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Research Article

Prevalence and Antibiotic Resistance of Salmonella sp., E. coli O157, and L. monocytogenes in Meat and Dairy Products

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ABSTRACT

Bacteria-related food poisoning is the most prevalent cause of food borne diseases, reaching up to 33 percent of the incidents. The study aimed to provide data for the risk assessment processes focusing on poisoning due to the consumption of foods of animal origin. Bovine meat, chicken meat, white cheese, and kosher samples were collected from five different stores in Tekirdağ, Turkey, monthly for twelve consecutive months, from January 1 to December 31, 2019. Ten samples of bovine meat, ten samples of chicken meat, ten samples of white cheese, ten samples of kosher cheese, weighing 300 grams each, were collected at each monthly visit. The total number of samples collected for the study was 480. Results showed that 4,16% of the samples (n=12) were contaminated with *Salmonella* sp. (n=12), *Escherichia coli* O157 (n=4), and *Listeria monocytogenes* (n=6). Antibiotic sensitivity studies revealed that the microorganisms were resistant to 8 different antibiotics. Despite the low number of pathogens isolated, their presences with the high antibiotic resistance rates pose a significant threat to public health.
Keywords: Antibiotic resistance, E. coli O157, L. monocytogenes, Salmonella sp.

Et ve Süt Ürünlerinde Salmonella sp., E. coli O157 ve L. monocytogenes'in Prevalansı ve Antibiyotik Direnci

ÖZET

Dünya çapında önemli sorunlardan biri gıda zehirlenmeleridir. Çalışmalar gıda zehirlenmelerinin yaklaşık %33'ünün bakterilerden kaynaklandığını göstermiştir. AB Fasıl 12 kapsamındaki risk değerlendirme konusunda kaynaklık edebilecek veri hazırlamak amacıyla Tekirdağ ilindeki hayvansal ürünlerden *Salmonella* sp., *E. coli* O157, *L. monocytogenes* izolasyonu ve suşların antibiyotik duyarlılıklarının tespiti yapılmıştır. Bu amaçla materyal olarak 2019 yılı içerisinde her ay 10'ar adet ve her biri 300'er gram sığır eti, tavuk eti, beyaz peynir ve kaşar peyniri örnekleri Tekirdağ ilindeki marketlerden alınmıştır. Çalışmada toplam 480 numune üzerinde çalışılmıştır.Yapılan analizler neticesinde 12 adet *Salmonella* sp., 4 adet *E. coli* O157, 6 adet *L. monocytogenes* izole edilmiştir. Çalışmanın ikinci aşamasında izole edilen bakterilerin 8 farklı antibiyotiğe direnç gösterdiği tespit edilmiştir.Çalışma sonucunda Tekirdağ ili için izole edilen bakterilerin sayısal olarak düşük olması sevindirici olarak değerlendirilse de, yüksek antibiyotik dirençliliği halk sağlığını tehdit etmesi bakımından önemli bir sonuç olarak karşımıza çıkmaktadır.
Anahtar Kelimeler: Antibiyotik dirençliliği, E. coli O157, L. monocytogenes, Salmonella sp.

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Introduction

Food poisoning is a significant problem in all countries. The general definition is the ill condition developed by consuming food or water contaminated with pathogenic microorganisms. The reports show that bacteria-related food poisoning is the most prevalent cause of foodborne illnesses, reaching up to 33 percent of the incidents (Çakıcı et al., 2015).

The increase in the food variety and distribution accelerates food poisoning incidence . The *Salmonella* sp., *Escherichia coli* O157, and *Listeria monocytogenes* are the leading causes of food poisoning (Dorman et al., 2010).

Salmonella is a genus of rod-shaped Gram-negative bacteria belonging to the family *Enterobacteriaceae. Salmonella* species are intracellular pathogens and can invade different cell types, including epithelial cells, M cells, macrophages, and dendritic cells (Jantsch et al., 2011). The microorganism has an optimum growth temperature of 37 ºC with a vast range between 7 and 48 ºC and resistance to destruction by freezing (Sorrells et al., 1970). The optimum pH for the growth of *Salmonella* is between 6.5 and 7.5, ranging between 4.5 and 9.0 (Keerthirathne et al., 2016). The species might cause severe infections with severities varying from mild to fatal. Food consumption contaminated with *Salmonella* sp. develops different poisoning conditions, including a mild course or a severe form (Yildirim et al., 2016).

Salmonella species can be found in the digestive tracts of animals. Food or water, previously contacted with the faeces of infected animals, becomes a significant source for transmission of the microorganism if consumed by humans (Goldrick, 2003).

Dairy products and inadequately heat-treated derivatives are the risk-bearing food products for *Salmonella* poisoning (Akkaya & Alişarlı, 2006). The reports indicate that *Salmonella* causes an economic burden of 3.4 billion USD and a billion USD for the USA and Canada, respectively (Yildirim et al., 2016).

Escherichia coli (E. coli) is a Gram-negative, facultative anaerobic, nonspore forming, rod-shaped bacteria belonging to the *Enterobacteriaceae* family. The *E. coli* responsible for gastrointestinal diseases are called DEC, meaning diarrheagenic. Intestinal pathotypes are enterotoxigenic *E.coli* (ETEC), enteropathogenic *E.coli* (EPEC), Vero-toxin or Shiga-toxin producing *E.coli* (VTEC-STEC), enterohemorrhagic *E.coli* (EHEC), enteroaggregative *E.coli* (EAEC), enteroinvasive *E.coli* (EIEC), diffuse adherent *E.coli* (DAEC) (OmerovİC et al., 2017).

Among over a hundred serotypes, *E. coli* O157 of the EHEC group is the most prevalent serotype causing food poisoning. Bovine and sheep are the main reservoirs. *E. coli* O157 causes hemorrhagic colitis (HC), hemolytic uremic syndrome (HUS) and thrombotic thrombocytopenic purpura (TP) in humans. Besides, due to the resemblance to the toxin of Shigella dysentery type I, the verotoxin produced by the microorganism is called Shiga like toxin (SLT) increases its significance (Temelli, 2002).

The primary source of *E. coli* O157 is the gastrointestinal tract of the bovine and sheep. The organism's isolation rate in the faeces of the bovine and sheep might rise to 10%. *E. coli* O157 infections are caused by consuming water or food contaminated with faeces (Akkaya et al., 2007).

Listeria monocytogenes (*L. monocytogenes*) is a pathogenic, Gram-positive, rod-shaped, motile between 18-26 oC, nonspore forming, non-capsulated, intracellular bacteria (Berktaş et al., 2006). There are 13 serotypes of *L. monocytogenes* able to develop the disease. However, more than 90% of human isolates belong to serotypes 1/2a, 1/2b, and 4b. The serotype 4b strains are responsible for 33 to 35% of sporadic human cases (Ward et al., 2004). The microorganism can be isolated from humans, domestic animals, raw agricultural and fishery products (Lakicevic et al., 2015). The organism can be found in the animal's flesh, blood, and milk, regardless of the listeriosis symptoms. The infection might occur with raw and undercooked food, including cross-contamination following cooking procedures. Vegetables contaminated with sewage or soil fertilized with animal manure are other transmission sources with *L. monocytogenes* (Ekİcİ et al., 2018).

The resistance to antibiotics has become a global public health concern. Besides the acceleration in the resistance to commonly used broad-spectrum antibiotics, the reports show that new drugs have been quickly followed by the emergence of resistant strains (Hoge et al., 1998). In addition to developing resistant pathogenic bacteria, the administration of an antibiotic alters the gut microbiota and creates antibiotic-resistant intestinal bacteria that enable genetic transfer to the pathogenic bacteria and facilitate multi-drug resistance. Seemingly paradoxically, the broad and intensive use of antibiotics creates a bigger drug-resistant world in which the antimicrobials are less useful (Atabey, 2011).

Aiming to provide data for the risk assessment processes on poisoning due to the consumption of foods of animal origin, the study analyzed *Salmonella* sp., *E. coli* O157, and *L. monocytogenes* by isolation of the organisms from the meat and dairy products sold in Tekirdağ, Turkey and the analysis for antibiotic resistance.

Material and Methods

The study included samples collected from five different stores in Tekirdağ, Turkey, monthly for twelve consecutive months, from January 1 to December 31, 2019.

Ten samples of bovine meat, ten samples of chicken meat, ten samples of white cheese, ten samples of kosher cheese, weighing 300 grams each, were collected at each monthly visit. The total number of samples collected for the study was 480.

Bovine, chicken, white cheese and kosher cheese samples were taken in original packages and carried to the laboratory in cold-chain (4 ºC) containers.

Salmonella sp. isolation and identification were performed according to the ISO 6579-1 standard. *E. coli* O157 isolation and identification was performed according to the ISO 16654:2001 standards. *L. monocytogenes* isolation and identification was performed according to the ISO 11290-1 standard.

The isolated pathogens were cross-checked, and verification was confirmed by the VIDAS method. VIDAS verification was performed according to the ISO 16140-1:2016 standards. An automated, multi parametric immunoassay system which uses ELFA (Enzyme-Linked Fluorescent Assay) Phage and Immuno concentration technology, VIDAS® Salmonella (SLM) Immunoassay Method with Rappaport-Vassiliadis (RV) Medium, VIDAS Listeria monocytogenes II (LMO2), and VIDAS® E. coli O157 (ECO) and O157:H7 Plate Method were used for qualitative analysis.

Antibiotic sensitivity test

The antibiotic resistance of the pathogens obtained within the scope of the EUCAST 2018 standard was examined using the disk diffusion technique. Samples yielding positive results were incubated in Mueller-Hinton agar at 37 ºC for 24 hours. The

Table 1. Samples with positive results by months

	Salmonella sp.				*E. coli* O157				*L. monocytogenes*			
	Bovine	**Chicken**	**White cheese**	**Kosher cheese**	**Bovine**	**Chicken**	**White cheese**	**Kosher cheese**	**Bovine**	**Chicken**	**White cheese**	**Kosher cheese**
January		1										
February											1	
March	1											
April	1				1							
May		2							1		1	
June	1				1							
July		1										
August		1			1							
September		2			1						1	1
October												
November		1							1			
December		1										

bacterial inoculum was adjusted with SSF to the Mac Farland Nº 0,5 turbidity standard. Every inoculum was spread over plates containing Mueller-Hinton agar and a paper filter disc (6 mm). The inhibitory zone diameter of the discs were measured in mm scale. The diagnostic discs used in antibiogram tests were Ampicillin (AMP 25 µg), Ciprofloxacin (CIP 10 µg), Nalidixic acid (NA 30 µg), Streptomycin (S 25 µg), Gentamicin (CN 30µg), Sulphafurazole (SF 300 µg), Trimethoprim (W 5µg), Chloramphenicol (C 30µg), Tetracycline (TE 30µg), Colistin (CT 25µg), Cefotaxime (CTX 30µg), Ceftazidime (CAZ 30µg), Cefoxitin (FOX 30µg), Cefepime (FEP 30µg), Meropenem (MEM 10µg).

Results

Among the 480 samples, 22 (4.6%) was contaminated with the study microorganisms. *Salmonella* sp. was found in 12 (2.5%), *E. coli* O 157 was found in 4 (0.83%), and *L. monocytogenes* was found in 6 (1.25%) of the samples. In Table 1, the samples with positive results by months were presented.

Salmonella sp. was isolated from 3 (2.5%) bovine samples and 9 (7.5%) chicken samples. There were no white cheese and kosher cheese samples with positive results for *Salmonella* sp. The identification of *Salmonella* species isolated from the bovine samples showed that two samples included *S.* Typhimurium, and one specimen had *S. Bongori*. In chicken samples, *S.* Enteriditis and *S.* Typhimurium were identified in four and three samples, respectively. *S. Infantis* and *S. Dublin* were identified in one specimen for each.

E. coli O 157 was found in four (3.33%) of the bovine specimen and was not isolated from the chicken meat, white and kosher cheese samples.

L. monocytogenes was isolated from two (1.66%) bovine, three (2.5%) white cheese and one (0.83%) kosher cheese samples. There were no chicken samples positive for *L. monocytogenes*.

The isolated pathogens were cross-checked, and 100% verification was confirmed by the VIDAS method.

The antibiotic resistance study showed that the *S. Enteritidis* and *L. monocytogenes* strains had the maximum variety of antibiotic resistance with 11 different antimicrobials. *S. Typhimurium* was found resistant to 8 different antibiotics. *S. Infantis* and *S. Dublin* strains showed resistance to 5 different antibiotics each. *E. coli* O157 strains showed resistance to 10 and *L. monocytogenes* to 11 different antimicrobials. From the antibiotic resistance point of view, Streptomycin was the only antimicrobial to which all strains were found resistant. *S. Enteritidis* was the only microorganism that presented antibiotic resistance to gentamycin, ceftazidime and cefepime. Presenting the least number of antimicrobial resistance, *S. Dublin* was the only microorganism resistant to cefotaxime. *E. coli* O157 strains presented resistanceto colistin, and *L. monocytogenes* was the only isolate detected to be resistant to chloramphenicol. In Table 2, the samples with strains showing antibiotic resistance were presented.

Discussion

In our study, *Salmonella* sp. were isolated from 3 (2.5%) bovine samples. The reports conducted in Turkey show that the *Salmonella* sp. isolation rate found in the study were similar to the rates in others ranging between 2.5 and 6%. Büyükünal et al., (2015), Kahraman T & Aydın, (2009), and Yildirim et al., (2016) included an approximately similar number of samples and isolated *Salmonella* spp. from the bovine samples with rates of 1%, 2.5% and 6%. The studies from other countries presented similar rates with bovine specimen numbers ranging from 200 to 72292 samples, between 1.5% to 5% (Madden et al., 2001),(Zarei et al., 2013). It was worth noting that the isolation rates inclined as the sample size increased in the researches.

Salmonella sp. were isolated from 9 (7.5%) chicken samples. Studies conducted in Turkey with approximate sample sizes indicate comparable results. Tanoğlu & Gümüşsoy, (2008), Kahraman & Aydın, (2009) and Acaröz et al., (2018) reported similar isolation with 9.7%, %3, and %2.9, respectively. The researches from other countries with similar sample sizes present parallel to our results. One high rate was reported from South Africa, indicating that 19% of the samples were contaminated with *Salmonella* (van Nierop et al., 2005).

In white and kosher cheese samples, *Salmonella* sp. was not detected. There were studies conducted in Turkey reporting the same results Turantaş et al., (1989), Gülmez & Güven, (2001). However, Kahraman et al., (2010) and Akkaya & Alişarlı, (2006), have presented similar rates of *Salmonella* presence in cheese samples with 1.9 and 2%.

In our study, *E. coli* O157 was detected only in 4 (3.33%) bovine samples. The researches of Bingöl et al., (2013), Fantelli, (2001) and Büyükünal et al., (2015) reported that no *E. coli* O157 was found in bovine samples. However, Ahmed & Shimamoto,

Table 2. The number and percentages of samples with strains showing antibiotic resistance

	S. Enteritidis		*S.* Typhimurium		*S.* Bongori		*S.* Infantis		*S.*Dublin		*Total Salmonella* sp.		*E. coli* O157		*L. monocytogenes*	
	n	*4*	*n*	*5*	*n*	*1*	*n*	*1*	*n*	*1*	*n*	*12*	*n*	*4*	*n*	*6*
		%		*%*		*%*		*%*		*%*		*%*		*%*		*%*
Ampicillin	4	100,00%	3	60,00%	1	100,00%	0	0,00%	1	100,00%	9	75,00%	4	100,00%	6	100,00%
Ciprofloxacin	1	25,00%	1	20,00%	0	0,00%	1	100,00%	1	100,00%	3	25,00%	3	75,00%	6	100,00%
Nalidixic Acid	2	50,00%	1	20,00%	0	0,00%	0	0,00%	1	100,00%	4	33,33%	2	50,00%	6	100,00%
Streptomycin	3	75,00%	2	40,00%	1	100,00%	1	100,00%	1	100,00%	7	58,33%	3	75,00%	6	100,00%
Gentamycin	2	50,00%	0	0,00%	0	0,00%	0	0,00%	0	0,00%	2	16,67%	0	0,00%	0	0,00%
Sulphamethoxazole	4	100,00%	3	60,00%	1	100,00%	1	100,00%	0	0,00%	8	66,67%	3	75,00%	5	83,33%
Trimethoprim	4	100,00%	3	60,00%	1	100,00%	1	100,00%	0	0,00%	8	66,67%	4	100,00%	4	66,67%
Chloramphenicol	0	0,00%	0	0,00%	0	0,00%	0	0,00%	0	0,00%	0	0,00%	0	0,00%	4	66,67%
Tetracycline	0	0,00%	0	0,00%	1	100,00%	0	0,00%	0	0,00%	1	8,33%	3	75,00%	6	100,00%
Colistin	0	0,00%	0	0,00%	0	0,00%	0	0,00%	0	0,00%	0	0,00%	1	25,00%	1	16,67%
Cefotaxime	0	0,00%	0	0,00%	0	0,00%	0	0,00%	1	100,00%	1	8,33%	0	0,00%	0	0,00%
Ceftazidime	1	25,00%	0	0,00%	0	0,00%	0	0,00%	0	0,00%	1	8,33%	0	0,00%	0	0,00%
Cefoxitin	2	50,00%	1	20,00%	0	0,00%	1	100,00%	0	0,00%	3	25,00%	1	25,00%	6	100,00%
Cefepime	1	25,00%	0	0,00%	0	0,00%	0	0,00%	0	0,00%	1	8,33%	0	0,00%	0	0,00%
Meropenem	2	50,00%	1	20,00%	0	0,00%	0	0,00%	0	0,00%	3	25,00%	4	100,00%	2	33,33%

(2014) and Zarei et al., (2013) have reported similar isolation rates to our study with 2.6 and 2.8%, respectively.

There were no chicken and cheese samples contaminated with *E. coli* O157 among the collected samples. In a similar study, Manguiat & Fang (2013) and Jo et al., (2004) have reported that cheese samples were uncontaminated with *E. coli* O157. Also, Arslan & Özdemir, (2008) and Gonzalez et al., (2000) reported the same negative contamination results for chicken samples.

There were only two (1.66%) bovine samples contaminated with *L. monocytogenes*. Similar results have been reported from studies conducted in Turkey and other countries Büyükünal et al., (2015), Kahraman T & Aydın, (2009), Iannetti et al., (2016). A study conducted by Vitas & Garcia-Jalon, (2004) reported that 34.9% of the meat samples were contaminated with *L. monocytogenes*.

The chicken samples in our study were not contaminated with *L. monocytogenes*. Similar results were reported in studies of Yerlikaya (2015), Sağlam (2011). Vitas & Garcia-Jalon, (2004) isolated *L. monocytogenes* from 36.1% of the chicken samples, reporting a very high number similar to the result with bovine samples. However, Mena (2004) have reported that 60% of the chicken samples were contaminated with *L. monocytogenes*, expressing an extreme rate.

Among the cheese samples, *L. monocytogenes* was isolated from three (2.5%) white and one (0.83%) kosher cheese. The researches conducted by Aygun & Pehlivanlar (2006), and Çiftçioğlu & Uğur (1991), analyzing white cheese, indicate comparable findings with 2.85% and 2.9%. In the study of Ekİcİ et al. (2018), 3% and Kahraman et al. (2010) 1.7% of the kosher cheese samples were contaminated with *L. monocytogenes*, similar to our findings.

There might be various reasons for explaining the different isolation rates in the studies. There could be too many probable contamination points to consider, beginning from feeding the animals to the cleaning and disinfection procedures of the packaging and the shelves the products were kept. Also, sampling methods should be considered. Therefore the isolation results might be evaluated regionally or even locally to reach reliable interpretations.

The findings of the antibiotic resistance of the strains showed a variety of results. Streptomycin was the only antimicrobial to which all the microorganisms showed resistance.

A study conducted by Şahan et al. (2016) showed that among *S. Infantis* isolates, resistance to nalidixic acid, sulfonamides, tetracycline, and trimethoprim rates were 92.7%, 92.3%, 88.3%, and 78.6%, respectively. The resistance rates in *S.Typhimurium* isolates for sulfonamides, ampicillin, and trimethoprim were 65%, 47%, and 35%, respectively. The nalidixic acid and sulfonamide resistance in the *S.Enteriditis* strains were 75% and 92%, respectively. The research by Bozkurt (2018) showed that all of the *Salmonella* sp. were resistant to penicillin and 66% to ampicillin and erythromycin. Similar high rates for *Salmonella* sp. were reported in a study by Yang et al. (2020) with 72.3% to nalidixic acid, 55.3% to ampicillin and 48.7% to streptomycin.

The antibiotic resistance analysis of *E. coli* conducted by Dursun (2008) showed that the resistance rates for cefalotin, chloramphenicol, sulphametaxosole-trimethoprim, erythromycin, and amoxicillin-clavulanic acid were 100%, 87.5%, 81.25%, 81.25%, and 62.5%, respectively. Various studies highlighted *E. coli* O157 showing resistance to streptomycin, cefalotin, tetracyclines, amikacin, cefotaxime, erythromycin, chloramphenicol, nalidixic acid, neomycin, ofloxacin (Çadırcı et al., 2017; Elafify et al., 2020).

Alonso-Hernando et al. (2012) have reported an increase in the rate of one or more antibiotic-resistant *L. monocytogenes* isolates from 37.2 % to 96% in 13 years. Interestingly, in both studies conducted in 1993 and 2006, the nalidixic acid resistance rate was 100%. In the study, the multi-drug resistance among *L.*

monocytogenes isolates was reported to increase from 18.6% to 84% in the time frame. Regarding resistance to enrofloxacin and ciprofloxacin, the rates were increased from 23.3% and 25.6% to 68% and 52%. Alonso-Hernando et al. (2012) indicate that in addition to the number of antibiotics *L. monocytogenes* isolates were resistant to, the percentage of the strains with resistance also increased. A similar study conducted by Maung et al. (2019) presented a five-year difference in the *L. monocytogenes* strains' resistance to fosfomycin and oxacillin between 2012 and 2017. The resistance to fosfomycin and oxacillin were increased from 57.3% and 72% to 95.7% and 82%, respectively. The multi-drug resistance rate of the *L. monocytogenes* strains rose from 46.7% to 82.62%.

The previous studies show similar results to our findings. In recent years, reports highlight the increase in the strength and variety of antibiotic resistance of the pathogenic bacteria.

The study results for the Tekirdağ region might include low isolate numbers. Nevertheless, the findings indicate a significant risk to public health and should be in consideration. Also, the increased rate and variety in antibiotic resistance results boost the amount at public health risk.

At this point, the careful prescription of antibiotics to animals with performing antibiogram tests, avoiding misuse and repetition of the same molecule, and following gold-standard treatment methods might decelerate antibiotic resistance rates. Moreover, following HACCP processes in the production of aminal foods such as adequate sanitation conditions and sufficient thermal procedures might help eliminate pathogenic bacteria at the source.

Conflict of Interest

The authors declare no conflicts of interest.

References

Acaröz, U., Gurler, Z., Kara, R., Arslan-Acaröz, D., & Zemheri, F. (2018). Afyonkarahisar İlinde Satışa Sunulan Tavuk Eti ve Sakatatlarında Salmonella spp. Varlığının Belirlenmesi. *Kocatepe Veterinary Journal*, 1–5. https://doi.org/10.30607/kvj.444137

Ahmed, A. M., & Shimamoto, T. (2014). Isolation and molecular characterization of Salmonella enterica, Escherichia coli O157:H7 and Shigella spp. From meat and dairy products in Egypt. *International Journal of Food Microbiology*, *168–169*, 57–62. https://doi.org/10.1016/j.ijfoodmicro.2013.10.014

Akkaya, L., & Alişarlı, M. (2006). Afyonkarahisar'da Tüketime Sunulan Peynirlerde Listeria monocytogenes ve Salmonella spp. Varlığının Belirlenmesi. *Yüzüncü Yıl Üniversitesi Veteriner Fakültesi Dergisi*, *17*(1–2), 87–91.

Akkaya, L., Alişarlı, M., Kara, R., & Telli, R. (2007). Afyonkarahisar'da Tüketime Sunulan Çig Süt ve Peynirlerde E. coli O157:H7 Varlığının Belirlenmesi. *YYÜ VET FAK DERG*, *18*(1), 1–5.

Alonso-Hernando, A., Prieto, M., García-Fernández, C., Alonso-Calleja, C., & Capita, R. (2012). Increase over time in the prevalence of multiple antibiotic resistance among isolates of Listeria monocytogenes from poultry in Spain. *Food Control*, *23*(1), 37–41. https://doi.org/10.1016/j.foodcont.2011.06.006

Arslan, S., & Özdemir, F. (2008). Prevalence and antimicrobial resistance of Listeria spp. In homemade white cheese. *Food Control*, *19*, 360–363.

Atabey, C. (2011). *Piyasada Satışa Sunulan Peynirlerden Elde Edilen Jenerik Escherichia coli Ve Staphylococcus Aureus Suşlarının Antibiyotik Dirençliliklerinin Belirlenerek, Mastitis Kontrol Ve Tedavi Programlarında Kullanılan Antibiyotiklerle İlişkisinin Belirlenmesi.* [Yüksek Lisans Tezi]. Adnan Menderes Üniversitesi Sağlık Bilimleri Enstitüsü.

Aygun, O., & Pehlivanlar, S. (2006). Listeria spp. In the raw milk and dairy products in Antakya, Turkey. *Food Control*, *17*(8), 676–679. https://doi.org/10.1016/j.foodcont.2005.09.014

Berktaş, M., Bozkurt, E. N., Bozkurt, H., Alişarlı, M., & Güdücüoğlu, H. (2006). Et ve Et Ürünlerinde Listeria monocytogenes'in İzolasyonu. *Van Tıp Dergisi*, *13*(2), 36–41.

Bingöl, E. B., Dümen, E., Kahraman, T., Akhan, M., Issa, G., & Ergun, O. (2013). Prevalence of Salmonella spp., Listeria monocytogenes and Escherichia coli O157 in meat and meat products consumed in Istanbul. *Medycyna Weterynaryjna-Veterınary Medıcıne-Scıence And Practıce*, *69*(8), 488–491.

Bozkurt, B. (2018). *Bozkurt, B. (2018). Çiğ Ve Yarı-Pişmiş Bazı Et Ürünlerinde Salmonella Spp. Ve Staphylococcus Aureus'un Belirlenmesi Ve Antibiyotik Dirençliliklerinin Araştırılması. Balıkesir Üniversitesi Fen Bilimleri Enstitüsü, Yüksek Lisans Tezi, Balıkesir.* [Yüksek Lisans Tezi]. Balıkesir Üniversitesi Fen Bilimleri Enstitüsü.

Büyükünal, S. K., Şakar, F. Ş., Turhan, İ., ErgİNbaş, Ç., Sandikçi Altunatmaz, S., Yilmaz Aksu, F., Yilmaz Eker, F., & Kahraman, T. (2015). Geleneksel Türk Fermente Et Ürünlerinde (Sucuk ve Pastırma) Salmonella spp., Listeria monocytogenes, Escherichia coli O157 ve Nitrat-Nitrit Varlığı. *Kafkas Universitesi Veteriner Fakultesi Dergisi*. https://doi.org/10.9775/kvfd.2015.14238

Çadırcı, Ö., Gücükoğlu, A., Terzi Güzel, G., Uyanık, T., Abdulahi, A., & Alişarlı, M. (2017). Characterization and Antimicrobial-Resistance Profile of Escherichia coli O157 and O157: H7 Isolated from Modified Atmosphere Packaged Meat Samples. *Turkish Journal of Agriculture - Food Science and Technology*, *5*(10), 1142. https://doi.org/10.24925/turjaf.v5i10.1142-1147.1228

Çakıcı, N., Demirel Zorba, N. N., & Akçalı, A. (2015). Food industry employees and staphylococcal food poisoning. *Turkish Bulletin of Hygiene and Experimental Biology*, *72*(4), 337–350. https://doi.org/10.5505/TurkHijyen.2015.21704

Çiftçioğlu, G., & Uğur, M. (1991). *Ülkemizde tüketilen beyaz peynirlerde Listeriaların varlığı üzeririne bir araştırma.* II. Ulusal Gıda Sempozyumu (Bildiriler), Bursa.

Dorman, V., Aslan, S., Ceylan, A., Küçük, S. N., Günel, A., Sari, H., Yaşli, N., & Yalim, D. (2010). Aynı fabrikadan yemek alan iki inşaat firması işçilerinde meydana gelen toplu besin zehirlenmesi. *Dicle Tıp Dergisi*, *37*(3), 248–253.

Dursun, S. (2008). *Broiler Piliçlerinden Escherichia coli O157:H7 Serotipinin İdentifikasyonu ve Antibiyotik Duyarlılıklarının Belirlenmesi.* [Doktora Tezi]. Adnan Menderes Üniversitesi Sağlık Bilimleri Enstitüsü.

Ekİcİ, G., Dümen, E., Bayrakal, G. M., & ErgİN, S. (2018). Taze Kaşar Peyniri ve Süt Kaymağından İzole Edilen Listeria monocytogenes ve Esherichia coli O157:H7'nin Moleküler Tanımlaması. *Kafkas Universitesi Veteriner Fakultesi Dergisi*. https://doi.org/10.9775/kvfd.2018.20702

Elafify, M., Khalifa, H. O., Al-Ashmawy, M., Elsherbini, M., El Latif, A. A., Okanda, T., Matsumoto, T., Koseki, S., & Abdelkhalek, A. (2020). Prevalence and antimicrobial resistance of Shiga toxin-producing *Escherichia coli* in milk and dairy products in Egypt. *Journal of Environmental Science and Health, Part B*, *55*(3), 265–272. https://doi.org/10.1080/03601234.2019.1686312

Fantelli, K. (2001). Prevalence and characteristics of Shigatoxin-producing Escherichia coli and Listeria monocytogenes strains isolated from minced meat in Switzerland. *International Journal of Food Microbiology*, *70*(1–2), 63–69. https://doi.org/10.1016/S0168-1605(01)00515-3

Goldrick, B. (2003). Foodborne Diseases: More efforts needed to meet the Healthy People 2010 objectives. 103 (3): 105–106. *The American Journal of Nursing.*, *103*(3), 105–106.

Gonzalez, A. G. M., Rosa, A. C. P., Andrade, J. R. C., & Tibana, A. (2000). Enteropathogenicity markers in Escherichia coli strains isolated from soft white cheese and poultry in Rio de Janeiro, Brazil. *Food Microbiology*, *17*, 321–328.

Gülmez, M., & Güven, A. (2001). Beyaz ve çeçil peynirlerinde Campylobacter, Salmonella ve Listeria türlerinin araştırılması. *Kafkas Üniversitesi Veteriner Fakültesi Dergisi*, *7*(2), 155–161.

Hoge, C. W., Gambel, J. M., Srijan, A., Pitarangsi, C., & Echeverria, P. (1998). Trends in Antibiotic Resistance Among Diarrheal Pathogens Isolated in Thailand Over 15 Years. *Clinical Infectious Diseases*, *26*(2), 341–345. https://doi.org/10.1086/516303

Iannetti, L., Acciari, V. A., Antoci, S., Addante, N., Bardasi, L., Bilei, S.,

Calistri, P., Cito, F., Cogoni, P., D'Aurelio, R., Decastelli, L., Iannetti, S., Iannitto, G., Marino, A. M. F., Muliari, R., Neri, D., Perilli, M., Pomilio, F., Prencipe, V. A., … Migliorati, G. (2016). Listeria monocytogenes in ready-to-eat foods in Italy: Prevalence of contamination at retail and characterisation of strains from meat products and cheese. *Food Control*, *68*, 55–61. https://doi.org/10.1016/j.foodcont.2016.03.036

ISO 6579-1 (2017-2) Microbiology of the food chain — Horizontal method for the detection, enumeration and serotyping of *Salmonella.*

ISO 11290-1 (2017-5) Microbiology of the food chain — Horizontal method for the detection and enumeration of *Listeria monocytogenes* and of *Listeria* spp.

ISO 16140-1 (2016) Microbiology of the food chain - Method validation - Part 1: Vocabulary

ISO 16654 (2001-05-01) Microbiology of food and animal feding stuffs — Horizontal method for the detection of *Escherichia coli* O157.

Jantsch, J., Chikkaballi, D., & Hensel, M. (2011). Cellular aspects of immunity to intracellular Salmonella enterica: Cellular microbiology of Salmonella. *Immunological Reviews*, *240*(1), 185–195. https://doi.org/10.1111/j.1600-065X.2010.00981.x

Jo, M.-Y., Kim, J.-H., Lim, J.-H., Kang, M.-Y., Koh, H.-B., Park, Y.-H., Yoon, D.-Y., Chae, J.-S., Eo, S.-K., & Lee, J. H. (2004). Prevalence and characteristics of Escherichia coli O157 from major food animals in Korea. *International Journal of Food Microbiology*, *95*(1), 41–49. https://doi.org/10.1016/j.ijfoodmicro.2004.01.016

Kahraman T, & Aydın, A. (2009). Prevalence of Salmonella spp., Escherichia coli O157:H7 and Listeria monocytogenes in meat and meat products in Turkey Prävalenz von Salmonella spp., Escherichia coli O157:H7 und Listeria monocytogenes in Fleisch und Fleischerzeugnissen in der Türkei. *Archiv Für Lebensmittelhygiene*, *Archiv für Lebensmittelhygiene 60: 1, 6-11 (2009)*, 6–11. https://doi.org/10.2376/0003-925X-60-6

Kahraman, T., Özmen, G., Özinan, B., & Göksoy, E. O. (2010). Prevalence of Salmonella spp. And Listeria monocytogenes in different cheese types produced in Turkey. *BFJ*, *112*(11), 1230–1236.

Keerthirathne, T., Ross, K., Fallowfield, H., & Whiley, H. (2016). A Review of Temperature, pH, and Other Factors that Influence the Survival of Salmonella in Mayonnaise and Other Raw Egg Products. *Pathogens*, *5*(4), 63. https://doi.org/10.3390/pathogens5040063

Lakicevic, B., Nastasijevic, I., & Raseta, M. (2015). Sources of Listeria Monocytogenes Contamination in Retail Establishments. *Procedia Food Science*, *5*, 160–163. https://doi.org/10.1016/j.profoo.2015.09.046

Madden, R. H., Espie, W. E., Moran, L., McBride, J., & Scates, P. (2001). Occurrence of Escherichia coli O157:H7, Listeria monocytogenes, Salmonella and Campylobacter spp. On beef carcasses in Northern Ireland. *Meat Science*, *58*(4), 343–346. https://doi.org/10.1016/S0309-1740(00)00153-4

Manguiat, L. S., & Fang, T. J. (2013). Microbiological quality of chicken- and pork-based street-vended foods from Taichung, Taiwan, and Laguna, Philippines. *Food Microbiology*, *36*(1), 57–62. https://doi.org/10.1016/j.fm.2013.04.005

Maung, A. T., Mohammadi, T. N., Nakashima, S., Liu, P., Masuda, Y., Honjoh, K., & Miyamoto, T. (2019). Antimicrobial resistance profiles of Listeria monocytogenes isolated from chicken meat in Fukuoka, Japan. *International Journal of Food Microbiology*, *304*, 49–57. https://doi.org/10.1016/j.ijfoodmicro.2019.05.016

Mena, C. (2004). Incidence of Listeria monocytogenes in different food products commercialized in Portugal. *Food Microbiology*, *21*(2), 213–216. https://doi.org/10.1016/S0740-0020(03)00057-1

Omerović, M., Müştak, H. K., & Kaya, İ. B. (2017). Escherichia coli Patotiplerinin Virülens Faktörleri. *Etlik Veteriner Mikrobiyoloji Dergisi*, *28*(1), 1–6. https://doi.org/10.35864/evmd.530084

Sağlam, A. (2011). *İstanbul Pazarında Listeria Varlığı Üzerine Bir Araştırma. Yüksek Lisans Tezi. İstanbul.* [Yüksek Lisans Tezi]. İstanbul Üniversitesi Sağlık Bilimleri Enstitüsü.

Şahan, Ö., Aral, E. M., Aden, M. M. A., Aksoy, A., Yılmaz, Ö., Jahed, R., & Akan, M. (2016). Türkiye'deki broyler tavuk işletmelerinden izole edilen Salmonella serovarlarının antimikrobiyel direnç durumu. *Ankara Üniversitesi Veteriner Fakültesi Dergisi*, *63*(1), 1–6. https://doi.org/10.1501/Vetfak_0000002701

Sorrells, K. M., Speck, M. L., & Warren, J. A. (1970). Pathogenicity of Salmonella gallinarum After Metabolic Injury by Freezing 1. *Applied Microbiology*, *19*(1), 39–43. https://doi.org/10.1128/AM.19.1.39-43.1970

Tanoğlu, B. T., & Gümüşsoy, K. S. (2008). Erzincan Garnizonunda Tüketime Sunulan Tavuk Ve Hindi Etlerinden Konvansiyonel Kültür Ve Moleküler (Pzr) Metodla Salmonella Spp.'Nin Teşhisi. *Sağlık Bilimleri Dergisi*, *17*(3), 150–155.

Temelli, S. (2002). Gıda Zehirlenmesine Neden Olan E. coli O157:H7 Ve Önemi. *Uludağ Üniversitesi J.Fac.Vet.Med*, *21*, 133–138.

Turantaş, F., Ünlütürk, A., & Göktan, D. (1989). Microbiological and compositional status of Turkish white cheese. *International Journal of Food Microbiology*, *8*(1), 19–24.

van Nierop, W., Dusé, A. G., Marais, E., Aithma, N., Thothobolo, N., Kassel, M., Stewart, R., Potgieter, A., Fernandes, B., Galpin, J. S., & Bloomfield, S. F. (2005). Contamination of chicken carcasses in Gauteng, South Africa, by Salmonella, Listeria monocytogenes and Campylobacter. *International Journal of Food Microbiology*, *99*(1), 1–6. https://doi.org/10.1016/j.ijfoodmicro.2004.06.009

Vitas, A. I., & Garcia-Jalon, V. A. e I. (2004). Occurrence of Listeria monocytogenes in fresh and processed foods in Navarra (Spain). *International Journal of Food Microbiology*, *90*(3), 349–356. https://doi.org/10.1016/S0168-1605(03)00314-3

Ward, T. J., Gorski, L., Borucki, M. K., Mandrell, R. E., Hutchins, J., & Pupedis, K. (2004). Intraspecific Phylogeny and Lineage Group Identification Based on the prfA Virulence Gene Cluster of Listeria monocytogenes†. *Journal of Bacteriology*, *186*(15), 4994–5002. https://doi.org/10.1128/JB.186.15.4994-5002.2004

Yang, J., Zhang, Z., Zhou, X., Cui, Y., Shi, C., & Shi, X. (2020). Prevalence and Characterization of Antimicrobial Resistance in *Salmonella enterica* Isolates from Retail Foods in Shanghai, China. *Foodborne Pathogens and Disease*, *17*(1), 35–43. https://doi.org/10.1089/fpd.2019.2671

YerliKaya, O. B. (2015). *Kayseri' De Satışa Sunulan Kanatlı Eti Ürünlerinde Listeria Spp. Varlığının Belirlenmesi.* [Yüksek Lisans Tezi]. Erciyes Üniversitesi Sağlık Bilimleri Enstitüsü,.

Yildirim, T., Siriken, B., & Yavuz, C. (2016). Sığır kıyma ve köftelerinde Salmonella spp. Varlığı. *Veteriner Hekimler Derneği Dergisi*, *87*(1), 11–23.

Zarei, M., Basiri, N., Jamnejad, A., & Eskandari, M. H. (2013). Prevalence of Escherichia coli O157:H7, Listeria monocytogenes and Salmonella spp. In Beef, Buffalo and Lamb Using Multiplex PCR. *Jundishapur Journal of Microbiology*, *6*(8). https://doi.org/10.5812/jjm.7244