



## Prevalence and antibiotic susceptibility pattern of *Campylobacter* species isolated from broiler chicken meat samples in district Bannu, Pakistan

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### ABSTRACT

The *campylobacter* genus of bacteria is important in public health as it comprises many species causing diarrhea in humans. Poultry and their products are recognized as vital causes of campylobacteriosis in humans. For bacterial food-borne diseases, *Campylobacter* is considered as the leading cause. Higher prevalence has been reported in developed countries. Our study was a cross-sectional study directed to determine the prevalence of *Campylobacter* species in retail broiler meat in the Bannu district of Khyber Pakhtunkhwa, Pakistan, from January to June 2018. A total of 200 poultry meat samples were collected from four different areas of district Bannu Khyber Pakhtunkhwa province of Pakistan that includes Lakki gate, Tanchi bazar, Bannu Township and Mangal milla. Mueller-Hinton medium was used for disc diffusion method to determine antibiotic resistance of *Campylobacter* species. Amongst 200 broiler meat samples, 60 (30%) samples were found positive for *Campylobacter* species. The highest prevalence was observed in samples from Bannu Township (50%) while lowest prevalence (12%) was observed in samples from Mangal milla broiler meat samples. Amongst different types of meat samples, highest prevalence was found in thigh meat (46%), while lowest prevalence was observed in cloacal swab (20%). Highest resistance was observed against Amoxicillin (AMX) 80% while the resistance observed against other antibiotics were Ampicillin (AMP) 70%, Tetracycline (TET) 65%, Sulphamethoxazole + Trimethoprim (SXT) 60%, Chloramphenicol (CHL) 56.66%, Clarithromycin (CLR) 50%, Streptomycin (STR) 40%, Gentamycin (GEN) 36.66%, Ofloxacin (OFX) 20%, Ciprofloxacin (CIP) 15%, Levofloxacin (LEV) 15% and Azithromycin (AZM) 10%. The lowest resistance was observed against Ceftriaxone (CRO) 5%. Our Study concludes that *Campylobacter* species is prevalent highly in district Bannu, and it might be a hazard to public health.

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### 1. Introduction

*Campylobacter* species are spiral rod-shaped gram-negative bacteria. They are motile, non-spore-forming bacteria and grow in micro-aerobic conditions. In the globe, it is considered as one of the main public health problem (1).

*Campylobacter jejuni* is the major disease-causing strain of thermo-tolerant *Campylobacter*. This strain is commonly associated with the campylobacteriosis (2). Campylobacteriosis is a zoonotic problem transmitted from animal or their product to human. While it causes self-limiting infection in human but some of them may cause complication such as bacteremia, abortion, reactive arthritis, and Guillain-Barre syndrome (3).

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Eating contaminated raw or not properly cooked chicken products have been identified by many studies as the key vector for causing campylobacteriosis (4). *Campylobacter* species are pathogens mainly responsible for zoonosis, and they are commonly isolated from numerous species of animals, including poultry, pigs, sheep, cattle, wild birds, etc (5). The major route for infection in humans is considered due to the consumption and management of contaminated poultry meat (6). It has been considered a significant cause of human enteritis since 1970 (7). In comparison to *Salmonella* species, the major cause of gastroenteritis is considered as *campylobacter* (8).

Amongst the 17 accurately named species in the *Campylobacter* genus, *C.jejuni* ssp. *jejuni*, *Campylobacter coli*, *Campylobacter fetus* ssp. *fetus*, *Campylobacter upsaliensis*, *Campylobacter lari* and *campylobacter hyointestinalis* ssp. *hyointestinalis* are the acknowledged cause of human intestinal infections (9). The most commonly *campylobacter* species reported is *C. jejuni* (80-90%) while *C. coli* is reported (5-10%) (10).

Poultry and their products are recognized as vital causes of Campylobacteriosis in human. For bacterial foodborne diseases, *Campylobacter* is considered as the leading cause. Higher prevalence has been reported in developed countries (11). Diseases caused by *C. jejuni* and *C. coli* in humans are common and generally transmitted through meat, milk and water (12). The most frequent source of infection is retail meat products, predominantly meat from poultry and for campylobacteriosis it is measured as main risk factor in human (13). By expressing characteristics of antibiotic resistance and diverse virulence determinants, the pathogenicity and survivability of *Campylobacter* strains is improved (14).

The main cause of *Campylobacter* infection in humans is considered as poultry meat, and their acquisition is via the fecal-oral route. Food Standards Agency shows 62.5% prevalence of *Campylobacter* species in poultry meat in the United Kingdom (15). Correspondingly, in poultry and chickens, *C. jejuni* have been reported in many earlier studies (16). Previous study done by Berrang *et al.* reported that the surface of poultry carcasses contamination by *Campylobacter* occur during handling of intestinal track (17). There might be a chance of cross-contamination from raw meat that can happen during cooking at home. The potential risk factors related with human *Campylobacter* and *Salmonella* infection is cross-contamination to other products and contaminated raw meats handling (18). Sporadic human incidence might occur due to eating not properly cooked poultry meat while epidemics are

mostly associated with the raw milk (19). In the United States approximately half of the total sporadic *Campylobacter* problems are associated with foods prepared in restaurants (20). Antibiotic resistance has been developed in many microbes including *E. coli*, *Salmonella*, *Enterococcus* and *Campylobacter* due to use of antibiotic in animals envisioned for food. Through food chain this resistance can be transferred to human (21). Due to the extensive usage of the drug in animals and poultry production, an increase in drug resistance to fluoroquinolones in isolates of *Campylobacter* has been observed in the United States (22). In foodborne pathogens multidrug resistance is often noticed. In a number of studies multidrug resistance in *Campylobacter* have been observed. A previous study done by Zoran *et al.* in Serbia shows that 10% of *C. jejuni* and 16.3% of *Campylobacter coli* were observed to be resistant to three or at least one in three classes of antibiotics (23). Other earlier studies reported that in *C. coli* multidrug resistance was common than *C. jejuni* (24,25). Therefore, this study was conducted to found the prevalence of *Campylobacter* species in raw broiler meat and to determine the antibiotic resistance in *Campylobacter* species isolated from broiler meat samples.

## 2. Materials and Methods

### 2.1.Sampling

A total of 200 poultry meat samples were collected from four different areas of district Bannu Khyber Pakhtunkhwa province of Pakistan that includes Lakki gate, Tanchi bazar, Bannu Township, and Mangal milla. From each area, 50 broiler meat samples were collected from January to June 2018. In an icebox, all the collected samples were transported to the laboratory where they were handled on the same day for the isolation and identification of *Campylobacter* species.

### 2.2.Isolation

Conventional methods were used for isolation and identification of *Campylobacter* species. In 1:10 buffered peptone water, the samples were homogenized in a stomacher for 2 min. Into 45 ml of Preston broth (Oxoid cat no SR0129, England) supplemented with antibiotics such as Polymyxin B, Rifampicin, Trimethoprim, and Cycloheximide (Oxoid), 5 ml of the homogenized sample was added for enrichment. The first media was incubated at 37°C for 4 h, then under microaerophilic condition it was incubated at 44°C for 44 h. Microaerophilic condition was created by using campy gas sachet (Gaspak EZ company container BBL 260680) in an anaerobic jar. After 48 h combined incubation, on surface of *Campylobacter* blood-free selective agar plate

(Oxoid cat no CM0739, england) comprising growth supplements (Oxoid cat no SR0155E england), 100 microliter of the broth culture was spread evenly. Under microaerophilic conditions, for 48 h the plates were incubated. Positive growth of *Campylobacter* isolates was further subjected to gram staining, motility test, and standard biochemical tests consisting of oxidase, nitrate reduction, catalase, indoxyl acetate.

### 2.3. Antibiotic susceptibility testing

The disc diffusion method described by CLSI, (2006) (26) was used for antibiotic susceptibility testing against all isolates. Mueller-Hinton broth supplemented with sodium pyruvate, sodium metabisulphite, and ferrous sulphate was used for the enrichment of each isolate. The inoculum was allowed to reach 0.5 McFarland standard turbidity level. After attaining the desired turbidity, then on the surface of Mueller- Hinton agar plate, supplemented with 5% lysed horse blood, 0.1 ml aliquot was spread. For drying, the plates were allowed, and then antibiotic disks were placed over the plates. The plates were then incubated for 48 h at 42°C. By using a digital caliper, the zones of inhibition were measured. The following antibiotics including AZM (15 µg), AMP (10 µg), SXT (25 µg), CIP (5 µg), OFX (5 µg), LEV (5 µg), CLR (15 µg), CHL (30 µg), TET (30 µg), STR (10 µg), GEN (10 µg), AMX (20 µg) and CRO (30 µg) (Oxoid) were used for the susceptibility study.

**Table 1.** Distribution of samples

Sample type	Number of samples
Breast piece	50
Leg piece	50
Skin	50
Cloacal swab	50
<b>Total</b>	<b>200</b>

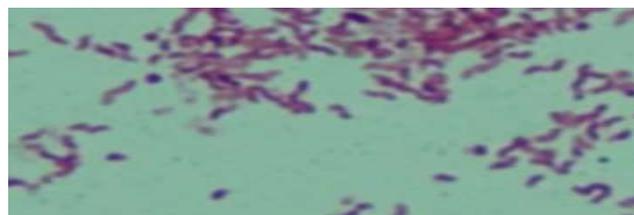
### 2.4. Statistical Analysis

SPSS version 22 for windows was used for the statistical analysis of data.

## 1. Results

A total of 200 poultry meat samples were collected from four different areas, microscopically the bacteria observed were gram negative rods (Fig. 1). Greyish small flat colonies were observed on selective medium

(Fig. 2). The results of the identification tests are given in (Table 2). Among 200 broiler meat samples 60 (30%) samples were found positive for *Campylobacter* species (Table 3). Highest prevalence was observed in samples from Bannu Township (50%), followed by Lakki gate (30%) and Tanchi bazar (28%) while lowest prevalence (12%) was observed in samples from Mangal milla meat samples (Fig. 3). Among different type meat samples highest prevalence was found in thigh meat (46%), followed by breast piece (30%) and skin (24%) while lowest prevalence was observed in cloacal swab (20%) (Fig. 4). Highest resistance was observed against AMX (80%) while the resistance observed against other antibiotics were AMP (70%), TET (65%), SXT (60), CHL (56.66%), CLR (50%), STR (40%), GEN (36.66%), OFX (20%), CIP (15%), LEV (15%) and AZM (10%). Lowest resistance was observed against CRO (5%) (Table 4).



**Figure 1.** Gram staining of *Campylobacter* species



**Figure 2.** Growth of *Campylobacter* species on selective media

**Table 2.** Results of identification testing for *Campylobacter* species

Serial number	Test	Result
1	Catalase	Positive
2	Oxidase	Positive
3	Nitrate reduction	Positive
4	Indoxyl acetate	Positive
5	Motility	Positive

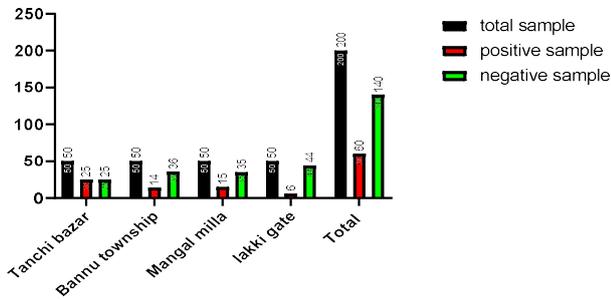


Figure 3. Area wise prevalence of *Campylobacter* species in broiler meat sample in district Bannu

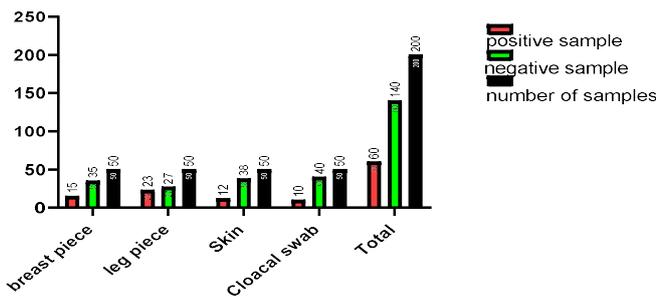


Figure 4. Sample wise prevalence of *Campylobacter* species in broiler meat sample in district Bannu

2. Discussion

*Campylobacter* species are spiral rod shaped gram negative bacteria. They are motile, non-spore-forming bacteria and grow in micro-aerobic condition. In the globe it is considered as one of the main public health problem (1). *C. jejuni* is the major disease causing strain of thermo-tolerant *Campylobacter*. This strain is commonly associated with the campylobacteriosis (2).

Campylobacteriosis is a zoonotic problem transmitted from animal or their product to human. While it cause self-limiting infection in human but some, it cause complication such as bacteremia, abortion, and reactive arthritis and Guillain-Barre syndrome (3). Eating of contaminated raw or not properly cooked chicken products have been identified by many studies as the key vector for causing campylobacteriosis (4).

Table 3. Over all prevalence of *Campylobacter* species in broiler meat sample in district Bannu

Sample	Positive n (%)	Negative n (%)
Broiler meat	60 (30)	140 (70)

Microscopically the bacteria observed were gram-negative rods. Greyish small flat colonies were observed on selective medium. The results of the identification tests are given in (Table 2). Among 200-broiler meat samples, 60 (30%) samples were found positive for *Campylobacter* species. Highest prevalence was observed in samples from Bannu Township (50%), followed by Lakki gate (30%) and Tanchi bazar (28%) while lowest prevalence (12%) was observed in samples from Mangal milla meat samples. Among different type meat samples highest prevalence was found in thigh meat (46%), followed by breast piece (30%) and skin (24%) while lowest prevalence was observed in cloacal swab (20%). Highest resistance was observed against AMX (80%) while the resistance observed against other antibiotics were AMP (70%), TET (65%), SXT (60), CHL (56.66%), CLR (50%), STR (40%), GEN (36.66%), OFX (20%), CIP (15%), LEV (15%) and AZM (10%). Lowest resistance was observed against CRO(5%).

In poultry meat, different prevalence of *Campylobacter* have been reported in different countries such as in Northern Ireland 85% (27), in Poland 87% (28), in Estonia 20.8% (29) and in Italy 73-81% (30,31). These results are not in accordance with our reported prevalence and this might be due to different climatic conditions, techniques of slaughtering etc. Sampling type may also be the reason for this. In the world after infections, antibiotic resistance is one of the greatest hazard to the public health. Different countries reported different pattern of antimicrobial resistance in *Campylobacter* species. In Switzerland, Ledergerber et al. observed 28.7% resistance to Ciprofloxacin followed by 12.6% to Tetracycline, 11.8% to Sulphonamide and observed lowest (10.3%) resistance to Ampicillin (32).

**Table 4:** Antibiotic resistance profile of *Campylobacter* species isolates

Serial No	Antimicrobial drugs	Concentration	Code	Drug susceptibility	<i>Campylobacter</i> species (n)%
1	Tetracycline	30µg	TET	Susceptible	21 (35)
				Resistant	39 (65)
2	Azithromycin	15µg	AZM	Susceptible	54 (90)
				Resistant	6 (10)
3	Chloramphenicol	30µg	CHL	Susceptible	26 (43.33)
				Resistant	34 (56.66)
4	Ciprofloxacin	5µg	CIP	Susceptible	51 (85)
				Resistant	9 (15)
5	Levofloxacin	5 µg	LEV	Susceptible	51 (85)
				Resistant	9 (15)
6	Ampicillin	10µg	AMP	Susceptible	18 (30)
				Resistant	42 (70)
7	Sulphamethoxazole + Trimethoprim	25 µg	SXT	Susceptible	24 (40)
				Resistant	36 (60)
8	Ofloxacin	5 µg	OFX	Susceptible	48 (80)
				Resistant	12 (20)
9	Clarithromycin	15 µg	CLR	Susceptible	30 (50)
				Resistant	30 (50)
10	Streptomycin	10 µg	STR	Susceptible	36 (60)
				Resistant	24 (40)
11	Gentamycin	10 µg	GEN	Susceptible	38 (63.33)
				Resistant	22 (36.66)
12	Amoxicillin	20 µg	AMX	Susceptible	12 (20)
				Resistant	48 (80)
13	Ceftriaxone	30 µg	CRO	Susceptible	57 (95)
				Resistant	3 (5)

AMP (47.4%), CIP (42.1%), Erythromycin (12.1%), GEN (25.6%), Nalidixic acid (46.4%) and TET (45.3%) resistance was observed by Mattheus et al. in a study done in Belgium (33). For Tetracycline 18.4% resistance and for Ampicillin 17.6% resistance was reported by Miflin et al. in a study done on *C. jejuni* (34). In *Campylobacter* species from broiler meat in South Africa Bester et al. observed highest resistance for Tetracycline and Ceftriaxone as 98.2% and 96.4% respectively (35). Extensive resistance

of *Campylobacter* to various antibiotics including Lincomycin (51-100%), Ampicillin (33.3-60.2%) and Tetracycline (5.6-40.7%) have been observed in a study done by Obeng et al. (36). In a recent study done by Wieczorek et al. in poultry observed 92.5% resistance to Ciprofloxacin followed by 88.9% in Nalidixic acid and 68.4% in Tetracycline in Poland (37). In Poland another study done by Wysok et al. observed 52.7% resistance to Ciprofloxacin, 56% to Nalidixic acid and 61.3% to Doxycycline (38). All these previous studies along with current study give a clue of antimicrobial resistance in *Campylobacter* species in the world. The result difference might be due to variability in geographical location, change in climatic condition and use of different antibiotics in feeds of poultry and other animals.

**3. Conclusion**

Our Study conclude that *Campylobacter* species is highly prevalent in district Bannu. Potential source of *Campylobacter* might be raw meat from broiler and this can be a possible source of infection to people by consuming raw or not properly cooked meat. To most of the available antimicrobial agents, high percentages of resistance was observed and this might be due to use of antimicrobial agents for growth promotion or treatment in poultry. Hence it require quick attention of the concerned authorities for veterinary and public health as the diseases is zoonotic that could be hazardous to public health.

**Conflict of interests**

The authors declare no competing interests.

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**References**

- Salehi M, Bameri Z, Zahedani SS, et al. Prevalence and Antimicrobial Resistance of *Campylobacter jejuni*. Int J Infect 2014; 1: 2.
- Skirrow MB, Campylobacteriosis. In: Zoonoses biology clinical practice and public health control, New York: Oxford University Press. 1998; p. 37-46.
- Borsoi A, Gonsalves CC, Pires ER, et al. Campylobacter inoculation and quantification from broiler cecal samples to compare two plate counting methodologies. Semina: Ciências Agrárias, Londrina, 2015; 36, 1: 285-290.
- Zorman T, Heyndrickx M, Uzunović-Kamberović S, et al. Genotyping of *Campylobacter coli* from retail chicken meat

and humans with campylobacteriosis in Slovenia and Bosnia and Herzegovina. *Int J Food Microbiol* 2006; 110: 24-33.

5. Meerburg BG, Jacobs-Reitsma WF, Wagenaar JA, et al. Presence of *Salmonella* and *Campylobacter* species in wild small mammals on organic farms. *Appl & Environ Microbiol* 2006; 72: 960-962.

6. Corry JE, Atabay, HI. Poultry as a source of *Campylobacter* and related organisms. *J Appl Microbiol* 2001; 90: 96S-114S.

7. Anonymous. Emerging infections program. *Food Net News*, 2007;1 (1).

8. EFSA-ECDC. The community summary report on trends and sources of zoonoses and zoonotic agents in the European Union in 2007. *EFSA J* 2009; 223-240.

9. Lastovica AJ, Allos BM. Clinical significance of *Campylobacter* and related species other than *Campylobacter jejuni* and *Campylobacter coli*. *Campylobacter* 2008; p. 123-149.

10. Fitzgerald C, Whichard J, Nachamkin I. *Campylobacter*. In Nachamkin, I, Szymanski, C., Blaser, M. (Eds.). *Diagnosis and antimicrobial susceptibility of Campylobacter species*, 2008; p. 227-243.

11. Goni MD, Abdul-Aziz S, Dhaliwal GK, et al. Occurrence of *Campylobacter* in dogs and cats in Selangor Malaysia and the associated risk factors. *Malaysian J Microbiol* 13, 2017; 164-171.

12. Huang JL, Xu HY, Bao GY, et al. Epidemiological surveillance of *Campylobacter jejuni* in chicken, dairy cattle and diarrhoea patients. *Epidemiol & Infect* 2009; 137: 1111-1120.

13. Meldrum RJ, Wilson IG. *Salmonella* and *Campylobacter* in United Kingdom retail raw chicken in 2005. *J Food Protect* 2007; 70: 1937-1939.

14. Young KT, Davis LM, DiRita VJ. *Campylobacter jejuni*: Molecular biology and pathogenesis. *Nature Rev* 2007; 5, 665-679.

15. European Food Safety Authority (EFSA). Joint opinion on antimicrobial resistance (AMR) focused on zoonotic infections. *Europ Food Safe Author J* 2009; 7, 1372.

16. Hussain I, Mahmood MS, Akhtar M, et al. Prevalence of *Campylobacter* species in meat, milk and other food commodities in Pakistan. *Food Microbiol* 2007; 24: 219-222.

17. Berrang ME, Northcutt JK, Cason JA. Recovery of *Campylobacter* from broiler feces during extended storage of transport cages. *Poultry Sci* 2004; 83: 1213-1217.

18. Smerdon WJ, Adak GK, O'Brien SJ, et al. General outbreaks of infectious intestinal disease linked with red meat, England and Wales, 1992-1999. *Commun Dis & Pub Health* 2001; 4, 259-267.

19. Denis M, Refrégier-petton J, Laisney MJ, et al. *Campylobacter* contamination in French chicken production from farm to consumers. Use of a PCR assay for detection and identification of *Campylobacter jejuni* and *C. coli*. *J Appl Microbiol* 2001; 91: 255-267.

20. Friedman CR, Hoekstra RM, Samuel M, et al. Risk factors for sporadic *Campylobacter* infection in the United States: A case-control study in FoodNet sites. *Clinic Infect Dis* 2004; 38: S285-S296.

21. Akinbowale OL, Peng H, Barton MD. Antimicrobial resistance in bacteria isolated from aquaculture sources in Australia. *J Appl Microbiol* 2006; 100: 1103-1113.

22. Oliver SP, Murinda SE, Jayarao BM. Impact of antibiotic use in adult dairy cows on antimicrobial resistance of veterinary and human pathogens: A comprehensive review. *Foodborne Pathogen & Dis* 2011; 8: 337-355.

23. Zoran T, Biljana MS, Radoje D, et al. Susceptibility of *Campylobacter jejuni* and *Campylobacter coli* isolated from animals and humans to tetracycline. *Afric J Microbiol Res* 2010; 4: 1246-1250.

24. Uaboi-Egbenni PO, Bessong PO, Samie A, et al. Potentially pathogenic *Campylobacter* species among farm animals in rural areas of Limpopo province, South Africa: A case study of chickens and cattles. *Afric J Microbiol Res* 2012; 6: 2835-2843.

25. Tambur Z, Stojanov I, Konstantinovic S, et al. Multidrug resistance of *Campylobacter jejuni* and *Campylobacter coli* to tested antibiotics in strains originating from humans, poultry and swine. *Zbornik Matice Srpske Zaprirodne Nauke* 2010; 118: 27-35.

26. Clinical laboratory Standards Institute (CLSI), 2006. Performance standards for antimicrobial disc susceptibility testing. 16th International edition. Document M100-S16. CLSI, Wayne, PA.

27. Moran L, Scates P, Madden RH. Prevalence of *Campylobacter* species in raw retail poultry on sale in Northern Ireland. *J Food Protect* 2009; 72: 1830-1835.

28. Wiczorek K, Wołkiewicz T, Osek J. Antimicrobial resistance and virulence-associated traits of *Campylobacter jejuni* isolated from poultry food chain and humans with diarrhea. *Front Microbiol* 2018; 9:1508.

29. Mäesaar M, Praakle K, Meremäe K, et al. Prevalence and counts of *Campylobacter* species in poultry meat at retail level in Estonia. *Food Control* 2014; 44: 72-77.

30. Parisi A, Lanzilotta SG, Addante N, et al. Prevalence, molecular characterization and antimicrobial resistance of thermophilic campylobacter isolates from cattle, hens, broilers and broiler meat in south-eastern Italy. *Vet Res Commun* 2007; 31: 113-123.

31. Pezzotti G, Serafini A, Luzzi I, et al. Occurrence and resistance to antibiotics of *Campylobacter jejuni* and *Campylobacter coli* in animals and meat in northeastern Italy. *Int J Food Microbiol* 2003; 82: 281-287.

32. Ledergerber U, Regula G, Stephan R, et al. Risk factors for antibiotic resistance in *Campylobacter* species. Isolated from raw poultry meat in Switzerland. *BMC Publ Health* 2003; 3- 39.

33. Mattheus W, Botteldoorn N, Heylen K, et al. 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.
34. Miflin JK, Templeton JM, Blackall PJ. Antibiotic resistance in *Campylobacter jejuni* and *Campylobacter coli* isolated from poultry in the South-East Queensland region. *J Antimicrob Chemother* 2007; 59: 775-778.
35. Bester LA, Essack SY. Prevalence of antibiotic resistance in *Campylobacter* isolates from commercial poultry suppliers in KwaZulu-Natal. *South Afric J Antimicrob Chemother* 2008; 62: 1298-1300.
36. Obeng AS, Rickard H, Sexton M, *et al.* Antimicrobial susceptibilities and resistance genes in *Campylobacter* strains isolated from poultry and pigs in Australia. *J Appl Microbiol* 2012; 113: 294-307.
37. Wieczorek K, Wołkowicz T, Osek J. Antimicrobial resistance and virulence-associated traits of *Campylobacter jejuni* isolated from poultry food chain and humans with diarrhea. *Front Microbiol* 2018;4: 1508.
38. Wysok B, Wojtacka J, Wiszniewska A, *et al.* Prevalence and antimicrobial resistance of *Campylobacter* isolates from poultry offals. *Med Wet* 2017; 73: 561-566.