



Microbiological and Some Physicochemical Properties of Chicken Döner Kebabs Consumed in Karaman

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HIGHLIGHTS

- Heat treatment had significant effect on the microbial load of the chicken döner kebabs ($p<0,01$).
- Some microbiological and physicochemical properties of chicken döner kebabs were in accordance with the limits specified in standards in Türkiye.

Abstract

Chicken döner is the most frequently consumed kebab type in terms of both the ease of preparation, cooking and serving processes and its taste. In this study, some physical, chemical and microbiological characteristics of the chicken döner kebabs consumed in Karaman in Türkiye was determined. For this purpose, the samples of raw and cooked chicken döner kebabs were collected from 20 different restaurants. Moisture (%), protein (%), total fat (%), total ash (%), total salt (%), pH, water activity (aw), color (L^* , a^* , b^*) and thiobarbituric acid (TBA) contents were analysed. In addition, total aerobic mesophilic bacteria count (TAMB), total aerobic psychrophilic bacteria count (TAPB), total coliform bacteria count (TCB), fecal coliform bacteria count (FCB), *Escherichia coli*, total yeast mold count (TYM), the presence of *Staphylococcus aureus*, *Clostridium perfringens*, *Salmonella* spp and *Escherichia coli* O157 were investigated for 40 chicken döner kebabs. Mean moisture, protein, total fat, total ash and total salt contents of raw and cooked chicken döners were determined as 71.12%-53.40%; 14.06%-27.47%; 3.93%-15.90%; 1.97%-3.02% and 1.65%-2.33%, respectively. Mean pH, aw, TBA and color (L^* , a^* , b^*) values of raw and cooked chicken döners were determined as 6.02-6.23; 0.962-0.926; 0.30-0.57 mg malonaldehyde/kg; 50.25-56.58; 17.26-12.36 and 35.52-29.34, respectively. Also effect of heat treatment on the microbiological quality of samples were found statistically significant ($p<0,01$). TAMB, TAPB, TCB, FCB and total yeast numbers of raw and cooked döners were found as 2.92-2.40 cfu/g; 2.87-1.53 cfu/g; 96.16-1.04 pcs/g; 207.77-5.19 pcs/g and 96.16-1.04 cfu/g, respectively. 45% *E. coli* and 5% *Salmonella* were detected but the presence of *E. coli* O157, *Staphylococcus aureus* and *Clostridium perfringens* was not detected at all the samples. The effect of heat treatment on the microbiological quality of doner kebab was found to be significant. Compliance with food safety rules in all production stages of doner kebab is important for public health.

Keywords: Chicken; Döner; Food Safety; Heat Treatment; Karaman.

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1. Introduction

Fresh meat and meat products are very perishable foods due to their biological composition. Many factors, such as storage temperature, atmospheric oxygen, endogenous enzymes, moisture, light and microbial load affect the freshness and shelf life of meat. On the other hand, meat is an ideal environment for the growth and reproduction of spoilage microorganisms and foodborne pathogens. For these reasons, it is very important to apply preservation techniques that are sufficiently effective to maintain the quality and safety of meat. Meat and meat products can generally be preserved by freezing, cooling, canning, heat treatment (cooking), drying, salting, smoking and fermenting. However nowadays, shelf life can be extended by means of many different and new methods such as irradiation, vacuum packaging, high hydrostatic pressure application, pulsed electrical field and ultrasound applications. If meat and meat products are stored under cold conditions, the level of microbial growth can be further limited (Akkara and Kayaardı 2014).

Pseudomonas, *Acetobacter*, *Brochothrix thermosphacta*, *Moraxella*, *Enterobacter*, *Lactobacillus*, *Leuconostoc*, *Proteus* etc. are the main organisms that cause microbial spoilage in meat and meat products. With the growth of these microorganisms in meat and meat products, lipids and proteins are exposed to destruction and adverse changes occur in the flavour, texture and appearance of the products. Woraprayote et al. (2016) reported that most of these microorganisms do not have a direct harmful effect on human health, but when they are taken into the body through foodstuffs in high concentrations, they trigger and increase gastrointestinal disorders. Pathogenic microorganisms that develop in meat and meat products can cause food poisoning and even death in humans. *Salmonella* spp., thermophilic *Campylobacter jejuni*, enterohaemorrhagic *Escherichia coli* O157:H7, *Clostridium perfringens*, anaerobic *Clostridium botulinum*, *Listeria monocytogenes*, *Staphylococcus aureus*, *Bacillus cereus* and *Yersinia enterocolitica* are pathogenic microorganisms that can grow in meat and meat products (Woraprayote et al. 2016).

Today, the changing lifestyle and the concept of spending time have had an impact on the change in the eating habits of our society. The increase in the time spent outside the home for various reasons has led individuals to foodstuffs that are more easily accessible, prepared as ready-to-eat products (Haskaraca 2017). According to the 2016 data of the Association of White Meat Industrialists and Breeders Association, poultry meat consumption per capita in Türkiye was reported as 23.24 kg in total (Anonymous 2019). It was stated that the consumption of chicken döner kebab is quite high in Türkiye, daily consumption is over 30,000 kg and according to a study conducted in 2023, chicken döner kebab was chosen as the most popular food in many countries (Anonymous 2024). It has been reported that döner kebab, which is an easy-to-prepare, highly nutritious and economical meat product, has a history of almost 4000 years in some sources, that the production technique was developed by modifying the process of turning lamb, which has been applied since ancient times, and that the term of "döner" was first used by "İskender Bey" who lived in Bursa in Türkiye, 150 years ago (Al-Shadefat 2011). Döner Kebab is also known by different names such as "donair, doner, gyros, dona-kebab, donnakebab, shiwarma, chawarma" in various parts of the world (Acar and Çiftçioğlu 1997).

In this study; it was aimed to determine some physicochemical, microbiological quality and to evaluate the security of chicken döner kebabs offered for sale in the centre of Karaman in Türkiye. In addition to the fact that a similar study has not been carried out the province to date, this study is important in terms of determining the suitability of chicken döner kebabs offered for consumption in terms of food safety.

2. Materials and Methods

2.1. Material

The chicken döner kebabs used in the study were collected raw and cooked randomly from 20 different restaurants sold in the city centre of Karaman, Türkiye. The samples were taken in sterile sample bags and delivered to Karamanoğlu Mehmetbey University Faculty of Engineering, Department of Food Engineering laboratories where the research was carried out under aseptic and chilled conditions. The study was carried out in two temporal replicates and three parallels.

2.2. Experimental design

The raw and cooked ready-to-eat chicken döner kebabs randomly were collected from 20 different restaurants in central Karaman. The samples were placed in separate sterile, single-use sample containers in accordance with standard procedures and transported to the laboratory under cold conditions, where analysis began immediately. For microbiological analysis were homogenised using a stomacher (BagMixer 400 P, Interscience, France).

After microbiological analyses, physicochemical analyses of the samples were performed immediately after passing through a meat grinder (KitchenAid, USA) with a 3 mm pore diameter for chemical analyses.

2.3. Methods

2.3.1. Microbiological analyses

The samples were firstly sampled under aseptic conditions for microbiological analyses and the methods specified in Anonymous (2002) were applied.

Total aerobic mesophilic bacteria (TAMB), total aerobic psychrophilic bacteria (TAPB) and total yeast-mold (TYM) counts of raw and cooked chicken döner kebabs were determined according to Harrigan (1998).

The Most Probable Number (MPN) (3-tube) method was used for total coliform bacteria (TCB) counting. 1 mL of the prepared dilutions was added to 3 tubes containing Lauryl Sulphate Tryptose Broth (LSTB) with Durham tubes and left for incubation at 37 °C for 24-48 hours. At the end of the incubation, "gas positive" tubes were determined and the number of coliform bacteria was expressed as "pcs/g" using the MPN table. To prove the results of the probability test, all gas-positive tubes were inoculated with Brilliant Green Bile Broth (BGBB) containing Durham's tubes and the petri dishes were incubated at 37 °C for 24-48 hours. At the end of this period, the number of coliform bacteria in 1 ml of the first dilution was determined using the MPN table. This value was multiplied by the dilution factor of the first dilution to calculate the number of coliform bacteria in 1 gram of the sample (pcs/g) (Feng et al. 1998).

In order to count fecal coliform bacteria (FCB), the LSTB tubes that gave positives in total coliform bacteria (TCB) analysis were inoculated with a ring core into EC (*Escherichia coli*) Broth medium containing Durham tubes and incubated at 45±0.5 °C for 24-48 hours. At the end of this period, the tubes in which gas formation was observed were identified and the number of possible FCB in 1ml of the first dilution was calculated using the MPN table. This value was multiplied by the initial dilution factor to determine the possible number of FCB in 1 gram of sample (pcs/g) (Feng et al. 1998).

For the detection and clear differentiation of *Escherichia coli* and coliform bacteria in a single medium, samples weighed 10 g each were diluted with 90 ml of peptone water and inoculated on CCA (Chromogenic Coliform Agar) medium by smear plate method and incubated at 36±2 °C for 21±3 hours. At the end of incubation, all colonies with "positive" β-D-galactosidase and β-D-glucuronidase reaction (dark blue violet) were accepted as *Escherichia coli*. All colonies with "positive" β-D-galactosidase reconstitution (pink red) were considered as possible coliform bacteria that were not *Escherichia coli*. Pink coloured probable coliform colonies were subjected to oxidase test. Probable Coliform colonies were inoculated on Plate Count Agar (PCA) medium by drawing method and incubated at (36±2) °C for 21±2 hours for 10 suspected colonies (single petri divided into 10). Oxidase kits were used for the oxidase test. The formation of dark blue-violet colour within 30 s was considered as "positive reaction". Coliform bacteria are oxidase negative. There is no colouration on the paper (Anonymous 2014). At least 5 of the *Escherichia coli* colonies giving dark blue-violet colour in CCA medium were taken and subjected to Gram staining and confirmation analysis with Singlepath *Escherichia coli* O157 test kit (Feng et al. 1998).

Baird Parker Agar (BPA-Merck, 1.05406) was used to determine the presence of *Staphylococcus aureus* in raw and cooked chicken döner kebabs and incubation was carried out at 35-37 °C for 24-48 hours after sowing by smear plate method. After incubation, 1-3 mm in diameter, black, shiny and convex colonies in petri dishes were considered as suspicious. For identification, suspected colonies were transferred to DNase Agar (Merck, 1.10449) for DNase activity and incubated at 35-37 °C for 24-48 hours (APHA 2001). Gram staining and

catalase test were performed for confirmation. Small brown-black colonies developing in the same medium and not forming a zone were considered as *Staphylococcus-Micrococcus* spp. They were subjected to confirmation analysis with the Singlepath *Staphylococcus aureus* test kit (Reginald and Gayle 1998).

Tryptose Sulfite Cycloserin Agar (TSCA-Merck, 1.11972) was used to determine the presence of *Clostridium perfringens*. 1 mL of the dilution was taken and sown on sterile petri dishes by double layer pouring method. It was incubated under anaerobic conditions at 37 °C for 24-48 hours. Fluorescent colonies were analysed (AOAC 2002; Harrigan 1998).

In order to determine the presence of *Salmonella* spp. in chicken döner kebabs, 25 g of the sample was transferred into a sterile flask, 225 mL of buffered peptone water was added, homogenised and incubated at 37 °C for 18-20 hours (first pre-enrichment). At the end of incubation, the pre-enrichment culture was transferred to tubes containing Selenite Cystine Broth medium (2nd pre-enrichment). At the end of 48 hours of incubation at 37 °C, a sample was taken from the enriched culture with a sterile swab and inoculated into Bismuth Sulfite Agar (BSA) medium by drawing method (Andrews 1992). Petri dishes containing BSA were incubated at 37 °C for 48 hours (Gökalp et al. 1999). At the end of incubation, dark black violet colonies were transferred to tubes containing Triple Sugar Iron (TSI) agar with a needle core. At the end of 24 hours of incubation at 37 °C, the presence of *Salmonella* was analysed by considering the changes in the media and subjected to the Analytical Profile Index (API) test (Gökalp et al. 1999; Anonymous 2013). It was also subjected to confirmation analysis using Singlepath *Salmonella* test kit. For this purpose, the 1st pre-enrichment culture was transferred to Rappaport-Vassiliadis medium (mRVB) and incubated at (42±0.5) °C for 18-24 hours. After, the presence of *Salmonella* was determined by dropping of the culture into Singlepath kits under sterile conditions (Anonymous 2013).

2.3.2. Physicochemical analyses

Following the microbiological analyses of the samples, physicochemical analyses were determined immediately after passing through a meat grinder (Kitchenaid, Germany) with a 3 mm pore diameter. Moisture and total fat content of chicken döner kebabs were determined according to Association of Official Analytical Collaboration International (1990a), protein content (AOAC 1990b), total ash (AOAC 2000) and total salt (Less 1975). Also pH (AOAC 2002), water activity (aw) (Troller and Christian 1978), colour (Hunt et al. 1991) and thiobarbituric acid (TBA) (Tarladgis et al. 1960) were analysed.

2.4. Statistical analysis

The data obtained as a result of the research were subjected to one-way analyses of variance (ANOVA) using MINITAB release 13.0 programme in the form of tables prepared in accordance with the experimental design and Duncan Multiple Comparison Test was used to check whether the differences between group means were significant ($p < 0.05$) (Steel and Torrie 1980).

3. Results and Discussion

3.1. Microbiological findings

Analysis of Duncan Multiple Comparison Test of total coliform bacteria (TCB), fecal coliform bacteria (FCB), total yeast-mold (TYM), total aerobic mesophilic bacteria (TAMB) and total aerobic psychrophilic bacteria (TAPB) counts of raw and cooked chicken döner kebabs from different companies are given in Table 1.

The average counts of TCB ranged from 1.00 to 764 pcs/g, FCB from 1.00 to 575 pcs/g, total yeast count from 1.00 to 3.76 cfu/g, TAMB from 1.00 to 6.75 cfu/g and TAPB from 1.00 to 6.07 cfu/g in cooked and raw chicken döner kebabs obtained from 20 different restaurants (Table 1). There is no limit for TAMB, TAPB, TCB and FCB counts for heat-treated meat products in Turkish Food Codex (TFC). But the numbers of TYM, *Staphylococcus aureus* and *Clostridium perfringens* were determined as 1.00-6.64 cfu/g and 1.00-4.64 cfu/g, respectively. The maximum acceptable number of microorganisms in 1 g of 3 out of 5 samples should be 10^2

cfu/g; while in the remaining 2 samples, it should be 10³ cfu/g. Also *Escherichia coli*, *Escherichia coli* O157:H7 and *Salmonella* spp. should not be present in a 25 g sample (Anonymous 2016c).

Heat treatment applied to the chicken döner kebabs were highly effective ($p < 0.01$) on the microbial quality (Table 1) and this can be explained by the reduction in the microbial load due to the effect of the heat (Haskaraca 2017).

TCB and FCB numbers are accepted as the most important indicators of fecal contamination in meat products. High numbers of TCB and FCB in heat-treated meat products are accepted as an indicator of cross-contaminations (Üzümçüoğlu 2001).

The mean numbers of TCB, FCB, total yeast, TAMB and TAPB in cooked and raw chicken döner kebabs were determined as 5.19 and 207.77 pcs/g; 1.04 and 96.16 pcs/g; 1.04 and 1.38 cfu/g; 2.40 and 2.92 cfu/g and 1.53 and 2.87 cfu/g, respectively (Table 1). In addition, the difference between the total mold counts of samples were found to be statistically nonsignificant ($p > 0.05$).

Table 1. Results for TCB, FCB, total yeast, TAMB and TAPB counts of chicken döner kebabs*

SV	n	TCB	FCB	Total Yeast	TAMB	TAPB	SV	n	TCB	FCB	Total Yeast	TAMB	TAPB
Restaurant (A)							AxB						
1	12	86.25 ^{cd}	1.00 ^f	1.00 ^b	5.31 ^a	1.39 ^{cd}	5xR	6	286.83 ^{cdef}	129.33 ^{cd}	1.10 ^b	4.20 ^b	3.33 ^c
2	12	99.25 ^{bcd}	99.25 ^{cd}	1.35 ^b	2.73 ^{bcd}	1.75 ^{cd}	5xC	6	1.00 ^g	1.00 ^e	1.00 ^b	1.45 ^c	1.00 ^f
3	12	382.50 ^a	1.00 ^f	2.38 ^a	1.00 ^e	3.53 ^{ab}	6xR	6	533.33 ^{abc}	3.67 ^d	1.30 ^b	2.94 ^{bc}	3.20 ^{cd}
4	12	138.08 ^{bcd}	1.00 ^f	1.07 ^b	3.22 ^{bcd}	1.80 ^{cd}	6xC	6	2.00 ^f	2.00 ^d	1.66 ^b	1.95 ^c	1.57 ^e
5	12	143.92 ^{bcd}	65.17 ^d	1.05 ^b	2.83 ^{bcd}	2.17 ^{bcd}	7xR	6	4.83 ^f	1.00 ^e	1.22 ^b	1.93 ^c	2.35 ^d
6	12	267.67 ^{abc}	2.83 ^{ef}	1.48 ^b	2.45 ^{bcd}	2.39 ^{bcd}	7xC	6	1.00 ^g	1.00 ^e	1.00 ^b	1.00 ^d	1.00 ^f
7	12	2.92 ^e	1.00 ^f	1.10 ^b	1.47 ^{de}	1.68 ^{cd}	8xR	6	18.67 ^f	18.67 ^d	1.49 ^b	3.27 ^b	1.00 ^f
8	12	9.83 ^d	9.83 ^e	1.25 ^b	2.14 ^{cde}	1.00 ^d	8xC	6	1.00 ^g	1.00 ^e	1.00 ^b	1.00 ^d	1.00 ^f
9	12	192.17 ^{abcd}	192.17 ^b	1.23 ^b	2.64 ^{bcd}	2.16 ^{bcd}	9xR	6	383.33 ^{bcd}	383.28 ^b	1.46 ^b	3.38 ^b	3.33 ^c
10	12	47.92 ^d	1.00 ^f	1.42 ^b	4.02 ^{ab}	4.65 ^a	9xC	6	1.00 ^g	1.00 ^e	1.00 ^b	1.89 ^c	1.00 ^f
11	12	67.67 ^{cd}	54.67 ^d	1.12 ^b	4.03 ^{ab}	4.35 ^a	10xR	6	94.83 ^{def}	1.00 ^e	1.85 ^b	3.36 ^b	3.89 ^c
12	12	32.67 ^d	32.67 ^d	1.13 ^b	3.10 ^{bcd}	1.58 ^{cd}	10xC	6	1.00 ^g	1.00 ^e	1.00 ^b	4.68 ^b	5.40 ^b
13	12	295.92 ^{ab}	288.00 ^a	1.05 ^b	3.38 ^{bc}	2.82 ^{bc}	11xR	6	134.33 ^{def}	108.33 ^{cd}	1.23 ^b	3.48 ^b	3.40 ^c
14	12	175.50 ^{bcd}	175.50 ^{bc}	1.14 ^b	1.86 ^{cde}	2.19 ^{bcd}	11xC	6	1.00 ^g	1.00 ^e	1.00 ^b	4.59 ^b	5.29 ^b
15	12	12.08 ^d	12.08 ^e	1.12 ^b	2.59 ^{bcd}	1.75 ^{cd}	12xR	6	64.33 ^{ef}	64.27 ^d	1.18 ^b	4.25 ^b	2.16 ^d
16	12	17.67 ^d	0.92 ^f	1.09 ^b	1.98 ^{cde}	1.59 ^{cd}	12xC	6	1.00 ^g	1.00 ^e	1.08 ^b	1.95 ^c	1.00 ^f
17	12	11.17 ^d	1.00 ^f	1.05 ^b	2.19 ^{cde}	1.71 ^{cd}	13xR	6	575.00 ^{ab}	575.00 ^a	1.10 ^b	4.60 ^b	4.64 ^{bc}
18	12	89.67 ^{cd}	1.00 ^f	1.10 ^b	1.75 ^{cde}	1.66 ^{cd}	13xC	6	16.83 ^f	1.00 ^e	1.00 ^b	2.17 ^{bc}	1.00 ^f
19	12	25.92 ^d	1.00 ^f	1.03 ^b	1.97 ^{cde}	1.53 ^{cd}	14xR	6	350.00 ^{bcd}	350.08 ^b	1.27 ^b	2.48 ^{bc}	3.37 ^c
20	12	30.92 ^d	30.92 ^d	1.10 ^b	2.53 ^{bcd}	2.26 ^{bcd}	14xC	6	1.00 ^g	1.00 ^e	1.00 ^b	1.25 ^c	1.00 ^f
Treatment (B)							15xR	6	23.17 ^f	23.33 ^d	1.24 ^b	3.10 ^b	2.51 ^d
Raw (R) 120		207.77 ^a	96.16 ^a	1.38 ^a	2.92 ^a	2.87 ^a	15xC	6	1.00 ^g	1.00 ^e	1.00 ^b	2.08 ^{bc}	1.00 ^f
Cooked (C) 120		5.19 ^b	1.04 ^b	1.04 ^b	2.40 ^b	1.53 ^b	16xR	6	31.67 ^f	1.00 ^e	1.19 ^b	2.18 ^{bc}	2.18 ^d
AxB							16xC	6	3.67 ^f	0.83 ^e	1.00 ^b	1.78 ^c	1.00 ^f
1xR	6	126.67 ^{def}	1.00 ^e	1.00 ^b	3.86 ^b	1.14 ^{ef}	17xR	6	19.50 ^f	1.00 ^e	1.10 ^b	2.18 ^{bc}	2.42 ^d
1xC	6	45.83 ^f	1.00 ^e	1.00 ^b	6.75 ^a	1.63 ^f	17xC	6	2.83 ^f	1.00 ^e	1.00 ^b	2.01 ^{bc}	1.00 ^f
2xR	6	197.50 ^{def}	197.50 ^f	1.61 ^b	2.57 ^{bc}	2.50 ^d	18xR	6	167.50 ^{def}	1.00 ^e	1.20 ^b	2.37 ^{bc}	2.32 ^d
2xC	6	1.00 ^g	1.00 ^e	1.08 ^b	2.89 ^{bc}	1.00 ^f	18xC	6	11.83 ^f	1.00 ^e	1.00 ^b	1.91 ^c	1.00 ^f
3xR	6	764.00 ^a	1.00 ^e	3.76 ^a	1.00 ^d	6.07 ^a	19xR	6	50.83 ^f	1.00 ^e	1.00 ^b	1.60 ^c	1.54 ^e
3xC	6	1.00 ^g	1.00 ^e	1.00 ^b	1.00 ^d	1.00 ^f	19xC	6	1.00 ^g	1.00 ^e	1.05 ^b	1.47 ^c	1.52 ^e
4xR	6	268.33 ^{cdef}	1.00 ^e	1.13 ^b	4.13 ^b	2.46 ^d	20xR	6	60.80 ^{ef}	60.83 ^d	1.21 ^b	2.46 ^{bc}	3.52 ^c
4xC	6	7.83 ^f	1.00 ^e	1.00 ^b	2.31 ^{bc}	1.14 ^{ef}	20xC	6	1.00 ^g	1.00 ^e	1.00 ^b	2.37 ^{bc}	1.00 ^f

*a-h: Means marked with different letters in the same column are statistically different ($p < 0.01$). TCB: Total coliform bacteria count (pcs/g); FCB: Fecal coliform bacteria count (pcs/g); TAMB: Total aerobic mesophilic bacteria count (cfu/g); TAPB: Total aerobic psychrophilic bacteria (cfu/g).

According to Turkish Standards (TS) 11566, "TAMB limits for raw döner kebab is reported as $\leq 5 \log \text{ cfu/g}$ " (Anonymous, 1995). The number of TAMBs in meat products is affected by many factors such as the quality of the raw material used in the production of that product, production area hygiene and cooking technique. The higher the number of TAMBs present in the raw product, the more bacteria can survive after heat treatment (Aldemir 2011).

Escherichia coli was found in 45% of the raw chicken döner kebabs, whereas *Escherichia coli* O157 was not detected. In addition, all colonies tested with the oxidase test were found to be "oxidase negative". The absence of *Escherichia coli*, in cooked samples can be explained by the inactivating effect of the heat treatment (cooking

process) on microorganisms and the inability of these bacteria to maintain their viability due to the loss of water in the product (Haskaraca 2017).

As a result of the tests for the presence of *Salmonella* using the Singlepath confirmation kit, we were determined that 5% of the raw samples tested "positive". According to the results of some literature studies conducted in Türkiye, it was reported that the number of *Salmonella* detected in different döner kebabs varied between <1.0 log cfu/g and 1.5 log cfu/g (Kayışoğlu 1996; Kolsarıcı 2014). It may be related to cross-contamination as well as fecal contamination, which may be caused by personnel working in meat products (Tunalıgil 2009).

The presence of *Escherichia coli* O157, *Staphylococcus aureus* and *Clostridium perfringens* was not detected in the all samples used in this study and this situation is in accordance with the criteria specified in TFC (Anonymous 2016b).

3.2. Physicochemical findings

The results of Duncan Multiple Comparison Test for the mean moisture (%), protein (%), total fat (%), total ash (%) and total salt (%) contents and pH, aw, colour (L^* -brightness/darkness, a^* -redness/greenness, b^* -yellowness/blueness) values and TBA amounts of raw and cooked chicken döner kebabs from 20 different restaurants are given in Table 2.

The average moisture, protein, fat, ash and salt contents of cooked and raw samples were 42-73%, 7.95-40.89%, 1.08-24.79%, 1.46-4.47% and 0.76-3.84%, respectively (Table 2). According to the TFC, chicken döner kebabs must contain a minimum of 12% protein, a maximum of 25% fat and a maximum of 2% salt (Anonymous 2016a). In this study, it was determined that the protein and fat contents of the chicken döner kebabs were in accordance with the TFC, but the salt content of the samples obtained from 11 restaurants were above the specified limits. This may be caused by the use of ingredients such as sauce, marinating agents, etc.

According to Table 2, the mean pH, aw, colour (L^* , a^* , b^*) values and TBA amounts of the samples were determined as 5.59-7.92; 0.846-0.986; 43.42-66.98; 4.99-21.53; 24.48-41.63 and 0.16-0.34 mg malonaldehyde/kg, respectively. The difference between raw and cooked chicken döner kebabs was found to be statistically significant ($p < 0.01$). Accordingly, pH, L^* (brightness/darkness) values and TBA amounts were lower in raw samples than cooked, while aw, a^* (redness/greenness) and b^* (yellowness/blueness) values were higher in raw samples than cooked. The pH values of raw and cooked döner kebabs were determined as 6.02-6.23, respectively. In some studies have been reported that proteins are denaturated as a result of heat treatment applied to meat products and this is effective on buffering and pH, which is low before heat treatment, reaches higher values after heat treatment (Wardlaw et al. 1973; Zaika et al. 1976).

The L^* values of the samples were found to be 50.25 in raw samples and 56.58 in cooked (Table 2). It is thought that this situation is caused by the melting of the fat around the product due to the effect of the heat treatment applied and the breakdown of the myoglobin pigment that gives the colour to the meat and the cooked samples get a lighter colour (Wiley 2010). The degree and duration of the heat treatment applied to the chicken döner kebabs used in this study, as well as the differences in the ingredients used in the kebabs, resulted in differences in the color values.

Table 2. Results for the moisture, protein, fat, ash and salt, pH, aw, colour (L^* , a^* , b^*) values and TBA counts

SV	n	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Salt (%)	pH	aw	L^*	a^*	b^*	TBA
Restaurant (A)												
1	12	68.63 ^a	13.77 ^m	7.14 ^{hi}	2.45 ⁱ	0.96 ^f	6.30 ^d	0.941 ^d	48.57 ^l	14.89 ^s	32.40 ^f	0.80 ^a
2	12	62.95 ^e	20.14 ^{hi}	8.43 ^s	2.87 ^d	1.59 ^{ji}	6.48 ^c	0.861 ^h	52.48 ^{sh}	17.20 ^b	35.17 ^c	0.47 ^f
3	12	63.21 ^e	30.19 ^a	8.85 ^{is}	2.01 ^m	1.44 ^k	5.87 ^l	0.920 ^f	55.20 ^d	9.29 ⁿ	31.69 ^s	0.50 ^e
4	12	63.90 ^d	19.52 ⁱ	8.53 ^{is}	2.64 ^f	1.46 ^k	6.06 ^s	0.926 ^f	52.75 ^s	12.78 ^k	28.97 ^t	0.52 ^d
5	12	63.01 ^e	22.33 ^{ef}	8.37 ^s	2.18 ^l	2.49 ^{bc}	6.02 ^h	0.932 ^e	54.34 ^e	14.60 ^h	33.86 ^d	0.35 ^m
6	12	60.74 ^s	21.17 ^{sh}	11.20 ^d	2.73 ^e	2.42 ^{cd}	5.93 ^j	0.915 ^s	51.91 ^{ij}	14.56 ^h	33.39 ^e	0.27 ^q
7	12	55.40 ^k	22.92 ^{de}	13.97 ^a	2.20 ^{kl}	1.37 ^k	5.99 ^j	0.935 ^e	52.44 ^{sh}	13.98 ^{ij}	30.16 ⁱ	0.62 ^b
8	12	62.98 ^e	16.93 ^k	10.49 ^e	2.51 ^h	1.83 ^b	6.11 ^f	0.940 ^e	52.08 ^{hi}	17.76 ^a	36.11 ^a	0.36 ^l
9	12	64.91 ^c	15.87 ^l	13.41 ^a	3.04 ^c	3.29 ^a	6.96 ^a	0.927 ^f	52.97 ^s	17.05 ^{bc}	35.03 ^c	0.33 ⁿ
10	12	59.38 ^j	21.10 ^{sh}	11.84 ^{bc}	3.52 ^a	1.86 ^b	6.21 ^e	0.977 ^a	54.04 ^{ef}	14.06 ⁱ	35.64 ^b	0.46 ^s
11	12	63.89 ^d	27.97 ^b	5.92 ^l	1.75 ⁿ	1.32 ^k	5.90 ^k	0.968 ^b	59.92 ^a	10.51 ^m	28.06 ^k	0.38 ^l

12	12	59.67 ^{ij}	19.81 ⁱ	12.26 ^h	2.30 ⁱ	2.30 ^{de}	6.00 ^h	0.953 ^c	51.49 ^{jk}	16.31 ^{ef}	34.14 ^d	0.37 ^k
13	12	62.58 ^f	25.28 ^c	7.50 ^h	2.24 ^k	2.41 ^{cd}	5.86 ^{lm}	0.964 ^b	56.58 ^c	16.46 ^e	31.16 ^b	0.41 ^j
14	12	60.86 ^g	18.51 ^j	11.84 ^{bc}	3.24 ^b	2.61 ^f	6.80 ^b	0.959 ^c	52.92 ^g	17.73 ^a	35.02 ^c	0.35 ^m
15	12	60.32 ^h	22.82 ^{def}	9.44 ^f	1.97 ^m	2.01 ^g	6.06 ^g	0.964 ^b	55.49 ^d	15.87 ^f	34.86 ^c	0.40 ^l
16	12	59.78 ⁱ	23.77 ^d	11.53 ^{cd}	2.18 ^l	1.61 ⁱ	5.93 ^j	0.960 ^c	51.02 ^k	16.85 ^{cd}	31.72 ^s	0.44 ^h
17	12	66.35 ^b	16.23 ^{kl}	6.68 ⁱ	2.56 ^g	2.24 ^{ef}	6.05 ^g	0.965 ^b	53.59 ^f	13.21 ^j	28.81 ⁱ	0.30 ^p
18	12	61.10 ^s	21.79 ^{fg}	10.45 ^e	2.51 ^h	2.19 ^{ef}	5.94 ^j	0.953 ^c	58.06 ^b	11.95 ^l	28.17 ^k	0.58 ^c
19	12	60.33 ^h	21.18 ^{sh}	11.26 ^{cd}	2.60 ^g	2.23 ^{ef}	5.85 ^m	0.955 ^c	53.58 ^f	14.42 ^h	30.97 ^h	0.29 ^p
20	12	65.17 ^c	14.07 ^m	9.25 ^f	2.42 ⁱ	2.14 ^{fg}	6.20 ^e	0.966 ^b	48.86 ⁱ	16.77 ^d	33.25 ^e	0.46 ^g
Treatment (B)												
Raw (R)	120	71.12 ^a	14.06 ^b	3.93 ^b	1.97 ^b	1.65 ^b	6.02 ^b	0.962 ^a	50.25 ^b	17.26 ^a	35.52 ^a	0.30 ^b
Cooked (C)	120	53.40 ^b	27.47 ^a	15.90 ^a	3.02 ^a	2.33 ^a	6.23 ^a	0.926 ^b	56.58 ^a	12.36 ^b	29.34 ^b	0.57 ^a
AxB												
1xR	6	73.81 ^a	17.64 ^m	1.96 ^{rs}	2.18 ^m	0.76 ^q	6.33 ^e	0.953 ^{cd}	44.80 ^r	16.36 ^g	35.26 ^g	0.59 ⁱ
1xC	6	63.45 ^l	9.90 ^f	12.32 ^k	2.71 ⁱ	1.16 ^{no}	6.26 ^{fg}	0.928 ^e	52.35 ^k	13.42 ^l	29.54 ^p	1.02 ^a
2xR	6	71.35 ^{efg}	15.47 ⁿ	1.08 ^j	2.17 ^m	1.35 ^{mn}	6.47 ^c	0.877 ^h	49.34 ^q	19.41 ^c	38.56 ^e	0.48 ^j
2xC	6	54.55 ^r	24.81 ^h	15.78 ^f	3.57 ^d	1.84 ^{hijk}	6.49 ^c	0.846 ^k	55.62 ^f	14.98 ⁱ	31.78 ^{ij}	0.47 ^j
3xR	6	70.51 ^{hi}	19.50 ^{kl}	2.80 ^q	1.74 ^s	1.21 ^{no}	5.59 ^w	0.986 ^a	43.42 ^s	13.55 ^l	30.49 ^{lmno}	0.30 ^f
3xC	6	55.90 ^p	40.89 ^a	14.90 ^{gh}	2.28 ^l	1.67 ^{hi}	6.16 ^{ij}	0.855 ⁱ	66.98 ^a	4.99 ^u	32.92 ^h	0.70 ^d
4XR	6	71.62 ^e	12.35 ^{qrs}	2.99 ^q	1.94 ^p	1.20 ^{no}	5.99 ^o	0.971 ^b	46.74 ^q	15.48 ^h	30.69 ^{klmn}	0.42 ^{op}
4XC	6	56.18 ^p	26.69 ^s	14.07 ^{hi}	3.35 ^e	1.72 ^{kl}	6.13 ^j	0.882 ^{bc}	58.76 ^d	10.09 ^q	27.26 ^e	0.62 ^s
5XR	6	71.52 ^{ef}	11.61 ^{rs}	4.22 ^p	1.85 ^{qr}	2.31 ^f	5.79 ^t	0.962 ^{bc}	51.27 ^l	19.41 ^c	38.31 ^{cd}	0.23 ^v
5XC	6	54.50 ^r	33.04 ^{cd}	12.52 ^{jk}	2.51 ^k	2.68 ^{de}	6.26 ^{fg}	0.902 ^f	57.42 ^e	9.78 ^t	29.40 ^{pq}	0.48 ^j
6xR	6	69.76 ^{ij}	15.44 ⁿ	4.72 ^p	1.94 ^p	2.34 ^f	5.81 st	0.964 ^{bc}	49.83 ^{no}	17.19 ^f	36.57 ^e	0.23 ^v
6xC	6	51.72 ^s	26.90 ^s	17.68 ^{de}	3.52 ^d	2.50 ^{ef}	6.05 ^j	0.866 ⁱ	53.99 ^{hi}	11.84 ⁿ	30.20 ^{no}	0.32 ^s
7xR	6	68.71 ^k	13.50 ^{opq}	3.15 ^q	2.08 ^{no}	1.10 ^{op}	5.84 ^{qr}	0.962 ^{bc}	51.54 ^l	17.38 ^f	35.84 ^f	0.28 ^u
7xC	6	42.08 ^y	32.35 ^d	24.79 ^a	2.32 ^f	1.64 ^{kl}	6.15 ^{ij}	0.908 ^f	53.33 ^{ij}	10.58 ^p	24.48 ^v	0.97 ^b
8xR	6	68.63 ^k	12.80 ^{pqr}	6.34 ^o	1.97 ^p	1.70 ^{kl}	5.86 ^q	0.956 ^{cd}	49.12 ^o	20.62 ^b	41.63 ^a	0.28 ^u
8xC	6	57.33 ^o	21.07 ⁱ	14.65 ^h	3.06 ^g	1.96 ^{shi}	6.37 ^d	0.924 ^e	55.06 ^{fg}	14.90 ⁱ	30.59 ^{klmno}	0.44 ^{mn}
9xR	6	72.31 ^{cd}	10.91 st	9.61 ^m	2.14 ^{mn}	2.74 ^d	6.00 ^{no}	0.968 ^{bc}	50.84 ^{lm}	18.69 ^e	37.83 ^d	0.23 ^v
9xC	6	57.51 ^o	20.84 ^{ij}	17.21 ^e	3.94 ^c	3.84 ^a	7.92 ^a	0.886 ^g	55.10 ^{fg}	15.42 ^h	32.24 ⁱ	0.43 ^{no}
10xR	6	71.36 ^{ef}	9.73 ^t	4.66 ^p	2.81 ^h	1.20 ^{no}	6.70 ^{bc}	0.971 ^b	46.62 ^q	21.53 ^a	40.81 ^b	0.28 ^u
10xC	6	47.40 ^x	32.47 ^d	19.02 ^c	4.21 ^b	2.51 ^{ef}	6.25 ^g	0.982 ^a	61.47 ^{bc}	6.60 ^t	30.47 ^{mno}	0.64 ^f
11xR	6	72.42 ^c	20.11 ^{ijk}	3.01 ^q	1.46 ^u	0.97 ^p	5.71 ^u	0.960 ^{bc}	53.39 ^{ij}	13.57 ^l	29.98 ^{op}	0.16 ^x
11xC	6	55.37 ^q	35.83 ^b	8.83 ^m	2.05 ^o	1.67 ^{kl}	6.10 ^k	0.975 ^b	66.46 ^a	7.45 ^v	26.15 ^t	0.61 ^h
12xR	6	70.15 ^{ij}	11.22 st	7.62 ⁿ	2.02 ^q	2.11 ^g	5.81 st	0.960 ^{bc}	48.22 ^p	20.39 ^b	40.90 ^b	0.27 ^u
12xC	6	49.19 ^v	28.39 ^{ef}	16.90 ^e	2.58 ^l	2.50 ^{ef}	6.20 ^h	0.946 ^d	54.76 ^{gh}	12.22 ⁿ	27.38 ^s	0.48 ^j
13xR	6	71.05 ^{fg}	18.94 ^{klm}	1.65 st	1.90 ^{pq}	1.76 ^{ijk}	5.81 st	0.974 ^b	54.00 ^{hi}	15.43 ^h	31.10 ^{kl}	0.38 ^q
13xC	6	54.11 ^r	31.62 ^d	13.34 ^{ij}	2.58 ^l	3.06 ^c	5.92 ^p	0.955 ^{cd}	59.17 ^d	17.49 ^f	31.22 ^k	0.45 ^m
14xR	6	70.14 ^{ij}	10.81 st	6.23 ^o	2.01 ^o	1.91 ^{ghi}	6.28 ^f	0.965 ^{cd}	51.08 ^k	18.81 ^{de}	37.89 ^d	0.34 ^{rs}
14xC	6	51.57 ^s	26.20 ^{gh}	17.44 ^{de}	4.47 ^a	3.31 ^b	7.32 ^b	0.953 ^{cd}	54.77 ^{gh}	16.66 ^g	32.14 ⁱ	0.36 ^t
15xR	6	69.69 ^{ij}	11.58 ^{rs}	3.23 ^q	1.89 ^{pq}	1.99 ^{ghij}	6.28 ^f	0.969 ^{bc}	50.16 ^{mn}	20.63 ^b	41.13 ^{ab}	0.27 ^u
15xC	6	50.96 ^t	34.06 ^c	15.65 ^{fg}	2.05 ^o	2.03 ^{sh}	5.84 ^{qr}	0.958 ^{cd}	60.82 ^c	11.12 ^o	28.60 ^r	0.53 ^k
16xR	6	71.83 ^{de}	18.65 ^{klm}	1.78 st	1.60 ^t	1.20 ^{no}	6.14 ^j	0.974 ^b	52.40 ^k	14.62 ^{ij}	32.36 ^{hi}	0.22 ^w
16xC	6	47.73 ^x	28.78 ^{ef}	21.28 ^b	2.76 ^{hi}	2.03 ^{sh}	5.72 ^u	0.947 ^d	49.64 ^{no}	19.08 ^{cd}	31.08 ^{klm}	0.67 ^e
17xR	6	71.39 ^{ef}	14.14 ^{nop}	1.97 ^{rs}	2.04 ^q	2.10 ^g	6.09 ^k	0.968 ^{bc}	55.79 ^f	11.93 ⁿ	28.70 ^r	0.20 ^w
17xC	6	61.31 ^m	18.33 ^{lm}	11.40 ^j	3.09 ^g	2.38 ^f	6.02 ^{mn}	0.962 ^{bc}	51.39 ^l	14.49 ^{jk}	28.91 ^{qr}	0.41 ^p
18xR	6	72.94 ^b	14.06 ^{nop}	2.84 ^q	1.80 ^{rs}	1.77 ^{ijk}	6.05 ^l	0.963 ^{bc}	54.18 ^h	14.69 ^{ij}	30.94 ^{klm}	0.22 ^w
18xC	6	49.26 ^u	29.51 ^e	18.06 ^d	3.22 ^f	2.61 ^{de}	5.83 ^{rs}	0.943 ^d	61.95 ^b	9.21 ^r	25.39 ^u	0.95 ^c
19xR	6	72.36 ^c	14.85 ^{no}	2.84 ^q	1.80 ^{rs}	1.77 ^{ijk}	6.05 ^l	0.963 ^{bc}	54.18 ^h	14.69 ^{ij}	30.79 ^{klmn}	0.22 ^w
19xC	6	48.31 ^w	27.51 ^{fg}	19.67 ^c	3.40 ^e	2.69 ^{de}	5.66 ^v	0.947 ^d	52.97 ^k	14.14 ^k	31.15 ^k	0.37 ^{qr}
20xR	6	70.85 ^{gh}	7.95 ^u	6.00 ^p	2.13 ^{mn}	1.53 ^{lm}	6.38 ^d	0.968 ^{bc}	48.00 ^p	20.72 ^b	40.65 ^b	0.38 ^q
20xC	6	59.49 ⁿ	20.18 ^{ijk}	12.50 ^{jk}	2.71 ⁱ	2.74 ^d	6.03 ^{lm}	0.964 ^{bc}	49.65 ^{no}	12.81 ^m	25.86 ^{tu}	0.55 ^j

a-y : Means marked with different letters in the same column are statistically different ($p < 0.01$). aw: Water Activity; L: Brightness/Darkness; a*: Redness/Greenness; b*: Yellowness/Blueness; TBA: Thiobarbituric acid number (mg malonaldehyde/kg); R: Raw chicken döner kebabs; C: Cooked chicken döner kebabs.

The a^* values of chicken döner kebabs were found to be 17.26 in raw samples and 12.36 in cooked. This is thought to be due to the leakage loss, water removal and denaturation of proteins caused by the heat treatment applied to the products (Haskaraca and Kolsarıcı 2013). The b^* values of cooked and raw chicken döner kebabs were determined as 29.34 and 35.52, respectively (Table 2). It is related to the removal of water and darkening of the colour during the heat treatment applied to the product. Furthermore, a shift in the color values of the products was observed, attributable to variations in the temperature of the heat treatment applied to the chicken döner kebabs. However, the type of meat, seasonal variations, and different marinating techniques applied to the meat have also affected the general chemical composition, physicochemical, and microbiological properties of chicken kebabs.

As a result of some studies, it has been reported that the heat treatment applied to meat-meat products is highly effective on general nutrient composition, textural parameters, physicochemical properties such as

water holding capacity, colour, pH and sensory qualities (Sosa-Morales et al. 2006, Shirsat et al. 2004, Silva et al. 2015). The degree of denaturation of the globular part of the myoglobin pigment, which gives the colour to the meat, due to the heat treatment applied determines the stability of the brown colour in cooked meat products. In addition, the heat treatment increases the pH of the meat and the myoglobin pigment can be better preserved, resulting in a more reddish colour. As the central temperature of the meat increases with the effect of heat treatment, L^* value increases, while a^* and b^* decrease (Wiley 2010). As a matter of fact, the results obtained in our study are similar to these explanations (Table 2).

The TBA amounts of raw and cooked döner kebabs were determined as 0.30 and 0.57 mg malonaldehyde/kg, respectively (Table 2). This may be associated with the realisation of oxidation in heat-treated samples, albeit at a limited level. In our study, the average TBA number of raw döner kebabs was found to be lower than cooked, which can be explained by the acceleration of oxidative reactions occurring in fats due to the heat treatment applied to the döner kebab and the increase in oxidation products (Wiley 2010). As a matter of fact, although TBA number is accepted as an indicator of oxidative reactions in meat products, it has been reported that this value should not exceed "1.0 mg malonaldehyde" in fresh meat products (Ergönül 2004).

4. Conclusion

In order to ascertain the microbial load present within the final product, it is imperative to consider the type and quantity of meat and other ingredients utilized in the production of döner kebab, as well as the microbial load inherent in the unprocessed product. In the context of Türkiye, there is some studies that hygienic conditions remain substandard in slaughterhouses, processing plants, warehouses, and sales outlets (Sağun et al. 1996, Altun and Atasever 2018). Consequently, chicken meat has been found to contain a significant number of indicator and pathogenic microorganisms. The cold chain must be well maintained at every stage, from poultry slaughterhouses to the units offered for sale, and slaughtering, storage, transportation, and sales in unsuitable environments must be strictly prevented.

Apart from the raw material, inadequate heat treatment also causes the microbiological load in the döner kebabs served to be high. It is frequently seen that döner kebabs are cut and served without being cooked well, especially during peak meal service hours. The number of microorganisms in the air in the production and service environment, the personal hygiene of the service and the cleanliness of the primary service materials are among the other factors that affect the number of microorganisms. The aforementioned factors elucidate the substantial variability observed in the microbial count outcomes.

Döner kebab is undoubtedly the most common fast-food in Türkiye and it is known that more than 500 tons of döner kebab is produced daily (Özsaraç et al. 2019). However, scientific research on döner kebab, which is becoming more and more popular in Türkiye, has shown that food safety and hygiene have not improved at the same rate, that satisfactory results have not been obtained in microbiological analysis results over the years, and that this situation needs to be improved.

In the production of döner kebab, it is very important to take the necessary hygiene and sanitation measures and to implement Food Safety Management Systems such as ISO 9001 Quality Management System and ISO 22000. Ready-to-eat döner kebabs that are not prepared, stored and sold under appropriate conditions and methods are likely to carry risks in terms of many pathogens. High microorganism load in raw materials or pathogen harboring, inadequate heat treatment, contaminated additives (food additives, spices, etc.), storage under unsuitable conditions, inadequate facility hygiene, untrained personnel and many other factors can be listed among the reasons for this situation.

Based on many years of research, it is clear that there is a need for improvement in the production, cooking and service of doner kebab as a high-risk food group that is consumed extensively in Turkey. It is important that governmental institutions carry out more effective food hygiene and business hygiene controls, and also increase the frequency of market inspections by taking samples and sending them to public laboratories and,

if necessary, imposing legal sanctions and putting an end to the sale of doner kebabs in the market, which are risky in terms of food safety and public health.

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