**Study on antibiotic resistance profile and multiple antibiotic resistance index (MAR Index) in the *Campylobacter* spp. isolates from domestic animals and water**

Seyedeh Ommolbanin Ghasemian1, Hamid Mahmoodipour2\*, Majid Gholami-Ahangaran3

1. Department of Veterinary Medicine, Behbahan Branch, Islamic Azad University, Behbahan, Iran

2. Department of Nursing and Midwifery, Behbahan Branch, Islamic Azad University, Behbahan, Iran

3. Department of Clinical Sciences, Shahrekord Branch, Islamic Azad University, Shahrekord, Iran

\***Correspondence author**: Hamid Mahmoodipour, Department of Nursing and Midwifery, Behbahan Branch, Islamic Azad University, Behbahan, Iran. email: Soghasemian1239@yahoo.com

**Abstract**

**Introduction**: The purpose of this study was comparison study on antibiotic resistance profile and multiple antibiotic resistance index (MAR Index) in the *Campylobacter* spp. isolates from domestic animals and water.

**Methods**: The totally 364 fecal samples collected from poultry (182), sheep (41), cow (141) farms and drinking water (28) samples from animal farms were examined forisolation of *Campylobacter* spp. using pre-treatment-Kapandis Baseri (prêt KB) method. The isolates were confirmed by sequencing of *16srRNA* genes. Furthermore, *Campylobacter* isolates were evaluated for antibiotic resistance and multiple antibiotic resistance index (MAR Index)by disk diffusion method.

**Results**: The results indicated that *Campylobacter* spp. isolated from 50 samples. The isolation rate was highest in poultry (37/50) and lowest in goat (2/50). 36 and 14 isolates were identified as *C. jejuni* and *C*. *coli,* respectively. All of *C. jejuni* and *C. coli* isolates found resistant to amoxicillin/clavulanic, erythromycin and chloramphenicol and all sensitive to ciprofloxacin, kanamycin, gentamicin, streptomycin, tobramycin, tetracycline and imipenem. 36 and 14 percent of *C. jejuni* and *C. coli* (respectively) had multiple antibiotic resistance index 0.2 and upper.

**Conclusion**: Therefore, based on foregoing evidence, all of the isolates were resistant to antibiotics, therefore, human infection with *Campylobacter* spp. via utilization of animal origin products is possible.

**Keywords:** ***Campylobacter***, Antibiotic resistance profile, Multiple antibiotic resistance index (MARI), Domestic animals, Water

 **Introduction**

Members of *Campylobacter* genus are Gram-negative, microaerophilic, and motile curved bacilli, whose characteristics are similar to those of Arcobacter, and Helicobacter. [1] These bacteria are characterized by oxidase, catalase, hydrogen sulfide production, indoxyl acetate hydrolysis, sensitivity to nalidixic acid and cephalothin, resistance to triphenyltetrazolium chloride and hippurate tests. Campylobacter strain do not oxidize and ferment carbohydrates, they do not hydrolyze urea, but they reduce nitrate, the following table presents the characteristics of some campylobacter strain. [2]

There are more than 30 species of *Campylobacter*. The species and subspecies that are most associated with human infections including *C. jejuni*, *C. coli*, *C. fetus*, *C. lari*. [3] *Campylobacters* spp., specifically *C. jejuni* and *C. coli*,cause campylobacteriosis in humans.[4]

*C. jejuni* is the cause of watery diarrhea or bloody diarrhea. Different strains of *C. jejuni*, like enterotoxigenic strains of *Escherichia coli* and *Shigella dysentery*, produce heat-resistant enterotoxin. Diarrhea-producing *C. jejuni* strains invade the intestinal epithelium with a method similar to *Shigella* infections. This bacterium is associated with Guillain-Barré syndrome. *Campylobacter* invades the lamina propria of the small and large intestine and causes cryptic abscesses. Unlike *C. fetus*, *C. jejuni* is very sensitive to the lysate and opsonic activity of antibodies and complement. [4]

The most common disease caused by *Campylobacter* is acute enteritis. After 3 to 5 days of latent period, the disease starts with severe watery or bloody diarrhea. Fever and abdominal pain are also accompanied by diarrhea. In some cases, abdominal pain is so severe that it looks more like appendicitis or acute ulcerative colitis. Stools contain Vibrio-like bacteria and may contain blood. *Campylobacteriosis* is a mild enteritis and is a self-limiting disease that usually lasts one to seven days. [5]

*Campylobacter* has been introduced as one of the main factors of sporadic food-borne enteritis in humans. [2] The transmission to individuals could take place by consumption of contaminated water, raw or unpasteurized milk, and contaminated food, especially poultry products*.* However, there are other sources like direct contact with domestic and wild animals. [3]

*Campylobacters* gradually acquire resistance with respect to antibiotics and some of them have developed multidrug resistance. [6] For years, macrolides and fluoroquinolones were the first and the second selections for antimicrobial treatment of enteritis caused by *campylobacters*. [7[ Use of fluoroquinolones as prophylaxis in poultry causes increased resistance in relation to fluoroquinolones. [8, 9] Chai *et al.* (2008) reported that the resistance of *C. jejuni* to the fluoroquinolones group of antibiotics is related to agricultural activities. [6]

Krumperman reported the usefulness of the Multiple Antibiotic Resistance Index for the identification of bacterial isolates from high-risk environments or contaminated stools. [10]

The studies on the two species *C. jejuni* and *C. coli* show that antimicrobial resistance (AMR) genes can rapidly transmit between animal and human strains. [5, 9] The transmission of this resistant campylobacter to human can complex the treatment of *Campylobacteriosis* in human and transfer resistant genes to gastrointestinal microflora of human.

Therefore, the present study conducted to comparison the antibiotic resistance pattern and multiple antibiotic resistance index (MAR Index) in the *Campylobacter* spp. isolates from animals and farm waters, in order to find alternative drugs, promising source of pharmaceutical agents, guiding therapy and epidemiological monitoring of resistance.

**Materials and methods**

*Sample collection*

This study was approved from respective Ethics Committee of Behbahan branch, Islamic Azad University (IR.BEH.EC. 12387). In all, 392 fecal and 28 drinking tap water samples were collected from 28 animal farms of Behbahan city (Khozestan Province, Iran). From these, 364 fecal samples were collected from poultry, cow, sheep and goat and 28 samples were collected from drinking tap water of animal farms. There was no history of previous disease outbreak in these farms. The Sampling was achieved between Jan and Sep 2021.

The samples were collected on sterile bags and falcon tube and examined for *Campylobacter* detection.

 *Sample processing and isolation*

In this study, the isolation of *Campylobacter* was achieved according to pre-treatment-Kapandis Baseri (prêt-KB) technique by antibiotic free Kapandis Baseri (KB, Merk, Germany) medium. For this, the fecal and water samples were suspended at 10% sterile phosphate-buffered saline (0.1 mol L-1, pH = 7). The suspension was centrifuged at 8500 rpm for 10 min and 0.1 ml supernatant from the prepared samples was cultured on the KB. The water samples were mixed with 10% sterile phosphate-buffered saline (0.1 mol L-1, pH = 7) and centrifuged in 4000 rpm within 10 minutes; then, 0.1 ml supernatant from the tube was cultured on the KB. [11]

All plates were incubated in microaerophilic conditions at 37°C for 48 h. All cultures examined daily for 5 days.

*Identification and confinement of Campylobacter spp.*

All suspected colonies grew on the KB were confirmed by typical morphology, motility, gram staining, catalase and oxidase tests. The isolates were examined for standard *Campylobacter* phenotypic identification that recommended by Atabay and Corry (1997). [12] These tests included H2S by lead acetate strip, nitrate reduction, growth in 1% glycine and 3.5% NaCl, at temperatures 25°C, 37°C, and 42°C. Furthermore, indoxyl acetate hydrolysis, hippurate hydrolysis, urease production, and resistance to nalidixic acid (30 μg) and cephalothin (30 μg) was examined. The Additional tests including oxidative-fermentative test, alkaline phosphatase production, and glucose fermentation for identification of *Campylobacters* were carried out.

At the end, the PCR method was utilized to confirm the phenotyping results.

*DNA extraction and PCR method*

DNA was extracted from suspected colony using phenol chloroform method. The PCR method was achieved in 25 ml of volume with 1μg of template DNA, 1 µmol L-1 universal primer (27F/1492R) or specific primer (*Campylo* 16SrRNAF/ *Campylo* 16SrRNAR), 3.2 m mol L-1 MgCl2, and 2 U/ 50μl of Taq DNA polymerase. The characteristics of primers were illustrated in table 1. All items used in the PCR were purchased from Yekta Tajhiz Azma (Tehran, Iran). PCRs were performed on a veriti 96-well fast thermal cycler (Applied Biosystems, Singapore), with an initial denaturation step of 94°C for 1 minute followed by 30 cycles of 94°C for 20 s, 54°C for 30 s (for 27F/1492R at 55°C for 30 s), and 72 °C for 40 s, along with a final extension step at 72 °C for 2 minutes. PCR products were electrophorized using 1% agarose gel at 80 V for 60 minutes. The amplified genumes were visualized with UV transilluminator (Heidolph*,* Germany) after staining ethidiumbromide (CinnaGen*,* Iran). A 100-bp DNA ladder (Yekta Tajhiz Azma, Tehran, Iran) was used as a DNA molecular ladder. The PCR products sent to Macrogen Company (Macrogen Inc. Seoul, Republic of Kore) for sequencing. The Basic Local Alignment Search Tool (BLAST) alignment tool (http://www.ncbi.nlm.nih.gov/BLAST/) was used to identify sequences in GenBank with the highest similarity to the isolated bacteria.

Table 1. The characteristics of primers

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Name of primers | Sequence (5 to 3) | Target gene | Annealing temperature (°C) | Amplicon size | Reference |
| 27F | AGAGTTTGATCMTGGCTCAG | 16SrRNA | 55 | 1490 | [13] |
| 1492R | CGGTTACCTTGTTACGACTT |
| *Campylo* 16SrRNAF | CCGGGAACGTATTCACCG | 16SrRNA | 54 | 1232 | [14] |
| *Campylo* 16SrRNAR | TGCCCTACACAAGAGGACAAC |

*Antibiotic susceptibility by disc diffusion method:*

The antimicrobial susceptibility pattern of the strains under study was studied by the disc diffusion method designed by Bauer et al. (1966). [15] To performing the disc diffusion method, each culture was grown in 5 mL of Muller-Hinton broth until the turbidity corresponded to 0.5 MacFarland standard tube (1.5×108 cells mL-1). The suspension was spread inoculated using sterile cotton swab onto Muller- Hinton agar plate and 14 types of antibiotics that are frequently used in clinical and agricultural practices were placed on it. After incubating, the plates at 37°C under microaerophilic conditions for 48 h, the inhibition zones were recorded.

The antibiotic discs included: ampicillin (10μg), amoxicillin/clavulanic ac. (20/10 μg), cephalotin (30 μg), cefotaxime (30 μg), imipenem (10 μg), streptomycin (10IU), gentamicin (15μg (10 IU)), kanamycin (30IU), tobramycin (10 μg), erythromycin (15 IU), nalidixic acid (30 μg), ciprofloxacin (5 μg), tetracycline (30 IU), and chloramphenicol (30 μg) ( [Padtanteb](https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwiwtemitfvRAhWFcRQKHadBBvQQFggaMAA&url=http%3A%2F%2Fwww.padtanteb.ir%2Fen-US%2F&usg=AFQjCNFNu-El5OOYEbsebyjwGIgtC75LtQ), Iran). [16]

*Multiple antibiotic resistance index (MAR index)*

The MAR index of the isolates was determined as a/b, where ‘a’ represents the number of multiple antibiotics to which the specific isolates are resistant, and ‘b’ represents the number of multiple antibiotics to which the specific isolates are exposed. [10]

**Results**

The fragment of 1490 bp was amplified in poultry, cow, sheep, and water samples (Figure 1). The highest and lowest frequency of *Campylobacter* species were isolated from poultry and sheep samples, respectively. The total of 50 *Campylobacter* isolates were identified in PCR method. The frequency of *Campylobacter* isolates was summarized in table 2.

****

Figure 1. PCR product electrophoresis (M: Marker, 1: positive control, 2 to 20: positive samples)

**Table 2. Frequency of *Campylobacter* spp. isolated from domestic animal feces and water**

|  |  |  |  |
| --- | --- | --- | --- |
| **Samples** | **No. of samples** | **No. of *Campylobacter* spp. isolated** | **occurrence of *Campylobacter* spp. isolated(%)** |
| Poultry feces | 182 | 37 | 20.3 |
| Cow faeses | 141 | 8 | 5.7 |
| Sheep feces | 41 | 2 | 4.9 |
| Water | 28 | 3 | 10.7 |
| Total | 392 | 50 | 12.8 |

In phenotyping evaluation and molecular confirmation, 36 strains of *C. jejuni* (72%) and 14 strains of *C*. *coli* (28%) were identified.

The highest and lowest frequency of *C. jejuni* and *C. coli* was isolated from poultry and sheep fecal samples, respectively*.* The frequency of *C. jejuni* and *C. coli* isolates in poultry, cow and sheep fecal samples and water samples was presented in Table 3.

**Table 3. Frequency of *C. jejuni* and\ *C. coli* isolated from domestic animal feces and water samples**

|  |  |  |  |
| --- | --- | --- | --- |
| **Samples** | **No. of *Campylobacter* spp. isolated** | **No. of *C. jejuni* isolated (%)** | **No. of *C. coli* isolated (%)** |
| Poultry feces | 37 | 29(78.4) | 8(21.6) |
| Cow feces | 8 | 4(50) | 4(50) |
| Sheep feces | 2 | 1(50) | 1(50) |
| Water | 3 | 2(66.67) | 1(33.34) |
| Total | 50 | 36(72) | 14(28) |

As shown in Table 4, all the isolates of Campylobacter were sensitive to ciprofloxacin, kanamycin, gentamicin, streptomycin, tobramycin, tetracycline, imipenem and resistant to amoxicillin/clavulanic, erythromycin and chloramphenicol. Amongst C. jejuni isolates, 91.7 of them were sensitive to cephalotin. Less than 50% of the C. jejuni and *C. coli* isolates were sensitive to nalidixic acid, ampicillin and cefotaxime. Amongst C. coli isolates, 85.7 of them were sensitive to cephalotin.

**Table 4.** **susceptibility of environmental *Campylobacter’s* isolates from domestic animal feces and water samples by disc diffusion method**

|  |  |  |
| --- | --- | --- |
| Antibiotics | *C. jejuni* (36) | *C. coli* (14) |
| \*CIP | 100 | 100 |
| NAL | 5.6 | 14.3 |
| KAN | 100 | 100 |
| GEN | 100 | 100 |
| STR | 100 | 100 |
| TOB | 100 | 100 |
| AMC | 0 | 0 |
| AMP | 36.1 | 8.6 |
| CEF | 91.7 | 85.7 |
| CTX | 36.1 | 7.1 |
| ERY | 0 | 0 |
| TET | 100 | 100 |
| IPM | 100 | 100 |
| CHL | 0 | 0 |

\*CIP: Ciprofloxacin, NAL: Nalidixic acid, KAN: Kanamycin, GEN: Gentamicin, STR: Streptomycin, TOB: Tobramycin, AMC: Amoxicillin/clavulanic ac., AMP: Ampicillin, CEF: Cephalotin, CTX: Cefotaxime, ERY: Erythromycin, TET: Tetracycline, IPM: Imipenem, CHL: Chloramphenicol

**Table 5. Antibiotic resistance profile and multiple antibiotic resistance index of *C.jejuni* and *C.coli* from poultry,cow and sheep and goat and water samples.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ***Campylobacter*species** | **Antimicrobial Resistance Pattern** | **Antimicrobial****Classes** | **No. of isolates (%)** | **MAR index** |
| ***C.jejuni*** | AMC, AMP, ERY, CHL | 4 | 1(2.8**%**) | 0.29 |
| NAL,AMC, ERY, CHL | 4 | 5(13.9**%**) | 0.29 |
| AMC, AMP,CTX, ERY, CHL | 5 | 1(2.8**%**) | 0.36 |
| NAL,AMC,CTX, ERY, CHL | 5 | 7(19.4**%**) | 0.36 |
| NAL,AMC, AMP, ERY, CHL | 5 | 6(16.6**%**) | 0.36 |
| NAL,AMC, CEF,CTX, ERY, CHL | 6 | 1(2.8**%**) | 0.43 |
| NAL,AMC, AMP,CTX, ERY, CHL | 6 | 13(36.1**%**) | 0.43 |
| NAL,AMC, AMP, CEF, ERY, CHL | 6 | 1(2.8**%**) | 0.43 |
| NAL,AMC, AMP, CEF,CTX,ERY, CHL | 7 | 1(2.8**%**) | 0.5 |
| ***C.coli*** | AMC, AMP, ERY, CHL | 4 | 1(7.1%) | 0.29 |
| AMC, AMP,CTX, ERY, CHL | 5 | 1(7.1**%)** | 0.36 |
| NAL,AMC,CTX, ERY, CHL | 5 | 4(28.6**%**) | 0.36 |
| NAL,AMC, AMP,CTX, ERY, CHL | 6 | 4(28.6**%**) | 0.43 |
| NAL,AMC, CEF,CTX, ERY, CHL | 6 | 2(14.3**%)** | 0.43 |
| NAL,AMC, AMP,CEF,CTX, ERY,CHL | 7 | 2(14.3**%**) | 0.5 |

AMC: Amoxicillin/clavulanic ac., AMP: Ampicillin, ERY: Erythromycin, CHL: Chloramphenicol, NAL: Nalidixic acid, CTX: Cefotaxime, CEF: Cephalotin

The antimicrobial resistance profile and MAR index of the *Campylobacter* isolates are shown in Table 5. All of the isolates were resistant to multiple antibiotics, with a multiple antibiotic resistance index (MARI) *≥* 0.2. The 36 *C. jejuni* strains exhibited 9 different antibiogram patterns. The majority of the *C.jejuni* strains (15 isolates) were resistant to six antibiotics (MAR index of 0.43) with the resistant pattern NAL AMC AMP CTX ERY CHL (13 isolates) dominating the group. The 14 *C.coli* strains showed 6 different resistance patterns. The majority of the *C.coli* strains (6 isolates) were resistant to six antibiotics (MAR index of 0.43). The resistant patterns AMC AMP ERY CHL, AMC AMP CTX ERY CHL and NAL AMC AMP CEF CTX ERY CHL were shared by one *C.jejuni* and one *C.coli* strains while NAL AMC CTX ERY CHL was common to seven *C.jejuni* and four *C.coli* strains. The resistant pattern NAL AMC AMP CTX ERY CHL was shared by 13 *C.jejuni* and 4 *C.coli* strains while NAL,AMC, CEF,CTX, ERY, CHL was common to one *C.jejuni* and two *C.coli* strains.

**Discussion**

Several researchers have stated that the use of antibiotics in animals and poultry as a growth supplement leads to antibiotic resistance and reduction in the effectiveness of these products in medicine and veterinary use. It is possible that during or after the antibiotic treatment, these resistant strains appear. [17] In the present study, all the isolated strains were sensitive to ciprofloxacin, tetracycline, imipenem, gentamicin, streptomycin, kanamycin, and tobramycin. Our study results for ciprofloxacin were similar to the findings by other researchers. [11, 18] In the recent decades, some of the authors have reported the increasing trend of resistance to ciprofloxacin in some of the *Campylobacter* species, especially those that are isolated from poultry. [9, 19, 20, 21] In our study, the *Campylobacter* isolates were sensitive in relation to tetracycline; similar reports have been delivered by other researchers. However, a few authors also reported resistance to tetracycline. [9, 19, 20] In our research, all isolates were sensitive in relation to aminoglycosides (gentamicin, streptomycin, kanamycin and tobramycin). Similar results have been reported by some authors. [18, 22, 23] In opposition, others have reported few cases of resistance in relation to these antibiotics in the *Campylobacter* species. [19, 21, 24] In our research, all the *Campylobacter* isolates were resistant to amoxicillin/clavulanic acid, erythromycin, and chloramphenicol. Some of the isolates exhibited variable resistances in relation to nalidixic acid, ampicillin, cefotaxime, and cephalothin. In our research, 100% of the isolated *Campylobacter* species were resistant to erythromycin, which is supported by the findings of other researchers. [18, 24] Numerous authors have reported results similar to our research for the resistance of *Campylobacter* isolates in relation to amoxicillin/clavulanic acid, ampicillin, nalidixic acid, cefotaxime, cephalothin, and chloramphenicol. [25, 26] However, some of the authors have reported cases of *Campylobacter* isolates’ sensitivity to amoxicillin/clavulanic acid, ampicillin, nalidixic acid, cefotaxime, cephalothin, and chloramphenicol. [23, 24] Our studies showed that all the *Campylobacter* isolates showed resistance to four to seven antibiotics. In our research, all isolates had multiple antibiotic resistance index 0.29-0.5. In Conclusion: The resistance of *C. jejuni* and *C. coli* to macrolides (erythromycin), amoxicillin/clavulanic acid, ampicillin, nalidixic acid, cefotaxime, cephalothin, and chloramphenicol was an alarming finding in this study since this resistance could result from the broad and non-methodical usage of these antibiotics in the veterinary field. Considering our research, ciprofloxacin is introduced as a selective antibiotic for campylobacteriosis and aminoglycosides, tetracycline and imipenem as the alternate antibiotics in this geographical zone. In this study, the entire isolates resistance to antibiotic had an MRA Index of 0.29 to 0.5. Considering of this index, the consumption of sheep, cows, or poultry, and contaminated food derived from them can be a source of danger and potential contamination. This could impact human health as well as the state of the commercial industry that deals with such edibles.

**Acknowledgements**

The authors thank to the laboratory manager of microbiology at the Behbahan Branch, Islamic Azad University, Behbahan, Iran.

**Approval of Ethics Committee**

This study approved in Ethics Committee of veterinary medicine faculty of Behbahan Branch, Islamic Azad University, Behbahan, Iran (IR.BEH.EC. 12387)

**References**

1. Rahimi E, Hormozipoor H, Ahangaran MG, Yazdi F. Prevalence of *Arcobacter* species on chicken carcasses during processing in Iran. J Appl Poult Res 2012; 21(2): 407-412.

2. Idris U, Lu J, Maier M, Sanchez S, Hofacre CL, Harmon BG, Maurer J, Lee MD. Dissemination of fluoroquinolone-resistant *Campylobacter* spp. within an integrated commercial poultry production system. Appl Environ Microbiol 2006; *72*(5): 3441-3447.

3. Denis M, Tanguy M, Chidaine B, Laisney MJ, Mégraud F, Fravalo P. Description and sources of contamination by *Campylobacter* spp. of river water destined for human consumption in Brittany France. Pathol Biol 2011*; 59*(5): 256-263.

4. Epps SV, Harvey RB, Hume ME, Phillips TD, Anderson RC, Nisbet DJ. Foodborne *Campylobacter*: infections metabolism pathogenesis and reservoirs. Int J Environ Res Public Health 2013*;* 10(12): 6292-6304.

5. Corcoran D, Quinn T, Cotter L, Fanning S. An investigation of the molecular mechanisms contributing to high-level erythromycin resistance in *Campylobacter*. Int J Antimicrob Agents. 2006; 27(1): 40-45.

6. Chai LC, Fatimah AB, Ghazali FM, Lee HY, Tunung R, Shamsinar AT, Laila RA, Thahirahtul AZ, Malakar PM, Nakaguchi Y, Nishibuchi M. Biosafety of *Campylobacter jejuni* from raw vegetables consumed as Ulam with reference to their resistance to antibiotics. Int Food Res J. 2008; 15(2): 100-110.

7. Lehtopolku M, Nakari UM, Kotilainen P, Huovinen P, Siitonen A, Hakanen AJ. Antimicrobial susceptibilities of multidrug-resistant Campylobacter jejuni and C. coli strains: in vitro activities of 20 antimicrobial agents. Antimicrob. Agents Chemother. 2010; 54(3): 1232-1236.

8. Obeng AS, Rickard H, Sexton M, Pang Y, Peng H, Barton M. Antimicrobial susceptibilities and resistance genes in *Campylobacter* strains isolated from poultry and pigs in Australia. J Appl Microbiol. 2012; 113(2): 294-307.

9. Lapierre L, Gatica MA, Riquelme V, Vergara C, Yañez JM, San Martin B, Saenz L, Vidal M, Martínez MC, Araya P, Flores R. Characterization of antimicrobial susceptibility and its association with virulence genes related to adherence, invasion, and cytotoxicity in *Campylobacter jejuni* and *Campylobacter* *coli* isolates from animals, meat, and humans. Microb Drug Resis. 2016; 22(5): 432-444.

10. Krumperman PH. Multiple antibiotic resistance indexing of Escherichia coli to identify high-risk sources of fecal contamination of foods. Appl Environ Microbiol. 1983; 46(1): 165-170.

11. Baserisalehi M, Bahador N, Kapadnis BP. A novel method for isolation of Campylobacter spp. from environmental samples, involving sample processing, and blood‐and antibiotic‐free medium. J of Appl Microbiol. 2004; 97(4): 853-860.

12. Atabay HI, Corry JE. The prevalence of *campylobacters* and *arcobacters* in broiler chickens. J Appl Microb. 1997; 83(5): 619-26.

13. Linton D, Lawson AJ, Owen RJ, Stanley JP C R. PCR detection, identification to species level, and fingerprinting of *Campylobacter jejuni* and *Campylobacter coli* direct from diarrheic samples. J Clin Microb 1997; 35(10): 2568-2572.

14. Oyofo B A, Thornton SA, Burr DH, Trust TJ, Pavlovskis O R, Guerry P. Specific detection of *Campylobacter* *jejuni* and *Campylobacter* *coli* by using polymerase chain reaction. J Clin Microbiol 1992; 30(10): 2613-2619.

15. Bauer AW, Kirby WM, Sherris JC, Truck M. Antibiotic susceptibility testing by a standardized single disk method. Am J Clin Pathol 1966; 45: 493–496

16. Horri M, Gholami-Ahangaran M. Phenotypic and Genotypic Characterization of Antibiotic Resistance in *Escherichia* *coli* Strains Isolated from Broiler Chickens with Suspected Colibacillosis in Isfahan Province, Iran. Infect Epidemiol Microbiol 2022; 8(3): 100-110.

17. Avrain L, Humbert F, L’Hospitalier R, Sanders P, Vernozy-Rozand C, Kempf I. Antimicrobial resistance in *Campylobacter* from broilers: association with production type and antimicrobial use. Vet Microbiol. 2003; 96(3): 267-276.

18. Ghane M, Bahador N, Baserisalehi M, Eghbali M. A comparative study on antimicrobial susceptibility of *campylobacter* spp. isolates from fecal samples of domestic animals and poultry in Tonekabon and Shiraz, Iran. J Pharm Sci. 2011; 2(2): 21-29.

19. Mattheus W, Botteldoorn N, Heylen K, Pochet B, Dierick K. Trend analysis of antimicrobial resistance in Campylobacter jejuni and Campylobacter coli isolated from Belgian pork and poultry meat products using surveillance data of 2004–2009. Foodborne Pathog Dis. 2012; 9(5): 465-72.

20. Zhong X, Wu Q, Zhang J, Shen S. Prevalence, genetic diversity and antimicrobial susceptibility of Campylobacter jejuni isolated from retail food in China. Food Control. 2016; 62: 10-15.

21. Han X, Zhu D, Lai H, Zeng H, Zhou K, Zou L, Wu C, Han G, Liu S. Prevalence, antimicrobial resistance profiling and genetic diversity of Campylobacter jejuni and Campylobacter coli isolated from broilers at slaughter in China. Food Control. 2016; 69:160-70.

22. Ferro ID, Benetti TM, Oliveira TC, Abrahão WM, Farah SM, Luciano FB, Macedo RE. Evaluation of antimicrobial resistance of *Campylobacter* spp. isolated from broiler carcasses. Br Poult Sci. 2015;56(1):66-71.

23. Khoshbakht R, Tabatabaei M, Hoseinzadeh S, Raeisi M, Aski HS, Berizi E. Prevalence and antibiotic resistance profile of thermophilic *Campylobacter* spp. of slaughtered cattle and sheep in Shiraz, Iran. Vet Res Forum. 2016; 7(3): 241-249.

24. Al‐Natour MQ, Alaboudi AR, Osaili TM, Obaidat MM. Resistance of Campylobacter jejuni isolated from layer farms in northern Jordan using microbroth dilution and disc diffusion techniques. J Food Sci. 2016;81(7):M1749-53.

25. Hariharan H, Sharma S, Chikweto A, Matthew V, DeAllie C. Antimicrobial drug resistance as determined by the E-test in *Campylobacter* *jejuni*, C. coli, and *C*. *lari* isolates from the ceca of broiler and layer chickens in Grenada. Comp Immunol Microbiol Infect Dis. 2009;32(1):21-28.

26. Zendehbad B, Khayatzadeh J, Alipour A. Prevalence, seasonality and antibiotic susceptibility of *Campylobacter* spp. isolates of retail broiler meat in Iran. Food Control. 2015; 53:41-45.