), 119-128. https://doi.org/10.1016/S0924-2244(99)00034-5

Çimen, A., & Çiçek, Ü. (2021). Tokat ilinde satışa sunulan köfte ve dönerlerin bazı fiziksel, kimyasal ve serolojik özellikleri. *Gaziosmanpaşa Bilimsel Araştırma Dergisi*, *10*(2), 71-83.

Dinh, T.T., Thompson, L.D., Galyean, M.L., Brooks, J.C., Patterson, K.Y., & Boylan, L.M. (2011). Cholesterol content and methods for cholesterol determination in meat and poultry. *Comprehensive Reviews in Food Science and Food Safety*, *10*(5), 269-289. https://doi.org/10.1111/j.1541-4337.2011.00158.x

Güven, K., Mutlu, M.B., & Avci, O. (2006). Incidence and characterization of *Bacillus cereus* in meat and meat products consumed in Turkey. *Journal of Food Safety*, *26*(1), 30-40. https://doi.org/10.1111/j.1745-4565.2005.00031.x

Kadariya, J., Smith, T.C., & Thapaliya, D. (2014). *Staphylococcus aureus* and staphylococcal food-borne disease: an ongoing challenge in public health. *BioMed Research International*, *2014*(1), 827965. https://doi.org/10.1155/2014/827965

Kregel, K.K., Prusa, K.J., & Hughes, K.V. (1986). Cholesterol content and sensory analysis of ground beef as influenced by fat level, heating, and storage. *Journal of Food Science*, *51*(5), 1162-1165. https://doi.org/10.1111/j.1365-2621.1986.tb13073.x

Lorenzo, J.M., Franco Ruiz, D., & Carballo, J. (2017). Fat content of dry-cured sausages and its effect on chemical, physical, textural and sensory properties. *Fermented Meat Products, 1st ed.; Zdolec, N., Ed*, 474-487. ISBN: 9781315369846

Nuray, M., & Oz, F. (2019). The effect of using different types and rates of onion-water extract in meatball production on the formation of heterocyclic aromatic amines. *Journal of the Science of Food and Agriculture*, *99*(7), 3538-3547. https://doi.org/10.1002/jsfa.9574

Öğütcü, M., Gevrek, S., & Arifoğlu, N. (2018). Physicochemical, textural, microbial and sensory properties of Turkish Tire meatball. *Journal of Food Processing and Preservation*, *42*(10), e13768. https://doi.org/10.1111/jfpp.13768

Papadima, S.N., Arvanitoyannis, I., Bloukas, J.G., & Fournitzis, G.C. (1999). Chemometric model for describing Greek traditional sausages. *Meat science*, *51*(3), 271-277. https://doi.org/10.1016/S0309-1740(98)00137-5

Rakha, A., Fatima, M., Bano, Y., Khan, M.A., Chaudhary, N., & Aadil, R.M. (2022). Safety and quality perspective of street vended foods in developing countries. *Food Control*, *138*, 109001. https://doi.org/10.1016/j.foodcont.2022.109001

Rudel, L.L., & Morris, M.D. (1973). Determination of cholesterol using o-phthalaldehyde. *Journal of Lipid Research*, *14*(3), 364-366. https://doi.org/10.1016/S0022-2275(20)36896-6

Sarıcaoğlu, F.T., & Turhan, S. (2013). Chemical composition, colour and textural properties of Akcaabat meatball: A traditional Turkish meat product. *Gıda,* 38(4), 191–198.

Sunarti, L.S. (2024). Bacterial Contamination in Food: Sources, Risks, and Prevention Strategies. *International Journal of Pathogen Research*, *13*(6), 90-100. https://doi.org/10.9734/ijpr/2024/v13i6324

Şimşek, A., & Kılıç, B. (2020). Influences of encapsulated polyphosphate incorporation on oxidative stability and quality characteristics of ready to eat beef Döner kebab during storage. *Meat Science*, *169*, 108217. https://doi.org/10.1016/j.meatsci.2020.108217

Şimşek, A. (2022). An evaluation of the physicochemical and microbiological characteristics and the hygienic status of naturally fermented camel sausages (sucuks). *Food Science and Technology*, *42*, e81321. https://doi.org/10.1590/fst.81321

Uysal, C., Enişte, İ., Çifçi, M., Şimşek, A., & Kılıç, B. (2022). Effects of different packaging methods and storage temperatures on physicochemical, microbiological, textural and sensorial properties of emulsion-type sausage chips. *Journal of Stored Products Research*, *98*, 102002. https://doi.org/10.1016/j.jspr.2022.102002

Turkish Patent Institute. (2011). Burdur Şiş Köfte Geographical Indication. Official Gazette, July 3, 2011.

TFC (2011). Turkish Food Codex, Legislation of Microbiological Criteria. The Official Gazette No:29.12.2011/28157

TFC (2016). Turkish Food Codex, Legislation on Meat and Meat Products. The Official Gazette No, 18, 2016-29774

Yılmaz, İ., & Dağlıoğlu, O. (2003). The effect of replacing fat with oat bran on fatty acid composition and physicochemical properties of meatballs. *Meat Science*, *65*(2), 819-823. https://doi.org/10.1016/S0309-1740(02)00286-3

Yilmaz, I., Yetim, H., & Ockerman, H. W. (2002). The effect of different cooking procedures on microbiological and chemical quality characteristics of Tekirdağ meatballs. *Food/Nahrung*, *46*(4), 276-278. https://doi.org/10.1002/1521-3803(20020701)46:4<276::AID-FOOD276>3.0.CO;2-2

Yılmaz, I., & Demirci, M. (1995). A research on determining of the physical, chemical and microbiological properties of Tekirdağ meatball. *Journal of Tekirdag Agricultural Faculty*, 4(1/2),17-29.

Yu, S., Yu, P., Wang, J., Li, C., Guo, H., Liu, C., ... & Ding, Y. (2020). A study on prevalence and characterization of *Bacillus cereus* in ready-to-eat foods in China. *Frontiers in Microbiology*, *10*, 3043. https://doi.org/10.3389/fmicb.2019.03043