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Prevalence and Antibiotic Resistance of *Arcobacter* spp. Isolates from Meats, Meat Products, and Giblets

Simten YEŞİLMEN[1], Aydın VURAL[2], Mehmet Emin ERKAN[2], İbrahim Halil YILDIRIM[3], Hüsnü Şahan GÜRAN[2]

[1]Department of Microbiology, Dicle University, Faculty of Veterinary Medicine, Diyarbakır, Turkey
[2]Department of Food Hygiene and Technology, Dicle University, Faculty of Veterinary Medicine, Diyarbakır, Turkey
[3]Department of Genetic, Dicle University, Faculty of Veterinary Medicine, Diyarbakır, Turkey

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ORCID IDs of the authors: S.Y. 0000-0002-2952-5180, A.V. 0000-0002-6232-2131, M.E.E. 0000-0001-5581-3867, I.H.Y. 0000-0001-5518-5004, H.S.G. 0000-0002-6674-5510.

Abstract

In this study, the presence and the species distribution of *Arcobacter* spp. were determined in ground beef, ground lamb, meatballs, chicken meat, and chicken giblet samples (470 samples in total) using the 16S rDNA polymerase chain reaction-restriction fragment length polymorphism method. The presence of *Arcobacter* spp. was found to be 36.38% ($n=171$) in all samples analyzed; 23.3% ($n=63$) in ground beef, ground lamb, and meatball samples; 51.3% ($n=77$) in chicken meat, and 62% (n -= 31) in giblet samples. Chicken wings had the highest *Arcobacter* spp. contamination level (72%), and the lowest contamination was found in ground lamb (20%) samples. A higher prevalence of *Arcobacter* spp. was found in chicken meat and giblets than in other samples, and chicken leg and chicken breast with skin had higher prevalence of *Arcobacter* spp. than those without skin. *A. butzleri* was the most isolated species in all samples. In neck, leg, breast, and wings samples, *A. cryaerophilus* was the second most isolated species. In addition, we assessed antibiotic resistance of the isolates found in this study using 14 different antibiotics. All *A. butzleri* and *A. skirrowii* isolates, as well as most of the *A. cryaerophilus* isolates (96.7%), showed resistance to cefoperazone. *A. butzleri* isolates were mostly susceptible to norfloxacin (61.5%), florphenicol (60.5%), and amoxicillin/clavulanic acid. *A. skirrowii* isolates showed susceptibility to ciprofloxacin (91.6%), norfloxacin (88.8%), and chloramphenicol (83.3%). *A. cryaerophilus* isolates showed susceptibility to chloramphenicol (96.7%), streptomycin (83.8%), cefoperazone (83.8%), and florphenicol (80.6%). We have identified that many food samples examined in this study were contaminated with *Arcobacter* species. *Arcobacter* contamination poses a human health concern and multiple antibiotic resistance in the isolates and this may pose a risk to public health.

Keywords: Antibiotic resistance, *Arcobacter* spp., chicken giblet, chicken meat, red meat

Introduction

Arcobacters are gram-negative, mobile, spiral, S-shaped, slow-growing, and non-spore-forming microorganisms (Vandamme & De Ley, 1991). *Arcobacter* species are foodborne pathogens that can cause disease in humans and animals. The most probable route of transmission of *Arcobacter* spp. to humans is through the consumption of contaminated food and water. The extensive distribution and high prevalence of *Arcobacter* spp. in food are alarming in terms of public health. Recently, Waite et al. (2017) suggested that *Arcobacter* was proposed to constitute a new family of Arcobacteraceae (Waite et al., 2017). The genus *Arcobacter* currently comprises 33 recognized species isolated from different sources (LPSN–List of Prokaryotic names with Standing in Nomenclature). Three species, including *A. butzleri, A. cryaerophilus,* and *A. skirrowii*, have been reported to be a potential hazard to humans (Fera et al., 2008; Shah et al., 2011). *Arcobacters* are causative agents of diarrhea, mastitis, and abortion in animals and lead to bacteremia, endocarditis, peritonitis, gastroenteritis, and diarrhea in humans (Ferreira et al., 2016; Figueras et al., 2014; Jiang et al., 2010; Ramees et al., 2017). *Arcobacter* spp. has also been detected in raw food products such as vegetables, as well as in food products of animal origin, including products on the farm, in the production stages, or in retail. However, there are major differences in the results of studies that have investigated the presence of *Arcobacter* spp. in food. The presence of *Arcobacter* spp. has been reported at levels from 0%–47.6% for vegetables, 6.7%–7.7% for beef, 10%–55.6% for pork, 13.5%–92% for poultry, and 22.8%–68% for seafood (Ferreira et al., 2019). Consumption or processing of raw or undercooked contaminated food of animal origin is the most probable route of transmission. In various studies, the prevalence of *Arcobacter* spp. in chicken meat was found to be higher than in pork and beef. The most frequently isolated species from meat is usually

Corresponding Author: Simten YEŞİLMEN, • **E-mail:** simten@dicle.edu.tr

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A. butzleri, followed by *A. cryaerophilus* and A. skirrowii (Shah et al., 2011). Using classical culture methods and polymerase chain reaction (PCR), Mohan et al. (2014) found that the presence of *Arcobacter* spp. in poultry meat was 10% and 11.67%, whereas, in beef samples, it was 5% and 7.5%. Lehmann et al. (2015) isolated *Arcobacter* spp. at the level of 27% from poultry and 2% from minced meat.

Greater genetic diversity and an increase in antibiotic resistance have been reported among *Arcobacter* isolates recovered from different parts of the world (Bagalakote et al., 2014; Ferreira et al., 2016; Mohan et al. 2014; Rahimi, 2014; Ramees et al., 2017). Consumption of food contaminated with resistant *Arcobacter* species may pose a threat to human health due to reduced treatment options for severe infections and possible transfer of resistance markers to other pathogenic bacteria (Vicente-Martins et al., 2018).

This study aims to determine the prevalence of the *Arcobacter* species in retail ground beef, ground lamb, meatballs, chicken meat, and chicken giblet samples and to screen the susceptibility of the detected isolates to antibiotic to reveal possible public health risks.

Methods

Sampling

A total of 470 samples including ground beef ($n=90$), ground lamb ($n=90$), meatball ($n=90$), chicken neck ($n=25$), chicken leg ($n=25$), skinless chicken leg ($n=25$), chicken breast ($n=25$), skinless chicken breast ($n=25$), chicken wing ($n=25$), chicken liver ($n=25$), and chicken gizzard ($n=25$) were randomly collected from 19 butcher shops and 6 supermarkets in Diyarbakır province, Turkey, from April to May 2018. The chicken samples collected were in original packages and they belonged to different brands, production dates, lot numbers, and sell-by-date. The chilled ground beef, ground lamb, and meatball samples were collected into sterile plastic sampling bags under aseptic conditions. All the samples were transported within 3 hours in cold storage conditions (4°C) to the laboratory at the Department of Food Hygiene and Technology of the University of Dicle (Diyarbakir, Turkey) for *Arcobacter* analysis.

Method of Isolation and Identification

Twenty-five-gram samples were placed in a sterile sampling bag and homogenized for 5 minutes in a stomacher in 225 mL of *Arcobacter* enrichment broth (AEB). *Arcobacter* enrichment broth was prepared by adding cefoperazone–amphotericin–teicoplanin (CAT), a selective supplement to *Arcobacter* enrichment basal medium (Oxoid, CM965). One milliliter of the homogenized sample was added to 9 mL of AEB medium. They were incubated in a microaerophilic medium at 30°C for 2 days (Atabay et al., 2003). After incubation, 0.2 mL of enriched sample was inoculated onto blood agar base medium (Oxoid CM271) with 5% defibrinated sheep blood with the membrane filtration method. Cellulose acetate membrane filters with a diameter of 47 mm and pore size of 0.45 μm were used to remove other enteric bacteria (Shah et al., 2012). These filters were removed 1 hour after culturing and the samples were incubated under microaerophilic conditions for 5–7 days.

Clear, small gray-white and round colonies which were subjected to Gram's staining, growth under aerobic and microaerobic conditions at 30°C, cellular morphology, catalase test, oxidase test, hippurate hydrolysis, and motility (using wet mount method) tests were considered to be suspected *Arcobacter*. Gram-negative, motile, oxidase- and catalase–positive, and hippurate hydrolysis-negative colonies were kept in 20% glycerol at −80°C, and species identification was done using the 16S rDNA polymerase chain reaction-restriction fragment length polymorphism method.

DNA Extraction and PCR

This study was performed by polymerase chain reaction-restriction fragment length polymorphism (PCR-RFLP) method. This study was performed by PCR-RFLP method. DNA extraction from the study samples was carried out by using a commercial kit according to the manufacturer's instructions (PureLink Microbiome DNA PurificationKit, Thermo Scientific, USA). Extracted DNAs were kept at −20°C until they were used.

The primer pairs forward 5'-AAC ACA TGC AAG TCG AAC GA-3' and reverse 5'-GTC GTG AGA TGT TGG GTT AA-3'were used for the PCR amplification of a 1026 bp region of the 16S rDNA gene, as previously described Figueras et al. (2008). Polymerase chain reactions were done in 20 μL volume containing 1X buffer, 1.5 mM $MgCl_2$, 20 pM of primers, and 1 U Taq DNA polymerase (Thermo Scientific). Polymerase chain reactions conditions were: 7 minutes at 94°C and 36 cycles of 30 seconds at 94°C, 30 seconds at 52°C and 90 seconds at 72°C, and a final extension at 72°C for 10 minutes. Polymerase chain reaction products were separated on an agarose gel and 1026 bp bands were considered positive for *Arcobacter* spp. Amplified PCR products were digested with a FastDigest MseI restriction endonuclease at 65°C for 10 minutes. Restricted fragments were separated on 15% polyacrylamide gel electrophoresis in a 1X TBE (Tris/Boric Acid/EDTA) buffer at a constant 20 mA with a 50 bp GeneRuler. Gels were stained with ethidium bromide and were photographed (Figueras et al., 2008, 2012; Yesilmen et al., 2014).

Determination of Antibiotic Resistance

Antibiotic resistance testing of the *Arcobacter* isolates was done by the Kirby–Bauer disc diffusion method, according to the Clinical Laboratory Standard Institute protocol for *Enterobacteriaceae* CLSI, 2012 M100-S20). All isolates were cultured on Muller Hinton agar with 5% defibrinated sheep blood. The antimicrobial agents were tested and their corresponding concentrations were as follows: amoxicillin/clavulanic acid (30 μg), chloramphenicol (30 μg), cefoperazone (30 μg), cefoperazone (75 μg), cephalothin (30 μg), ciprofloxacin (5 μg), gentamicin (10 μg), erythromycin (15 μg), florfenicol (30 μg), nalidixic acid (30 μg), norfloxacin (10 μg), streptomycin (10 μg), tetracycline (30 μg), and vancomycin (5 μg). The antibiotic disc was purchased from Oxoid Ltd (Basingstoke, UK). All isolates were incubated microaerobically at 30°C for 48 hours. The susceptibility of the *Arcobacter* spp. to each antibiotic was measured, and the results were interpreted in accordance with interpretive criteria provided by CLSI. *Staphylococcus aureus* and *Escherichia coli* were used as quality control organisms in antibiotic resistance determination (Shah et al., 2013).

Results

Prevalence of *Arcobacter* spp.

In this study, *Arcobacter* spp. prevalence was investigated in 470 samples, including 270 ground beef, ground lamb, and meatball samples, 150 chicken meat, and 50 chicken giblet samples. The prevalence of *Arcobacter* spp. in the samples examined is shown in Table 1. *Arcobacter* spp. was found in 23.3% (63/270) of ground beef,

Table 1.
The Prevalence of Arcobacter spp. in Ground Beef, Ground Lamb, Meatball, Chicken Meat, and Giblet Samples

	No. of Positive Samples (%)			
Samples	***Arcobacter* spp.**	***A. butzleri***	***A. skirrowii***	***A. cryaerophilus***
Ground beef (*n* =90)	20 (22.2)	10 (50.0)	6 (30.0)	4 (20.0)
Ground lamb (*n* = 90)	18 (20.0)	10 (55.5)	5 (27.7)	3 (16.6)
Meatball (*n* = 90)	25 (27.7)	16 (64.0)	6 (24.0)	3 (12.0)
Chicken neck (*n* = 25)	16 (64.0)	8 (50.0)	3 (18.7)	5 (31.2)
Skinless chicken leg (*n* = 25)	11 (44.0)	7 (63.6)	2 (18.1)	2 (18.1)
Chicken leg (*n* = 25)	16 (64.0)	10 (62.5)	2 (12.5)	4 (25.0)
Skinless chicken breast (*n* = 25)	6 (24.0)	5 (83.3)	1 (16.6)	nd*
Chicken breast (*n* = 25)	10 (40.0)	7 (70.0)	1 (10.0)	2 (20.0)
Chicken wings (*n* = 25)	18 (72.0)	10 (55.5)	3 (16.6)	5 (27.7)
Chicken liver (*n* = 25)	16 (64.0)	11 (68.7)	3 (18.7)	2 (12.5)
Chicken gizzard (*n* = 25)	15 (60.0)	10 (66.6)	4 (26.6)	1 (6.6)
Total (*n* = 470)	171 (36.3)	104 (60.8)	36 (21.0)	31 (18.1)

Note: nd = not detected.

ground lamb, and meatball samples, 51.3% (77/150) of the chicken samples, and 62% (31/50) of the chicken giblet samples. A total of 63 *Arcobacter* strains were identified at species level using the PCR-RFLP method (Figure 1). The percentage of isolates identified as *A. butzleri, A. Skirrowii,* and *A. cryaerophilus* was 57.1%, 26.8%, and 15.8%, respectively, in ground beef, ground lamb, and meatball samples; 61.0%, 15.5%, and 23.3%, respectively, in chicken meat samples and 67.7%, 22.5%, and 9.6%, respectively, in chicken giblet samples. *A. butzleri* was the most frequently detected species in all the samples. *A. skirrowii* in ground beef, ground lamb, meatball, and chicken giblet, and *A. cryaerophilus* in chicken meat were the second most frequently detected species. All three *Arcobacter* spp. were isolated in all samples except in skinless breast. Co-colonization was not detected. Among the chicken meat samples, the highest contamination was found in samples from chicken wing meat (72%) and the lowest contamination was found in samples from skinless breast meat (24%). The highest contamination among the meat samples was observed in meatball samples (27.7%) and the lowest contamination was in ground lamb samples (20%). A higher prevalence of *Arcobacter* spp. was found in chicken meat than in ground meats and meatball samples, as well as in chicken leg and chicken breast samples containing

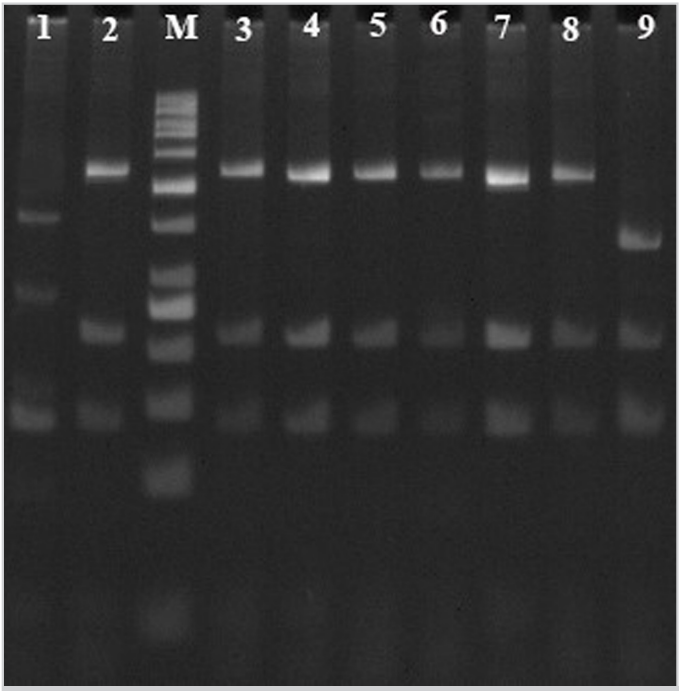

Figure 1
Restriction Fragment Length Polymorphism (RFLP) Patterns of Arcobacter *Strains; Lanes: M (50 bp ladder); Lanes 1,* A. skirrowii; *2-8,* A. butzleri; *9,* A. cryaerophilus.

skin as compared to those without skin. *Arcobacter* spp. was found at a prevalence of 64% in liver samples and 60% in gizzard samples.

Antibiotic Resistance of *Arcobacter* spp. Isolates

A total of 171 *Arcobacter* spp. isolates, including 104 *A. butzleri*, 36 *A. Skirrowii,* and *31 A. cryaerophilus* samples, obtained from this study, were tested for susceptibility to 14 antibiotics. Susceptibility of *Arcobacter* spp. to antibiotics is presented in Table 2. *A. cryaerophilus* isolates were not resistant to norfloxacin; however, all remaining isolates showed varying levels of resistance to all antibiotics. Cefoperazone resistance was detected in 99.42% (170/171) of all isolates. All *A. skirrowii* isolates (*n* = 36) were resistant to vancomycin and cefoperazone.

The highest resistance among *A. butzleri* isolates was for cefoperazone (100%; 104/104), with resistance to other antibiotics as well: cephalothin (88.4%; 92/104), vancomycin (86.5%; 90/104), nalidixic acid (86.5%; 90/104), erythromycin (76.9%; 80/104), tetracycline (61.5%; 64/104), and streptomycin (57.6%; 60/104). *A. skirrowii* isolates displayed resistance to cefoperazone (100%; 36/36), vancomycin (100%; 36/36), erythromycin (55.5%; 20/36), and cephalothin (52.7%; 19/36). *A. cryaerophilus* isolates showed resistance to cefoperazone (96.7%; 30/31), vancomycin (87.1%; 27/31), erythromycin (58.0%; 18/31), and cephalothin (51.6%; 16/31).

Discussion, Conclusion, and Recommendation

In this study, the prevalence and distribution of *Arcobacter* spp. were assessed at a species level in retail ground beef, ground lamb,

Table 2.
Antibiotic Susceptibility of A. butzleri, A. skirrowii, *and* A. cryaerophilus *Strains Isolated From Analyzed Samples*

	Antibiotic Susceptibility of *Arcobacter I*solates (%)								
	***A. butzleri* (*n* = 104)**			***A. skirrowii* (*n* = 36)**			***A. cryaerophilus* (*n* = 31)**		
Antibiotic	**S**	**I**	**R**	**S**	**I**	**R**	**S**	**I**	**R**
AMC	61 (58.6)	11 (10.5)	32 (30.7)	22 (61.1)	3 (8.3)	11 (30.5)	24 (77.4)	–	7 (22.5)
Chloramphenicol	50 (48.0)	16 (15.3)	38 (36.5)	30 (83.3)	2 (5.5)	4 (11.1)	30 (96.7)	–	1 (3.2)
Cefoperazone	–	–	104 (100.0)	–	–	36 (100.0)	0 (0.0)	1 (3.2)	30 (96.7)
Cefoperazone	40 (38.4)	34 (32.6)	30 (28.8)	16 (44.4)	2 (5.5)	18 (50.0)	26 (83.8)	–	5 (16.1)
Ciprofloxacin	40 (38.4)	14 (13.4)	50 (48.0)	33 (91.6)	–	3 (8.3)	20 (64.5)	3 (9.6)	8 (25.8)
Gentamicin	58 (55.7)	18 (17.3)	28 (26.9)	26 (72.2)	–	10 (9.6)	18 (58.0)	10 (32.2)	3 (9.6)
Erythromycin	15 (14.4)	9 (8.6)	80 (76.9)	16 (44.4)	–	20 (55.5)	13 (41.9)	–	18 (58.0)
Florfenicol	63 (60.5)	12 (11.5)	29 (27.8)	22 (61.1)	–	14 (13.4)	25 (80.6)	1 (3.2)	5 (16.1)
Cephalothin	12 (11.5)	–	92 (88.4)	17 (16.3)	–	19 (52.7)	13 (41.9)	2 (6.4)	16 (51.6)
Nalidixic acid	10 (9.6)	4 (3.8)	90 (86.5)	29 (80.5)	–	7 (19.4)	15 (48.3)	1 (3.2)	15 (48.3)
Norfloxacin	64 (61.5)	6 (5.7)	34 (32.6)	32 (88.8)	–	4 (11.1)	24 (77.4)	7 (22.5)	–
Streptomycin	30 (28.8)	14 (13.4)	60 (57.6)	28 (77.7)	4 (11.1)	4 (11.1)	26 (83.8)	3 (9.6)	12 (38.7)
Tetracycline	32 (30.7)	8 (7.6)	64 (61.5)	25 (69.4)	–	11 (30.5)	17 (54.8)	3 (9.6)	11 (35.4)
Vancomycin	–	14 (13.4)	90 (86.5)	–	–	36 (100.0)	–	4 (12.9)	27 (87.1)

Note: AMC = amoxicillin/clavulanic acid; S = susceptible; I = intermediate; R = resistant.

meatball, chicken meat, and giblets. Resistance levels of 171 isolates to 14 different antibiotics were investigated.

There are many studies that investigate the presence of *Arcobacter* spp. in chicken meat and giblets that have had varying results. Amare et al. (2011) have identified 39% *Arcobacter* spp. in fresh and cooled chicken thigh, wing, and breast meat samples. Di Noto et al. (2018) found 53.3% *Arcobacter* spp. in chicken wings, quarters, and carcass samples ($n = 15$). Collado et al. (2009) found 64.3% *Arcobacter* spp. in chicken meat samples. Aydin et al. (2007) found 68% *Arcobacter* spp. from whole carcasses, drumsticks, breasts, and wing samples. In these studies, all isolates were defined as *A. butzleri* (100%). The prevalence of *A. butzleri* and *A. cryaerophilus* isolates were 88.2% and 11.8% in Portugal (Vicente-Martins et al., 2018) and 63.6% and 36.3% in Brazil (De Oliveira et al., 2018) in poultry meat samples, respectively. This rate has been found to be 61.79% and 0.81% in isolates from the refrigerated chicken wings, neck skin, intestines, and gizzard samples (Kim et al., 2019). The positivity rate of *Arcobacter* spp. for drumstick, edible viscera, and ground or chopped breast samples was found to be 60% (9/15), 40% (6/15), and 20% (3/15), respectively, in a study by Villarruel-Lopez et al. (2003). The same study reported that the presence of *A. butzleri* was 66.7% (30/45) and *A. skirrowii* was 24.4% (11/45) in chicken meat. There are also studies in which all three species have been co-detected. Scullion et al. (2006) have found *A. butzleri* (84.4%), *A. cryaerophilus* (24.1%), and *A. skirrowii* (3.4%) in chicken meat. Molva & Atabay (2016) conducted a study of chicken meat in Izmir, Turkey, and indicated that the presence of *Arcobacter* spp. was 32.5% in leg, 64.7% in leg quarters, 81.3% in drumsticks, 72.7% in breasts, 50% in wings, and 83.3% in carcass samples. The distribution of the isolates obtained in the same study at species level was *A. butzleri* 80%, *A. cryaerophilus* 3.6%, and *A. skirrowii* 1.8%. *A. butzleri* was mostly isolated from wing samples (100%), followed by breast (87.5%), drumstick (84.6%), carcass (80%), leg (76.9%), and leg quarter (72.7%) samples. *A. cryaerophilus* has been found only in wing and carcass samples, while *A. skirrowii* only in drumstick samples. In the present study, as in the studies by Scullion et al. (2006) and Molva & Atabay (2016), three species were isolated. *A. cryaerophilus* was not detected in skinless breast samples. *A. butzleri* was detected as the only species or the species with the highest prevalence in many studies, whereas its rate in the present study (61.04%) was lower than the results reported by other studies (Kim et al., 2019; Molva & Atabay, 2016; De Oliveira et al., 2018; Scullion et al., 2006; Vicente-Martins et al., 2018; Villarruel-Lopez et al., 2003). Our results regarding *A. cryaerophilus* were also lower in chicken meat than those described by de De Oliveira et al. (2018) but higher than the results of other studies (Kim et al., 2019; Molva & Atabay, 2016; Scullion et al., 2006; Vicente-Martins et al., 2018). The presence of *A. skirrowii* detected in chicken meat was lower than the results reported by Villarruel-Lopez et al. (2003) and higher than the results reported by Scullion et al. (2006) and Molva & Atabay (2016). In the present study, the presence of *Arcobacter* spp. in chicken leg and wings samples was higher compared to the results of Molva & Atabay (2016), but our results regarding breast samples were lower. Differences in *Arcobacter* spp. isolation rates may be due to plant conditions, processing procedures, geographic location, seasonal differences, study design, analysis methods (Molva & Atabay, 2016), and the types and concentrations of antimicrobial agents in the media, which affect *Arcobacter* growth and isolation rates (Amare et al., 2011). Reports have suggested that *A. butzleri* is the predominant species in many poultry studies because its growth rate is higher as compared to that of *A. cryaerophilus* and *A. skirrowi* (Corry et al., 2003). Other reports suggest that this is due to the fact that *A. butzleri* is more competitive than *A. cryaerophilus* in the enrichment broth (Amare et al., 2011; Houf et al., 2002). Lower

isolation rates for *A. skirrowii* may be due to high susceptibility to antimicrobials found in the selection medium used or due to growth competition (Molva & Atabay, 2016). However, in the present study, *A. skirrowii* is relatively high, which can be explained by the resistance of the isolates to cefoperazone. This antibiotic is found in the composition of the medium in many studies.

Di Noto et al. (2018) determined that *Arcobacter* spp. contamination was at 7.7% in ground beef and ground pork samples from Italy. *A. butzleri* was the only species isolated from the samples examined in this study. Elmalı & Can (2016) found that *Arcobacter* spp. was present in 6.7% of the ground beef samples and 66.7% of the isolates were *A. butzleri* and 66.7% were *A. skirrowii*. *A. cryaerophilus* has not been identified. In a study conducted in Turkey, 37% of ground beef samples were contaminated with *Arcobacter* spp. and the most frequently isolated species was *A. butzleri* (33.3%), followed by A. *cryaerophilus* (3.7%). In this study, *A. skirrowii* could not be detected (Aydin et al., 2007). In Mexico, 38% of ground beef samples (17 of 45) were positive for *A. butzleri* and 9% (4 of 45) were positive for *A. skirrowii* (Villarruel-Lopez et al., 2003). De Smet et al. (2010) reported the presence of *Arcobacter* spp. at 9% in ground beef samples. 66.7% of the isolates were identified as *A. butzleri* and 33.4% as *A. cryaerophilus*. Rivas et al. (2004) found the presence of *A. butzleri* at 22% and 15% in ground beef and ground lamb, respectively, collected from butchers and supermarkets in three different regions. Except *A. butzleri*, no other species were detected in this study. The presence of *Arcobacter* spp. in the present study was higher than the results found by (Collado et al., 2009; De Smet et al., 2010; Elmalı & Can, 2016). *A. butzleri* was found lower than the results reported by other researchers (De Smet et al., 2010; Elmalı & Can, 2016). However, in the present study, all three species that are important for human health, including *A. butzleri, A. cryaerophilus* and *A. skirrowii*, were identified. In other studies, *A. butzleri* was reported as one isolate or one of two isolates. This may explain the low rate of *A. butzleri*. *A. Butzleri,* and *A. cryaerophilus* was mostly found in meatball samples and in ground beef samples, respectively, while *A. skirrowii* was identified in a similar number (six samples) of ground beef and meatball samples. The fact that meatball samples are subjected to more processing in production and there is addition of vegetables and spices into their composition may be the reason for higher *Arcobacter* spp. contamination. On the other hand, the region where the samples were taken, the slaughtering conditions, processing methods, the antibiotic resistance of the isolates, and the analysis methods may have caused these differences. It is possible that the differences in the study results are due to contamination in feces or slaughterhouse environment.

Abay et al. (2012) showed in their study that the resistance status varies according to the source from which *A. butzleri* isolates are obtained, the piece of meat, and the antibiotic tested. All of the *A. butzleri* isolates isolated from ground beef samples (100%) were susceptible to amoxicillin/clavulanic acid, enrofloxacin, and tetracycline, while the susceptibility of isolates obtained from chicken carcass was 98.71%, 67.74% and 58.06%, respectively. All *A. butzleri* isolates isolated from ground beef and chicken carcasses were susceptible to gentamicin, whereas they were resistant to cefuroxime sodium, rifampin, and trimethoprim/sulfamethoxazole. In a study by Šilha et al. (2017), strains of *A. butzleri* isolated from poultry meats were resistant to nalidixic acid (89.09%; 49/55), chloramphenicol (58.18%; 32/55), amoxicillin/clavulanic acid (23.64%; 13/55), gentamicin (3.64%; 2/55), and streptomycin (1.82%; 1/55) at different levels, while they were susceptible (100%) to ciprofloxacin, erythromycin, and tetracycline. In the same study, *A. cryaerophilus* strains were susceptible to amoxicillin/clavulanic acid, chloramphenicol, ciprofloxacin, gentamicin, streptomycin, and tetracycline (100%) and showed low resistance to erythromycin and nalidixic acid (3.64%). *A. butzleri, A. cryaerophilus,* and *A. skirrowii* isolates isolated from the samples analyzed in their present study were resistant to all of these antibiotics at different levels. The differences between the results can be explained by the species of the animal from which the strains are obtained and the differences in piece of meat and in meat products.

In many studies, tetracycline and aminoglycosides are recommended as the first choice for *Arcobacter* spp.-induced infections in humans and animals (Abay et al., 2012; Fera et al., 2003; Šilha et al., 2017; Son et al., 2007). Contrary to these studies, *A. butzleri, A. Skirrowii,* and *A. cryaerophilus* isolates were resistant to tetracycline at 61.54%, 30.56%, and 35.48%, respectively; to gentamicin at 26.92%, 27.78%, and 9.68%, respectively; and to streptomycin at 57.69%, 11.11%, and 38.71%, respectively in the present study. Vandenberg et al. (2004) reported that fluoroquinolones along with tetracyclines also lead to favorable results in *Arcobacter* infections. However, significant levels of resistance were detected against fluoroquinolones (ciprofloxacin, nalidixic acid, and norfloxacin) tested in *A. butzleri* and *A. skirrowii* isolates detected in this study. While the resistance of nalidixic acid, ciprofloxacin, and norfloxacin was 86.54%, 48.08%, and 25.37, respectively in *A. butzleri* isolates, this ratio was found to be 19.44%, 8.33%, and 11.11%, respectively in *A. skirrowii* isolates. *A. cryaerophilus* isolates were susceptible to norfloxacin and showed resistance at a level of 48.39% to nalidixic acid and 25.81% to ciprofloxacin. The species of sample analyzed, the region where the samples were collected, and the amount of antibiotics used in animals and humans may be the reason for these differences. In the present study, multiple antibiotic resistance was detected in *A. butzleri, A. Skirrowii,* and *A. cryaerophilus* isolates isolated from the samples analyzed. This result is compatible with other studies that reported multiple antibiotic resistance in *Arcobacter* spp. (Abay et al., 2012; Kabeya et al., 2004; Šilha et al., 2017; Son et al., 2007).

In this study, the presence of *Arcobacter* spp. was 36.38% in 470 samples consisting of ground beef, ground lamb, meatball, chicken meat, and chicken giblet. 60.82% of all isolates were identified as *A. butzleri*, 21.05% as *A. Skirrowii,* and 18.3% as *A. cryaerophilus*. Assessment of antibiotic resistance in the isolates from this study showed that there is relatively high antibiotic resistance and multiple antibiotic resistance in the majority of the isolates.

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