The Investigation of the Presence and Antimicrobial Profiles of Arcobacter Species in Sheep Carcasses and Feces

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Abstract

This study was designed to investigate the presence and the prevalence of Arcobacter butzleri, Arcobacter cryaerophilus, and Arcobacter skirrowii in sheep carcass swabs and feces from sheep with and without diarrhea raised in Istanbul. Also it was aimed to determine their resistance profiles against some antimicrobials. For this purpose, 50 fecal samples from sheep without diarrhea, 50 fecal samples from sheep with diarrhea, and 50 carcass swab samples from sheep were the material of this study. Arcobacter spp. were isolated from 49 (32.6%) of total 150 samples. 34 samples (68%) of 50 fecal samples from sheep with diarrhea, 5 samples (10%) from 50 fecal samples of sheep without diarrhea and 10 samples (20%) of 50 sheep carcass swabs were found to be positive according to isolation results. According to multiplex Polymerase Chain Reaction (mPCR) results, 31 of 49 were identified as A. skirrowii (63.3%), 9 of 49 were A. butzleri (18.3%), while 9 of 49 were A. cryaerophilus (18.3%). As a conclusion, Arcobacter species should be taken into consideration especially in sheep with diarrhea. Additionally, it should be considered that arcobacters have started to gain resistance against fluoroquinolones.

Keywords: Arcobacter butzleri, Arcobacter cryaerophilus, Arcobacter skirrowii, antibiotic sensitivity test, mPCR, sheep

Introduction

The importance of arcobacters that are described as foodborne and zoonotic entero-pathogens has increased in recent years. Arcobacter species (spp.) are considered emerging food-borne entero-pathogens (Abay et al., 2012; Atabay and Corry, 1998). Although it varies among species, these bacteria can be found in animals showing signs of gastroenteritis, abortion and mastitis whereas it can also be seen in healthy animals which do not have these symptoms (On et al., 2002, Vandamme et al., 1992b). Especially Arcobacter butzleri (A. butzleri) is the most known species that they can cause food-borne gastroenteritis and septicemia in human beings (Lau et al., 2002; Vandamme et al., 1992b).

Lately, Arcobacter spp. has been frequently isolated from animal source foods (Fernandez et al., 2015; Sekhar et al., 2017). Although they have shown significant phenotypic heterogeneity in terms of their biochemical and physiological characteristics, the genus Arcobacter is classified together with Campylobacter genus under the Campylobacteriaceae family (Vandamme and De Ley, 1991). Their ability to grow at temperatures below 30°C and aerotolerance characters are the features that separate Arcobacter species from Campylobacter species. Therefore, they have been defined as “aerotolerant campylobacters” (Neill et al., 1978).

Arcobacters have been identified as a potential zoonotic agent of food and water origin. The discovery of new species has enlarged the genus. Recently, the whole Arcobacter genus has been defined to contain 25 species (Ramees et al., 2017). In the genus, A. butzleri, A. cryaerophilus and A. skirrowii can more probably cause human diseases (Assanta et al., 2002). Among several Arcobacter species, A. butzleri, A. cryaerophilus, and A. skirrowii are reported to have veterinary and public health sig-

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nificance. *Arcobacter* spp. have been included among microorganisms that pose a high risk for human health and *A. butzleri* can be isolated from many human cases, it has been accepted as the most significant species in this genus by International Food Microbiology Specification Committee (Collado and Figueras, 2011).

Although there are many medium and different procedures for the identification of *Arcobacter* spp., no standard reference methods have been suggested. Atabay and Corry (1998) used an arcobacter broth with the addition of cefoperazone, amphotericin, and teicoplanin (CAT) supplements in their research, and more recently, Houf et al. (2001) developed an *Arcobacter*-specific isolation method with the use of an arcobacter medium. This medium consisted of five antibiotics, including cefoperazone, trimethoprim, amphotericin, novobiocin, and 5-fluorouracil.

Modified Charcoal Cefoperazone Deoxycholate Agar (mCCDA) with the addition of a CAT supplement was used by Kemp et al. (2005). Columbia agar containing 5% (vol/vol) of defibrinated horse blood was also used by Merga et al. (2011).

The biochemical properties of *Arcobacter* spp. reported by Vandamme et al. (1992a) are that *A. butzleri*, *A. cryaerophilus*, and *A. skirrowii* strains have oxidase and catalase activities and can not produce hydrogen sulfide on Triple Sugar Iron agar.

Methods used for direct detection and/or typing of the species in the genus include PCR, multiplex PCR (mPCR), real time PCR (RT-PCR), fluorescence *in situ* hybridisation (FISH), denaturing gradient gel electrophoresis PCR (DGGE-PCR), restriction fragment length polymorphism (RFLP) and matrix assisted laser desorption ionization mass spectrometry (MALDITOF MS). Enterobacterial repetitive intergenic consensus (ERIC) PCR was set up and optimized for the characterization of *A. butzleri*, *A. cryaerophilus*, and *A. skirrowii* strains (Houf et al., 2002).

Recently, mPCR has been developed as a very useful method for quick identification of *Arcobacter* species. It has been reported that there is no risk of false positive results based on the contamination with other bacteria from *Campylobacteriaceae* family. It can reduce the time required for the identification of *Arcobacter* spp. and eliminate the likelihood of false-positive results because of other *Campylobacteriaceae* family members (Neubauer and Hess, 2006; Snelling et al., 2006).

Fluoroquinolones and tetracycline have been suggested for the treatment of infections caused by *A. butzleri* in humans and animals (Son et al., 2007; Vandenberg et al., 2006). It is stated that the resistance to erythromycin and the susceptibility to ciprofloxacin may have human health effects, as the two antimicrobials are generally used as first-line drugs to treat the bacterial infections due to bacteria in the *Campylobacteriaceae* family (Rahimi, 2014).

Abay et al. (2012) argued as a conclusion of their study that gentamycin, streptomycin, and tetracycline would be suitable antibiotics for the treatment or control of the disease caused by *Arcobacter* spp. in veterinary and human medicine. Aski et al. (2016) reported that all *Arcobacter* isolates were resistant to rifampicin, vancomycin, ceftriaxone, trimethoprim, and cephalothin, and furthermore, the isolates showed high susceptibility to tetracycline, oxytetracycline, erythromycin, ciprofloxacin, kanamycin, amikacin, gentamicin, and enrofloxacin.

This study aimed to investigate the prevalence of *A. butzleri*, *A. cryaerophilus*, and *A. skirrowii* in sheep carcass swabs and feaces of sheep with and without diarrhea. It also aimed to determine their resistance profiles against some antimicrobials. In addition, the possible effects of season, gender, sample type, and age on the prevalence of arcobacters were examined.

**Materials and Methods**

This study was approved by Ethic Committee of the Istanbul University Faculty of Veterinary Medicine (Approval number: 2013/74).

**Samples**

Fifty fecal samples from healthy sheep, 50 fecal samples from sheep with diarrhea, and 50 swab samples from sheep carcasses were taken from different farms and slaughterhouses located in Istanbul, Turkey. All the samples were gathered in the same year and only one sample was received from each sheep. 150 samples were taken from 73 male and 77 female animals. The details of the samples and their collections were given in Table 1. The fecal samples were collected from rectum and stored in sterile plastic containers and the carcass swab samples were taken by using sterile cotton swabs. The swab samples were taken from the area from neck to the hips (50 cm²) according to the EU Regulation 2073/2005. All the samples were analyzed in the microbiology laboratory in 3 hours after they were collected from the sheep.

**Reference strains**

The positive control strains belong to *A. butzleri*, *A. cryaerophilus* and *A. skirrowii* were taken from Victor Segalen Bordeaux II University Hospital’s Bacteriological Laboratory.

**Culture**

Two grams of fecal materials were transferred into the test tubes including 9 ml of arcobacter broth (Oxoid, Basingstoke, UK), and each swab sample was transferred into the test tubes including 2 ml of arcobacter broth with the addition of 5-fluorouracil (100 mg/1000 mL) (Merck, Darmstadt, Germany), amphotericin B (10 mg/1000 mL) (Bioshop, Ontario, Canada), cefoperazone (16 mg/1000 mL) (Sigma-Aldrich, Saint Louis, USA), novobiocin (32 mg/1000 mL) (Sigma-Aldrich, Saint Louis, USA), and trimethoprim (64 mg/1000 mL) (Sigma-Aldrich, Saint Louis, USA) (Houf et al., 2001) as an enrichment broth, and were incubated aerobically.
at 30°C for 24 h. At the same time, motility tests were performed with each sample taken from arcobacter broth after 24 h as soon as the pre-enrichment stage was completed. Spiral or corkscrew motility types were observed. After the pre-enrichment phase, 15 μl was collected from broth culture and was inoculated onto modified charcoal-cefoperazone-deoxycholate agar (Scharlab, Barcelona, Spain) as a selective medium which consisted of CAT supplement (Oxoid, Basingstoke, UK). It was incubated for 48 h at 30°C under aerobic conditions. At the end of incubation, Gram staining was performed on gray-white, small, round, and S-type colonies. Gram negative colonies were transferred to Columbia agar (Biolife, Milan, Italy) as a selective medium which consisted of CAT supplement (Oxoid, Basingstoke, UK). It was incubated for 48 h at 30°C under aerobic conditions. At the end of incubation, Gram staining was performed on gray-white, small, round, and S-type colonies. Gram negative colonies were transferred to Columbia agar (Biolife, Milan, Italy) as a selective medium which consisted of CAT supplement (Oxoid, Basingstoke, UK).

Selected primer sequences shown in Table 2 were amplified according to the method by Houf et al. (2000) through PCR, using a reaction mixture containing 4 μl 10X PCR buffer+MgCl₂, 0.8 μl 10mM dNTPs, 2 μl (20 pmol/mL) of each of the four primers (BUTZ, ARCO, CRY1, CRY2) and 1 μl (20 pmol/mL) of SKIR primer, 0.3 μl of Taq DNA polymerase, 15.9 μl DNase-free water, and 10 μl bacterial DNA for each sample. PCR amplification kit (Qiagen, Germantown, USA) was used in the study. The reactions were performed in a thermal cycler (Biometra UNO-Thermoblock, Dublin, Ireland) with the following amplification conditions: a denaturation step for 3 min at 94°C; 37 amplification cycles: denaturation for 2 min at 94°C, annealing for 45 sec at 61°C, and for 30 sec. extension at 72°C; the final extension step was 7 min at 72°C.

The electrophoresis (Biometra, Dublin, Ireland) was performed approximately at 125V for 45 min. The bands were visualized on an UV illuminator. The resulting products sizes were 257 bp for A. cryaerophilus, 401 bp for A. butzleri, and 641 bp for A. skirrowii. Furthermore, all reference strains were identified with the same technique.

**Antibiotic sensitivity test**

The antibiotic resistance profiles of Arcobacter strains were determined by using disc diffusion technique. Blood agar that comprised 5% (v/v) of defibrinated horse blood in blood agar base no. 2 was used for this purpose. Sterile cotton-tipped swab was used for spreading on the plate. Later on, each antibiotic disc was placed onto the agar and the plates were kept at 4°C for about 15 min. The plates incubated in a micro-aerobic atmosphere at 30°C for 48 h and the diameters of the inhibition zones were measured with calipers. The diameters of the zones occurred around the discs were evaluated according to the criteria defined for materials for Campylobacter spp. by the National Committee for Clinical Laboratory Standards and also
according to the criteria specified for Enterobacteriaceae by the European Committee on Antimicrobial Susceptibility Testing (2015), since no standardized source was described yet to make comparison.

**Statistical analysis**
In order to determine the statistical significance of the findings, the results were evaluated with “Chi-square (χ²) test” by SPSS 13.0 programme (SPSS Inc.; IL, Chicago, USA) by comparing the positive rates of *A. butzleri*, *A. cryaerophilus*, and *A. skirrowii* under sex, age, season, and sample subgroups.

**Results**

**Culture and isolation studies**
A total of 150 samples were collected from 50 sheep with diarrhea, 50 healthy sheep, and 50 sheep carcasses from the slaughterhouses and farms in and around Istanbul province. Forty-nine (32.6%) of 150 samples were detected as *Arcobacter* spp.

Thirty-four (68%) of 50 fecal samples from sheep with diarrhea, 5 (10%) of 50 fecal samples from sheep without diarrhea and 10 (20%) of 50 sheep carcass swab samples were found to be positive according to isolation results.

**Multiplex Polymerase Chain Reaction (mPCR)**
Presumptive colonies were chosen according to their macroscopic and microscobic features. Only one suspicious colony from each culture were applied for PCR identification. A total of 49 culture positive samples were tested by mPCR and all 49 (100%) samples were positive in terms of *Arcobacter* species. As a result of the agarose gel electrophoresis of the mPCR products, 257 bp for *A. cryaerophilus*, 401 bp for *A. butzleri*, and 641 bp bands for *A. skirrowii* were detected. According to mPCR, 31 of 49 samples were identified as *A. skirrowii* (63.2%), 9 of 49 as *A. butzleri* (18.3%), while 9 of 49 as *A. cryaerophilus* (18.3%) (Figures 1, 2).

**Antibiotic sensitivity testing**
All strains identified as *A. butzleri* were susceptible to methicillin (30 µg) (Bioanalyse, Ankara, Turkey) and gentamycin (10 µg).
(Oxoid, Basingstoke, UK), and all *A. cryaerophilus* strains were susceptible to tetracycline (30 µg) (Oxoid, Basingstoke, UK), doxycycline (30 µg) (Oxoid, Basingstoke, UK), and Amikacin (30 µg) (Oxoid, Basingstoke, UK), while all *A. skirrowii* strains were found to be susceptible to tetracycline.

All of *A. butzleri* strains had intermediate sensitivity to erythromycin (15 µg) (Oxoid, Basingstoke, UK), whereas all *A. butzleri* strains had resistance to penicillin G (10 Unit/disk) (Oxoid, Basingstoke, UK), rifampicin (30 µg) (Oxoid, Basingstoke, UK), vancomycin (30 µg) (Oxoid, Basingstoke, UK), and nalidixic acid (30 µg) (Oxoid, Basingstoke, UK). And all *A. cryaerophilus* strains showed resistance to ofloxacin (5 µg) (Oxoid, Basingstoke, UK), vancomycin, and rifampicin. Other strains showed variable results as shown in Table 3.

### Table 3. Antibiotic sensitivity test results of Arcobacter strains

| Antimicrobial Agent | *A. butzleri (n)* | *A. cryaerophilus (n)* | *A. skirrowii (n)* |
|---------------------|-----------------|-----------------------|------------------|
|                     | R   | S  | I  | R   | S  | I  | R   | S  | I  |
| Penicillin          |     |    |    |     |    |    |     |    |    |
| Penicillin G 10 unit/disk | 9   | 0  | 0  | 9   | 0  | 0  | 29  | 0  | 2  |
| Ampicilin + Sulbactam 1:120 mg | 3   | 3  | 3  | 5   | 3  | 1  | 5   | 14 | 12 |
| Amoxicillin 25 µg    | 2   | 5  | 2  | 5   | 3  | 1  | 11  | 12 | 8  |
| Methicillin 30 µg    | 0   | 9  | 0  | 8   | 0  | 1  | 17  | 4  | 10 |
| Amoxicillin + Clavulanic acid 2:1 30 µg | 3   | 5  | 1  | 4   | 4  | 1  | 10  | 21 | 0  |
| Tetracyclines       |     |    |    |     |    |    |     |    |    |
| Tetracycline 30 µg   | 2   | 6  | 1  | 0   | 9  | 0  | 0   | 31 | 0  |
| Oxytetracycline 30 µg| 4   | 5  | 0  | 0   | 7  | 2  | 0   | 25 | 6  |
| Doxycycline 30 µg    | 1   | 6  | 2  | 0   | 9  | 0  | 1   | 30 | 0  |
| Quinolones           |     |    |    |     |    |    |     |    |    |
| Ofloxacin 5 µg       | 8   | 1  | 0  | 9   | 0  | 0  | 9   | 5  | 17 |
| Ciprofloxacin 5 µg   | 4   | 0  | 5  | 4   | 1  | 4  | 7   | 6  | 18 |
| Enrofloxacin 5 µg    | 2   | 2  | 5  | 3   | 3  | 3  | 2   | 22 | 7  |
| Nalidixic Acid 30 µg | 9   | 0  | 0  | 6   | 1  | 2  | 8   | 8  | 15 |
| Aminoglycosid        |     |    |    |     |    |    |     |    |    |
| Amikacin 30 µg       | 0   | 7  | 2  | 0   | 9  | 0  | 1   | 29 | 1  |
| Gentamisin 10 µg     | 0   | 9  | 0  | 0   | 8  | 1  | 2   | 28 | 1  |
| Macrolides           |     |    |    |     |    |    |     |    |    |
| Erythromycin 15 µg   | 0   | 0  | 9  | 0   | 1  | 8  | 1   | 0  | 30 |
| Rifamycin            |     |    |    |     |    |    |     |    |    |
| Rifampicin 30 µg     | 9   | 0  | 0  | 9   | 0  | 0  | 30  | 1  | 0  |
| Cephalosporins       |     |    |    |     |    |    |     |    |    |
| Cephalexin 30 µg     | 8   | 1  | 0  | 8   | 0  | 1  | 28  | 1  | 2  |
| Nitrofurantoin       |     |    |    |     |    |    |     |    |    |
| Nitrofurantoin 300 µg| 8   | 1  | 0  | 4   | 4  | 1  | 1   | 30 | 0  |
| Vancomycin           |     |    |    |     |    |    |     |    |    |
| Vancomycin 30 µg     | 9   | 0  | 0  | 9   | 0  | 0  | 29  | 1  | 1  |

R: resistant; S: sensitive; I: intermediate

### Discussion

Arcobacters have been accepted as “important zoonotic pathogenic” bacterial strains (Cardoen et al., 2009). The non-human sources of arcobacters have also been reported to be healthy or have affected animals of various species, various foods, and water (Kabeya et al., 2003).

In a study carried out in Turkey (Sürmeli, 2006), 104 sheep stool samples were taken under microaerobic conditions using membrane filtration technique and only one *A. cryaerophilus* was identified by mPCR method as reported. In Belgium, Van Driessche et al. (2003) collected 62 healthy sheep feces from slaughterhouses and performed a direct isolation from the feces samples. According to their report, they identified *A. butzleri* only in 3 (4.8%) samples, whereas 16% were isolated after pre-enrichment. In our study, 31 of 49 were identified as *A. skirrowii* (63.3%), 9 of 49 as *A. butzleri* (18.3%), while 9 of 49 as *A. cryaerophilus* (18.3%). Using the arcobacter broth medium-mCCDA-Columbia agar (defibrinated horse blood supplement) as an isolation technique may account for the increase in the isolation rate. Another explanation for the differences found in the rates may be the use of stool sample instead of swab. In this study, 8 *A. butzleri* (16%), 1 *A. cryaerophilus* (2%), and 1 *A. skirrowii* (2%)
were identified from 50 sheep carcass swab samples. Any information with regard to whether the animals having enteritis could not be obtained.

In a study carried out in Turkey (Ertas and Dogruer, 2009), Arcobacter spp. were isolated from 85 (42.5%) of 200 minced meat samples. A. butzleri was detected from 39% and A. skirrowii was detected from 4% of minced sheep meat samples, while A. butzleri was detected from 40% and A. skirrowii was detected from 2% of minced cattle meat. The prevalence rate of arcobacters in minced meat obtained from sheep in their study was higher than the prevalence rate we had from swab sample in our thesis study. The difference in prevalence suggested a possible increase in Arcobacter contamination as the meat samples were processed by equipment like mincer. Further, the microorganisms on the surface of the meat might have spread all over it during the course of grinding and mixing the minced meat leading to food spoilage.

In Japan, Kabeya et al. (2003) found 12 (3.6%) Arcobacter species from 332 healthy cattle feces samples, whereas Van Driessche et al. (2003) identified 39.2% Arcobacter species from healthy bovine feces samples and 16.1% Arcobacter species from healthy ovine feces samples. Nachamkin et al. (2008) reported that they identified A. butzleri from feces samples of pig, cattle, horse, ostrich, turtle, and A. skirrowii from sheep and cattle with diarrhea and hemorrhagic colitis. A. skirrowii was detected from sheep having enteritis and most A. butzleri strains were isolated from diarrheic feces of humans and animals (Vandamme et al., 1992a). In our study, 34 (68%) Arcobacter species were detected from 50 feces samples belonged to sheep with enteritis and we found 25 (50%) A. skirrowii, 8 (16%) A. cryaerophilus, and 1 (2%) A. butzleri.

It was reported that season, climate, geographical location, sampling type, and isolation method had an effect on the prevalence values to be obtained (Merga et al., 2011). Golla et al. (2002) stated that there was a direct correlation between increased age and increased prevalence of arcobacters in their studies. In our study, the incidence of A. cryaerophilus increased in proportion to the increase in age from 1 month to 3 years, but the graph showed a reverse slope for A. butzleri. The incidence of A. skirrowii reached the highest rate between 1 and 3 years.

Researchers reported that there was no significant difference in the rates of arcobacters between goats and sheep (p>0.05) (Van Driessche et al., 2003; Van Driessche et al., 2005). In our study, the effect of gender difference on the incidence of Arcobacter species was statistically insignificant (p>0.05). The effect of seasons on the incidence of A. cryaerophilus (p<0.05) and A. skirrowii (p<0.001) in this study was also statistically significant.

It was also reported in other research (Van Driessche et al., 2003; 2005), as reported in this study, that the difference in season and farm management could have an effect on the rates found. The heavy conditions of the winter season in Turkey and keeping the animals in narrow and unhygienic shelters may be another cause of the seasonal effect. The effect of the presence of diarrhea was found to be statistically significant on the isolation rates (p<0.001) of A. cryaerophilus (p<0.01) and A. skirrowii.

The most commonly prescribed drugs as antibiotics are erythromycin or a fluoroquinolone such as ciprofloxacin (Luber et al., 2003). Tetracycline, doxycycline, and gentamicin are sometimes listed as alternative drugs for treatment (Houf et al., 2004). Pérez-Cataluña et al. (2017) stated that the resistance to ciprofloxacin, one of the antibiotics recommended for the treatment of intestinal infections of Arcobacter, detected 10.7% of the strains, and indicated the importance of selecting the most effective treatment. In our study as well, most of the Arcobacter strains showed a resistance or an intermediate profile against some of the fluoroquinolones antibiotics, such as enrofloxacin, ofloxacin, and ciprofloxacin. The resistance to erythromycin and quinolone antibiotics found in this study can be considered as a worrisome condition, because these antimicrobial agents have been reported to be the first-line antibiotics used in the treatment of infections caused by members of the Campylobacteraceae family (Houf et al., 2004).

In Milesí’s research (2011), it was reported that all Arcobacter spp. isolates from animal originated food were detected as resistant to cephalothin, sulfamethoxazole / trimethoprim, and nalidixic acid. The majority of A. cryaerophilus and A. skirrowii strains were found as sensitive to tetracycline and amikacin, which is compatible with some other research results (Abay et al., 2012; Collado and Figueras, 2011; Son et al., 2007; Ünver et al., 2013). However, A. butzleri’s strains were detected to have started to gain some resistance against to these 2 antimicrobial agents.

The results have exhibited that A. skirrowii may also show a significant diarrhea effect in sheep, such as in human and other animals. Considering the increase in the prevalence of Arcobacter spp. isolates from sheep in autumn (Grove-White et al., 2014), another reason for the high incidence of A. skirrowii isolates in our research may be the gathering of diarrhea cases in November and December.

Although the results of the studies on fluoroquinolones indicate that it is the most effective antibiotic group in the treatment of Arcobacter infections, most of the Arcobacter strains detected in this research show resistance or half sensitivity to enrofloxacin, ofloxacin, and ciprofloxacin, which are the antibiotics of this group. In this study arcobacters cause diarrhea in sheep and these animals may play a very important reservoir role for humans. Hence, as with human beings, of the analyses of diarrhea cases should take into consideration the existence of Arcobacter species in sheep. As a result, the study suggests, in line with many other researches, that these varying sensitivity and resistance profiles to the antibiotics may be due to the
lack of a standard antimicrobial susceptibility test developed for *Arcobacter* species (Vandenberg et al., 2006).

In conclusion, *A. skirrowii A. butzleri* and *A. cryaerophilus* were identified with the rate of (63.3%), (18.3%) and (18.3%) respectively. *A. skirrowii* was found more than other *Arcobacter* species in fecal samples with diarrhea. Regarding the effect of gender, age, sample type and gender, only the effect of gender was not found statistically significant for none of these three *Arcobacter* species’ isolation ratios whereas the effect of season was found statistically significant for *A. cryaerophilus* and *A. skirrowii*’s isolation rates and the effect of age was statistically significant on *A. butzleri* and *A. skirrowii*’s isolation rates. The sample type was found also statistically important regarding *A. butzleri*, *A. cryaerophilus*, and *A. skirrowii*’s isolation rates. In terms of the medication of *Arcobacter* infections, it was observed that they started to gain resistance against fluoroquinolones which was known as the best antibiotic groups for arcobacters.

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