Jundishapur J Health Sci. 2021 July; 13(3):e116991. doi: 10.5812/jjhs.116991.

Published online 2021 August 24. **Research Article**

Evaluation of the Contamination of Poultry Carcasses with *Campylobacter jejuni* and *Campylobacter coli* in Southern Iran: A Molecular Study

Reyhaneh Rouhi Jahromi [1], Farhad Moradi [2,*], Saeideh Erfanian [1] and Mohammad Pourahmadi [3]

[1] Zoonoses Research Center, Jahrom University of Medical Sciences, Jahrom, Iran
[2] Department of Bacteriology and Virology, Shiraz University of Medical Sciences, Shiraz, Iran
[3] Research Center for Non-Communicable Diseases, Jahrom University of Medical Sciences, Jahrom, Iran

[*] *Corresponding author*: Department of Bacteriology and Virology, Shiraz University of Medical Sciences, Shiraz, Iran. Email: f.moradi1993@gmail.com

Received 2021 June 12; **Revised** 2021 August 04; **Accepted** 2021 August 10.

Abstract

Background: According to numerous reports, the contamination rates of *C. jejuni* (*C. jejuni*) and *Campylobacter coli* (*C. coli*) in animal sources, food products, and human clinical specimens were high in Iran.
Objectives: This study aimed to estimate the prevalence rate of these bacterial species in Fars province, south of Iran.
Methods: A total of 370 poultry carcasses were randomly collected from five slaughterhouses from January 2019 to June 2019. Using bacteriological and polymerase chain reaction (PCR) methods, we assessed *C. jejuni* and *C. coli* contamination rates in the samples.
Results: Based on the bacteriological results, 203 (54.8%) samples were recognized as Campylobacter species. Also, molecular analysis showed the prevalence of *C. coli* and *C. jejuni* in 73 (35.9%) and 130 (64.1%) samples, respectively.
Conclusions: Poultry carcasses are a potential public health risk regarding foodborne campylobacteriosis in south of Iran. Effective control measures and treatment strategies are necessary for poultry farms and slaughterhouses to decrease the transmission and occurrence of campylobacteriosis in human society.

Keywords: *C. coli*, *C. jejuni*, Prevalence, Poultry Products, Iran

1. Background

Campylobacter species are one of the four key global causes of foodborne and diarrheal diseases. The natural reservoirs for these organisms are warm-blooded animals such as poultry and sheep. Contaminated milk, water, and avian carcasses with campylobacter are generally known as the main transmission route of this bacterial species to human society. This contamination can occur during slaughtering process, infection with polluted feces, and poultry farm procedures. However, according to different studies, consumption of undercooked contaminated poultry is a major contributor for campylobacteriosis in humans (1-6). According to numerous reports, the occurrence of campylobacteriosis has increased in the world, especially in the Middle East regions and Asia (6, 7). As per the worldwide record, 20% - 35% of human diarrheas are caused by campylobacter species. In Iran, the prevalence rates of *Campylobacter jejuni* (*C. jejuni*) and *Campylobacter coli* (*C. coli*) in animal sources (34.71%, 68.73%), food products (42.18%, 72%), and human clinical specimens (7.77%, 25.84%) were high (4). In fact, campylobacteriosis is a zoonosis disease caused by *Campylobacter* species with common clinical symptoms and different complications. Antibiotics are considered as important and traditional agents for therapeutic or prophylactic purposes to control campylobacter infections in aviculture or poultry farms. Unfortunately, discontinuing administration of the offending antibiotic for treatment has led to appearance of antibiotic-resistant strains (4, 7-10). Today, an alternative approach to control and treat campylobacter infections is the usage of anti-campylobacter bacteriocins, campylobacter vaccines, and probiotics as food supplements in the poultry farms (11-22). Some studies showed the positive effects of probiotics on animals' immune systems (23-29). In addition, research on the epidemiology of infectious diseases, especially zoonosis microorganisms, is essential for designing a suitable plan, effective control measures,

and treatment strategies in poultry farms and slaughterhouses to reduce the prevalence of campylobacteriosis in human society.

2. Objectives

Although there are many epidemiological studies performed in Iran on *Campylobacter* species, information about the prevalence rate in poultry carcasses in Fars province is limited. Accordingly, this research aimed to evaluate the frequency of *C. jejuni* and *C. coli* among poultry carcasses through phenotypic and molecular methods.

3. Methods

3.1. Sample Collection

In this cross-sectional study, 370 samples of poultry carcasses were collected according to sample size formula ($n = Z^2P(1\text{-}P)/d^2$) from five slaughterhouses in south of Iran from January 2019 to June 2019. Twenty g of each sample was collected in a sterile vial, then transferred and kept at 4°C in Zoonosis Research Center of Jahrom University of Medical Sciences (JUMS) for next and molecular experiments.

3.2. Inclusion and Exclusion Criteria

Inclusion criteria were poultry carcasses directly provided after slaughtering process, and exclusion criteria were poultry products in the poultry farms, stores, and other avian carcasses.

3.3. Microbiological Assays

Sample collection and microbiological assays were determined according to Henao et al. (30) with some modification. Each sample was washed with 0.1% sterilized peptone water and centrifuged at 10000 × g for 20 minutes. The sediment was cultured in the Exeter broth (polymyxin 2500 IU/L, rifampin 5 mg/L, amphotericin B 2 mg/L, trimethoprim 10 mg/L, and cefoperazone 1.5 mg/L) and incubated at 42°C for 48 hours under microaerophilic conditions. Then, 100 μL of each sample was loaded on a selective Skirrow Agar (contained defibrinated horse blood 5%, polymyxin B 250 mg/L, vancomycin 10 mg/Lit, and trimethoprim 5 mg/L). After incubation for 48 hours, campylobacter colonies were identified with bacteriological methods such as colony features, gram staining, oxidase tests, nitrate reduction, catalase test, and hippurate hydrolysis test. In this study, *C. coli* (RTCC 2541) and *C. jejuni* (ATCC33560) strains were included as positive controls for both phenotypic and molecular identification. In addition, we provided the strains from Razi Vaccine and Serum Research Institute (Tehran, Iran) and Mast International Co. (USA). We selected the media plates with suspected colonies for polymerase chain reaction (PCR) assays.

3.4. DNA Extraction and Primers Information

In this study, four primer pairs were selected from the relevant articles and checked at https://blast.ncbi.nlm.nih.gov/Blast.cgi as follows: a 16s rRNA for detection of *Campylobacter* spp. (31), an *asp* (aspartokinase gene) for detection of *C. coli*, a *hipo* (hippuricase gene) for detection of *C. jejuni* (32), and a 16s Universal primer for internal control (15). For molecular assay, the primers and DNA extraction kit were purchased from Cinna Gen Inc., Tehran, Iran, and Iranian Nedaye Fan Company (Cat no.: PR881613), respectively.

3.5. Molecular Assays

The PCR was carried out using Jenet Bio kits (Cat no.: G-2000). Table 1 shows the information about primer sequences, annealing temperature, and amplicons size. The PCR micro tube contain; buffer (2.5 μL), Template (2 μL), Taq polymerase (1.25 units), $MgCl_2$ (1.5 mM), mixed dNTP 10 mM (1 μL), and primers (1 μL of 10 picomoles of each other and distilled water) and sterilized distilled water to complete the reaction volume (25 μL). The results were detected by gel electrophoresis and gel documentation (33).

3.6. Data Analysis and Statistics

Statistical analyses, calculated by chi-square test and ($P < 0.05$) using SPSS 21 software.

4. Results

According to biochemical and microbiological analyses, out of 370 poultry carcasses, 167 (45%) samples were not contaminated, and 203 samples were recognized as a *Campylobacter* species. Based on the molecular examination of these samples with suspected colonies in bacteriological examinations, 73 (19.7%; *C. coli*) and 130 (35.1%; *C. jejuni*) species were recognized as *Campylobacter* spp. (Figure 1).

Table 1. Characterization of Primers (F: Forward Primer, R: Revers Primer)

Target Gene	Primer Sequence	Annealing Temperature	Amplicon Size, bp	Reference
Universal	F: 5'- GGA GGC AGC AGT AGG GAA TA-3'	52°C	1062	(34)
	R: 5' TGA CGG GCG GTG AGTACA AG-3'			
***Campylobacter* spp. (16srRNA)**	F:5'-GGAGGATGACACTTTTCGGAGCG-3'	52°C	840	(31)
	R: 5'-TCGCGGTATTGCGTCTCATTGTATATGC-3'			
***C. jejuni* (*hipo*)**	F: 5'- GAC TTC GTG CAG ATA TGG ATG CTT-3'	52°C	344	(32)
	R: 5' GCT ATA ACT ATC CGA AGA AGC CAT CA-3'			
***C. coli* (*asp*)**	F: 5'- GGT ATG ATT TCT ACA AAG CGA G-3'	52°C	500	(32)
	R: 5' ATA AAA GAC TAT CGT CGC GTG-3'			

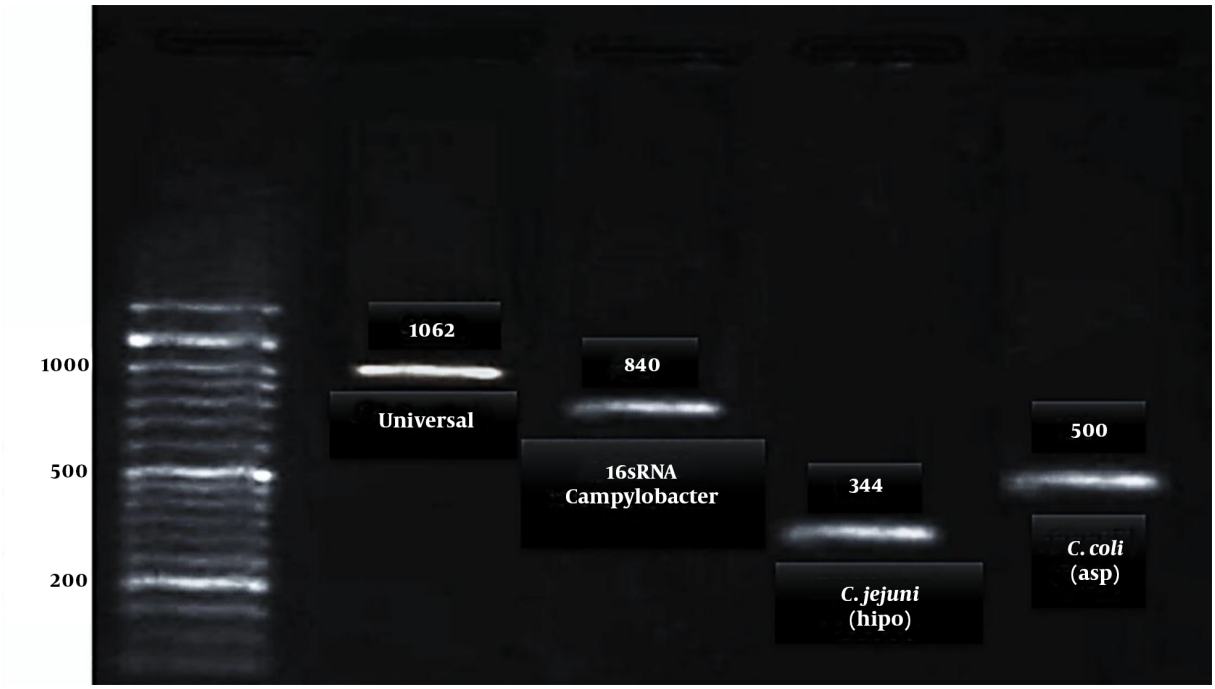

Figure 1. The results from electrophoresis of the products of the PCR-based amplification of DNA extracted from the *Campylobacter* Species

5. Discussion

Several studies reported that the prevalence and antibiotic-resistance rates of *C. coli* and *C. jejuni* are on the rise in Iran (4). According to our results, molecular detection confirmed the prevalence of these bacterial species among poultry carcasses in south of Iran. Today, *Campylobacter* spp. have a broad spread among aviculture and poultry farms in different countries. However, poultry carcasses and different avian products might be contaminated through animal feces during slaughtering technics in slaughterhouses. Also, these zoonotic bacteria are transmitted to the food chain and can be spread among human society. In the invasive form, *Campylobacter* can attack the intestinal mucosa cells and damage the tissues or remain without symptoms and keep shedding through carrier people. Generally, in this condition, using antibiotics is necessary to eliminate the carrier state and effective treatment. In addition, novel anti-*Campylobacter* treatments are suggested to decrease colonization in avian products and reduce campylobacteriosis in humans society. Today, different procedures are suggested to control the bacterial population in the poultry farms, including the use of probiotics to reduce the colonization in avians

and poultries as a feed additives or supplements besides decreasing the incidence of antibiotic-resistant strains and making poultry safer for human consumption (17, 28, 29, 35-38). In Iran, some poultry farms used these supplements in the food chain of young poultries with sterile gastrointestinal tract at birth time (28). Since information about epidemiology and frequency of the *Campylobacter* species among poultry carcasses after slaughtering process in our region is very limited, in this molecular study, we selected five slaughterhouses that process and sent the poultry products to different regions of the province. According to our results, molecular analysis confirmed the high prevalence of *C. coli* and *C. jejuni* among our samples compared to other studies in Iran. For instance; Abdi-Hachesoo et al. (39) showed the high contamination rate of *C. jejuni* (43/83) and *C. coli* (40/83) that isolated from poultry carcasses and other studies reported the occurrence of Campylobacter spp. in poultry meats in Tehran (Capital of Iran) and Mashhad (Khorasan Province) 63.2% and 76% respectively.). Furthermore, Taremi et al. (40) and Rahimi and Ameri (41)reported the incidence of *Campylobacter* spp. as 45.5% and 43.5% in ShahreKord, respectively (39-43). These findings are parallel with our results and disclosed a high prevalence of this bacterial species in Iran. Also, other studies showed the frequency of this bacterial species from Canada (62.4%), Korea (68.3%), and Japan (40% - 77%) (44, 45). Furthermore, a high incidence of campylobacter spp. in poultries was reported from Grenada, Reunion Island, China, and Spain (13-16). The high occurrence of zoonotic *Campylobacter* species in different countries indicates that poultry farms and slaughterhouses have different methods for slaughtering processes (17, 18, 39). Our study demonstrated that these products are a significant reservoir for *C. jejuni* and *C. coli* and increase the risk of transmission of this bacterial species to human society. Furthermore, this finding suggested that the revision of the poultry food programs, using probiotics as a nutritional supplement to health-promoting effects of poultries, and choosing suitable antibiotics to effective control of these bacterial species among animals are indispensable. in order to achieve the above objectives, it is hoped that further epidemiological studies be conducted to determine the frequency of *Campylobacter* species in other provinces of Iran.

5.1. Conclusions

The findings of this study indicated that consuming poultry carcasses is a potential public health risk in south of Iran regarding foodborne campylobacteriosis. Moreover, these data may assist in effective prevention of transmission of these bacterial species from slaughterhouses to human society, production of healthy animal food products, and revising treatment guidelines for poultries.

Acknowledgments

We would like to appreciate the collaboration of the Laboratory of Bacteriology and Zoonosis Research Center (JUMS).

Footnotes

Authors' Contribution: RR did study concept and design, expanding, revision, and editing the article. FM, SE, and MPA sample collection, and laboratory examinations. FM interpretation of data, literature search, and writing the first draft of the article. RR and FM definition of intellectual content and critical revision of the manuscript.

Conflict of Interests: The authors declare that there are no conflicts of interest regarding the publication of this article.

Ethical Approval: This study was approved by the Research Committee of JUMS (approval JUMS: REc.1394.048 and ethics code: 32/1393).

Funding/Support: This study was financially supported by the Research Committee of JUMS.

References

1. Es-Soucratti K, Hammoumi A, Bouchrif B, Asmai R, En-Nassiri H, Karraouan B. Occurrence and antimicrobial resistance of Campylobacter jejuni isolates from poultry in Casablanca-Settat, Morocco. *Ital J Food Saf.* 2020;**9**(1):8692. doi: 10.4081/ijfs.2020.8692. [PubMed: 32300573]. [PubMed Central: PMC7154602].
2. Soro AB, Whyte P, Bolton DJ, Tiwari BK. Strategies and novel technologies to control Campylobacter in the poultry chain: A review. *Compr Rev Food Sci Food Saf.* 2020;**19**(4):1353–77. doi: 10.1111/1541-4337.12544. [PubMed: 33337085].
3. Barletta F, Mercado EH, Lluque A, Ruiz J, Cleary TG, Ochoa TJ. Multiplex real-time PCR for detection of Campylobacter, Salmonella, and Shigella. *J Clin Microbiol.* 2013;**51**(9):2822–9. doi: 10.1128/JCM.01397-13. [PubMed: 23761159]. [PubMed Central: PMC3754658].
4. Moradi F, Akbari M, Zandi H, Rouhi Jahromi R. Prevalence and Antimicrobial Resistance of Campylobacter coli and Campylobacter jejuni in the Animals, Food Products, and Human Clinical Specimens in Iran During 2004 - 2017: A Review Study. *Jundishapur J Health Sci.* 2021;**12**(4). doi: 10.5812/jjhs.108609.
5. Younis G, Awad A, Khairy M. Molecular Characterization and Virulence of Campylobacter jejuni Isolated from Broiler Chickens. *Int J Poultry Sci.* 2018;**17**(10):499–506. doi: 10.3923/ijps.2018.499.506.

6. Moradi F, Hadi N, Akbari M, Hashemizadeh Z, Rouhi Jahromi R. Frequency and Antimicrobial Resistance of Shigella Species in Iran During 2000 - 2020. *Jundishapur J Health Sci*. 2021;**13**(2). doi: 10.5812/jjhs.114902.
7. Bakhshi B, Naseri A, Alebouyeh M. Comparison of Antimicrobial Susceptibility of Campylobacter Strains Isolated from Food Samples and Patients with Diarrhea. *Iran Biomed J*. 2016;**20**(2):91–6. [PubMed: 26783018]. [PubMed Central: PMC4726889].
8. Aslantaş Ö. Isolation and molecular characterization of thermophilic Campylobacter spp. in dogs and cats. *Kafkas Univ Vet Fak Derg*. 2019;**25**:341–8.
9. Rouhi R, Moradi F, Erfanian S, Faraji SZ, Farhang Zargar M, Razeghi B, et al. Molecular Analyses of the Prevalence of Campylobacter Detected from the Poultry Meat and its Byproducts. *Ambient Sci*. 2019;**6**(2):7–10.
10. Bardon J, Pudova V, Kolackova I, Karpiskova R, Roderova M, Kolar M. Virulence and antibiotic resistance genes in Campylobacter spp. in the Czech Republic. *Epidemiol Mikrobiol Imunol*. 2017;**66**(2):59–66. [PubMed: 28691828].
11. Rohi R, Erfanian S, Zargar MF, Shabani M, Moradi F, Hashempour A, et al. Molecular Assay of the Contamination of the Vaccinated Livestock Milk from West South of Iran: a Warning Report Against Brucellosis. *Ambient Sci*. 2018;**5**(2, Sp1 & Sp2). doi: 10.21276/ambi.2018.05.2.ra05.
12. Falsafi T, Ebrahimi M, Asgarani E, Mirtorabi V. The pattern, association with multidrug-resistance and transferability of plasmid-mediated tetracycline resistance inEscherichia coli isolates from the poultry in Iran. *Ann Microbiol*. 2009;**59**(2):199–205. doi: 10.1007/bf03178318.
13. Ma L, Wang Y, Shen J, Zhang Q, Wu C. Tracking Campylobacter contamination along a broiler chicken production chain from the farm level to retail in China. *Int J Food Microbiol*. 2014;**181**:77–84. doi: 10.1016/j.ijfoodmicro.2014.04.023. [PubMed: 24831929].
14. 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):21–8. doi: 10.1016/j.cimid.2008.01.010. [PubMed: 18329712].
15. Henry I, Reichardt J, Denis M, Cardinale E. Prevalence and risk factors for Campylobacter spp. in chicken broiler flocks in Reunion Island (Indian Ocean). *Prev Vet Med*. 2011;**100**(1):64–70. doi: 10.1016/j.prevetmed.2011.03.007. [PubMed: 21511349].
16. Torralbo A, Borge C, Garcia-Bocanegra I, Meric G, Perea A, Carbonero A. Higher resistance of Campylobacter coli compared to Campylobacter jejuni at chicken slaughterhouse. *Comp Immunol Microbiol Infect Dis*. 2015;**39**:47–52. doi: 10.1016/j.cimid.2015.02.003. [PubMed: 25770597].
17. Chopra I, Roberts M. Tetracycline antibiotics: mode of action, applications, molecular biology, and epidemiology of bacterial resistance. *Microbiol Mol Biol Rev*. 2001;**65**(2):232–60. doi: 10.1128/MMBR.65.2.232-260.2001. [PubMed: 11381101]. [PubMed Central: PMC99026].
18. Hamidian M, Sanaei M, Azimi-Rad M, Tajbakhsh M, Dabiri H, Zali M. fla-typing, RAPD analysis, isolation rate and antimicrobial resistance profile of Campylobacter jejuni and Campylobacter coli of human origin collected from hospitals in Tehran, Iran. *Ann Microbiol*. 2010;**61**(2):315–21. doi: 10.1007/s13213-010-0141-1.
19. Al-Mahmeed A, Senok AC, Ismaeel AY, Bindayna KM, Tabbara KS, Botta GA. Clinical relevance of virulence genes in Campylobacter jejuni isolates in Bahrain. *J Med Microbiol*. 2006;**55**(Pt 7):839–43. doi: 10.1099/jmm.0.46500-0. [PubMed: 16772409].
20. Rahimi E, Momtaz H, Ameri M, Ghasemian-Safaei H, Ali-Kasemi M. Prevalence and antimicrobial resistance of Campylobacter species isolated from chicken carcasses during processing in Iran. *Poult Sci*. 2010;**89**(5):1015–20. doi: 10.3382/ps.2009-00090. [PubMed: 20371855].
21. Perez-Boto D, Herrera-Leon S, Garcia-Pena FJ, Abad-Moreno JC, Echeita MA. Molecular mechanisms of quinolone, macrolide, and tetracycline resistance among Campylobacter isolates from initial stages of broiler production. *Avian Pathol*. 2014;**43**(2):176–82. doi: 10.1080/03079457.2014.898245. [PubMed: 24689432].
22. Qin SS, Wu CM, Wang Y, Jeon B, Shen ZQ, Wang Y, et al. Antimicrobial resistance in Campylobacter coli isolated from pigs in two provinces of China. *Int J Food Microbiol*. 2011;**146**(1):94–8. doi: 10.1016/j.ijfoodmicro.2011.01.035. [PubMed: 21349598].
23. Vicente A, Barros R, Florinda A, Silva A, Hanscheid T. High rates of fluoroquinolone-resistant Campylobacter in Portugal–need for surveillance. *Euro Surveill*. 2008;**13**(6). [PubMed: 18445426].
24. Luangtongkum T, Morishita TY, Ison AJ, Huang S, McDermott PF, Zhang Q. Effect of conventional and organic production practices on the prevalence and antimicrobial resistance of Campylobacter spp. in poultry. *Appl Environ Microbiol*. 2006;**72**(5):3600–7. doi: 10.1128/AEM.72.5.3600-3607.2006. [PubMed: 16672508]. [PubMed Central: PMC1472326].
25. Gibreel A, Kos VN, Keelan M, Trieber CA, Levesque S, Michaud S, et al. Macrolide resistance in Campylobacter jejuni and Campylobacter coli: molecular mechanism and stability of the resistance phenotype. *Antimicrob Agents Chemother*. 2005;**49**(7):2753–9. doi: 10.1128/AAC.49.7.2753-2759.2005. [PubMed: 15980346]. [PubMed Central: PMC1168676].
26. Taylor DE, Garner RS, Allan BJ. Characterization of tetracycline resistance plasmids from Campylobacter jejuni and Campylobacter coli. *Antimicrob Agents Chemother*. 1983;**24**(6):930–5. doi: 10.1128/AAC.24.6.930. [PubMed: 6318666]. [PubMed Central: PMC185410].
27. Tenover FC, Williams S, Gordon KP, Nolan C, Plorde JJ. Survey of plasmids and resistance factors in Campylobacter jejuni and Campylobacter coli. *Antimicrob Agents Chemother*. 1985;**27**(1):37–41. doi: 10.1128/AAC.27.1.37. [PubMed: 2984981]. [PubMed Central: PMC176201].
28. Johnson TJ, Shank JM, Johnson JG. Current and Potential Treatments for Reducing Campylobacter Colonization in Animal Hosts and Disease in Humans. *Front Microbiol*. 2017;**8**:487. doi: 10.3389/fmicb.2017.00487. [PubMed: 28386253]. [PubMed Central: PMC5362611].
29. Aziz Mousavi SMA, Mahmoodzadeh Hosseini H, Mirhosseini SA. A Review of Dietary Probiotics in Poultry. *J Appl Biotechnol Rep*. 2018;**5**(1):48–54. doi: 10.29252/jabr.05.02.02.
30. Henao OL, Jones TF, Vugia DJ, Griffin PM, Foodborne Diseases Active Surveillance Network W. Foodborne Diseases Active Surveillance Network-2 Decades of Achievements, 1996-2015. *Emerg Infect Dis*. 2015;**21**(9):1529–36. doi: 10.3201/eid2109.150581. [PubMed: 26292181]. [PubMed Central: PMC4550136].
31. Vanniasinkam T, Lanser JA, Barton MD. PCR for the detection of Campylobacter spp. in clinical specimens. *Lett Appl Microbiol*. 1999;**28**(1):52–6. doi: 10.1046/j.1365-2672.1999.00474.x. [PubMed: 10030032].
32. Andrzejewska M, Szczepanska B, Spica D, Klawe JJ. Prevalence, Virulence, and Antimicrobial Resistance of Campylobacter spp. in Raw Milk, Beef, and Pork Meat in Northern Poland. *Foods*. 2019;**8**(9). doi: 10.3390/foods8090420. [PubMed: 31533265]. [PubMed Central: PMC6770586].
33. Gibreel A, Tracz DM, Nonaka L, Ngo TM, Connell SR, Taylor DE. Incidence of antibiotic resistance in Campylobacter jejuni isolated in Alberta, Canada, from 1999 to 2002, with special reference to tet(O)-mediated tetracycline resistance. *Antimicrob Agents Chemother*. 2004;**48**(9):3442–50. doi: 10.1128/AAC.48.9.3442-3450.2004. [PubMed: 15328109]. [PubMed Central: PMC514748].
34. Persson S, Olsen KE. Multiplex PCR for identification of Campylobacter coli and Campylobacter jejuni from pure cultures and di-

rectly on stool samples. *J Med Microbiol*. 2005;**54**(Pt 11):1043–7. doi: 10.1099/jmm.0.46203-0. [PubMed: 16192435].
35. Kaakoush NO, Castano-Rodriguez N, Mitchell HM, Man SM. Global Epidemiology of Campylobacter Infection. *Clin Microbiol Rev*. 2015;**28**(3):687–720. doi: 10.1128/CMR.00006-15. [PubMed: 26062576]. [PubMed Central: PMC4462680].
36. Signorini ML, Rossler E, Diaz David DC, Olivero CR, Romero-Scharpen A, Soto LP, et al. Antimicrobial Resistance of Thermotolerant Campylobacter Species Isolated from Humans, Food-Producing Animals, and Products of Animal Origin: A Worldwide Meta-Analysis. *Microb Drug Resist*. 2018;**24**(8):1174–90. doi: 10.1089/mdr.2017.0310. [PubMed: 29708832].
37. Wieczorek K, Szewczyk R, Osek J. Prevalence, antimicrobial resistance, and molecular characterization of Campylobacter jejuni and C. coli isolated from retail raw meat in Poland. *Vet Med*. 2012;**57**(No. 6):293–9. doi: 10.17221/6016-vetmed.
38. Noormohamed A, Fakhr MK. A higher prevalence rate of Campylobacter in retail beef livers compared to other beef and pork meat cuts. *Int J Environ Res Public Health*. 2013;**10**(5):2058–68. doi: 10.3390/ijerph10052058. [PubMed: 23698698]. [PubMed Central: PMC3709364].
39. Abdi-Hachesoo B, Khoshbakht R, Sharifiyazdi H, Tabatabaei M, Hosseinzadeh S, Asasi K. Tetracycline Resistance Genes in Campylobacter jejuni and C. coli Isolated From Poultry Carcasses. *Jundishapur J Microbiol*. 2014;**7**(9). e12129. doi: 10.5812/jjm.12129. [PubMed: 25485062]. [PubMed Central: PMC4255377].
40. Taremi M, Mehdi Soltan Dallal M, Gachkar L, MoezArdalan S, Zolfagharian K, Reza Zali M. Prevalence and antimicrobial resistance of Campylobacter isolated from retail raw chicken and beef meat, Tehran, Iran. *Int J Food Microbiol*. 2006;**108**(3):401–3. doi: 10.1016/j.ijfoodmicro.2005.12.010. [PubMed: 16481059].
41. Rahimi E, Ameri M. Antimicrobial resistance patterns of Campylobacter spp. isolated from raw chicken, turkey, quail, partridge, and ostrich meat in Iran. *Food Control*. 2011;**22**(8):1165–70. doi: 10.1016/j.foodcont.2011.01.010.
42. Fani F, Aminshahidi M, Firoozian N, Rafaatpour N. Prevalence, antimicrobial resistance, and virulence-associated genes of Campylobacter isolates from raw chicken meat in Shiraz, Iran. *Iran J Vet Res*. 2019;**20**(4):283–8. [PubMed: 32042293]. [PubMed Central: PMC6983316].
43. Dallal MM, Doyle MP, Rezadehbashi M, Dabiri H, Sanaei M, Modarresi S, et al. Prevalence and antimicrobial resistance profiles of Salmonella serotypes, Campylobacter and Yersinia spp. isolated from retail chicken and beef, Tehran, Iran. *Food Control*. 2010;**21**(4):388–92. doi: 10.1016/j.foodcont.2009.06.001.
44. Sallam KI. Prevalence of Campylobacter in chicken and chicken by-products retailed in Sapporo area, Hokkaido, Japan. *Food Control*. 2007;**18**(9):1113–20. doi: 10.1016/j.foodcont.2006.07.005.
45. Mazi W, Senok A, Al-Mahmeed A, Arzese A, Bindayna K, Botta G. Trends in antibiotic sensitivity pattern and molecular detection of tet(O)-mediated tetracycline resistance in campylobacter jejuni isolates from human and poultry sources. *Jpn J Infect Dis*. 2008;**61**(1):82–4. [PubMed: 18219143].