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Antimicrobial resistance in *Campylobacter* species isolated from commercially sold steak (beef) and raw cow milk in Abakaliki, Nigeria

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Abstract. *Agumah NB, Effendi MH, Witaningrum AM, Tyasningsih W, Ugbo EN, Nwagwu CS, Ugbo IA. 2024. Antimicrobial resistance in* Campylobacter *species isolated from commercially sold steak* (*beef*) *and raw cow milk in Abakaliki, Nigeria. Biodiversitas 25: 950-956.* This study aimed to ascertain antimicrobial resistance in *Campylobacter* species isolated from commercially sold steak (Beef) and raw cow milk in Abakaliki. Pools of milk samples and steak were bought at various outlets and analyzed using standard microbiological methods. Results showed that two species of *Campylobacter*, namely *Campylobacter coli*, were isolated from the samples. In raw cow milk, *Campylobacter coli* had a frequency of 65% higher than *Campylobacter jejuni* (20%). While in steak, *C. coli* was 34.53% higher than *C. jejuni* (19.10%). The antibiotic susceptibility profile for *C. coli* isolated from raw cow milk ranged from 61.54% to 100%, especially for trimethoprim and cephalexin. Resistance ranged from 0.00 to 38.46%. The highest resistance was recorded for tetracycline. The antibiotic susceptibility profile for *C. coli* isolated from steak recorded susceptibility values ranging from 60.53% to 86.84%. Cephalexin had the highest effect on *C. coli* isolates from steak. Resistance values ranging from 13.16% to 42.11% were recorded with Nalidixic acid as the least effective antibiotic. *C. jejuni* isolated from cow raw milk, susceptibility ranging from 0.00% to 100% was recorded, especially for Cefotaxime, Imipenem, Cephalexin, and Nalidixic acid. Resistance ranged from 0.00% to 100%, especially for Chloramphenicol and Kanamycin. For *C. jejuni*, susceptibility values ranged from 26.57% to 85.71%, with imipenem presenting the highest effect. Resistance values ranged from 23.81% to 71.43%. Gentamycin had the least effect. Adequate sanitation, personal hygiene, and appropriate use of antibiotics are highly recommended for food handlers and farmers to safeguard human health by reducing AMR challenges, even in milk and meat/meat products.

Keywords: Beef, *Campylobacter coli*, *Campylobacter jejuni*, human health, milk, Nigeria

INTRODUCTION

Campylobacter is a Gram-negative, 0.2-0.5 μm long small curved spiral rod with a single unsheathed polar flagellum, sometimes present in large numbers in the small intestine of most animals, including pigs. They are the causative agents of campylobacteriosis in animals and humans, which is of public health importance, especially *Campylobacter enteritis* due to *Campylobacter jejuni* and *Campylobacter coli* (Gwimi et al. 2015; Nohra et al. 2019).

The most significant sources of *Campylobacter*-associated infections include consuming and/or handling raw or undercooked poultry meat or other meat sources, raw milk, contaminated water, seafood, and vegetables (Rukambile et al. 2019). Furthermore, cross-contamination of ready-to-eat foods during food preparation and direct contact with feces from infected humans and domestic pets have been recognized as risk factors (Kashoma et al. 2015). In the developing world, water and milk remain the predominant means of transmission of campylobacteriosis. Therefore, it is clear that reducing *Campylobacter* in water and foods is a desirable target for maintaining the safety of essential resources (Rukambile et al. 2019; Yanestria et al. 2023).

Several factors complicate *Campylobacter* control, including the distribution of these pathogens in different food animals/products and the environment. Several studies have revealed a range of *Campylobacter* prevalence (up to 70%) in cattle (Sanad et al. 2013). Furthermore, although the prevalence of *Campylobacter* in milk samples and cattle carcasses can be relatively low in comparison to other sources, studies have shown that approximately 15% of beef carcasses/meat can be contaminated with these pathogens (Wieczorek and Osek 2013). Milk can be considered a re-emerging risk factor because consuming unpasteurized raw milk and/or products made from raw milk is becoming more popular in most countries. Therefore, these observations pose a particular concern for countries where milk is consumed raw regularly or where no effort exists to prevent and control carcass contamination may be a risk factor for the spread of antimicrobial resistance to humans (Ansharieta et al. 2021; Tyasningsih et al. 2022).

The increasing antimicrobial resistance among *Campylobacter* spp. has been linked to antimicrobials in veterinary medicine and farming practices, mainly as prophylactic agents and growth promoters. This is important because some resistant isolates have been suspected of spreading from food animals to humans (Rozynek et al. 2010). While antimicrobial-resistant *Campylobacter* spp. has been reported worldwide, there is widespread and largely uncontrolled use of antimicrobials (Rukambile et al. 2019; Yanestria et al. 2023); these situations might be more severe in developing countries.

Campylobacter enteritis is usually self-limiting and does not require antimicrobial therapy, but in severe enteritis with complications and cases of the immune-compromised, antibiotics are necessary, in which case the fluoroquinolones and erythromycin are the drugs of choice (Luangtongkum et al. 2009; Iovine 2013). Moreover, increasing resistance among *Campylobacter* has been reported from different geographical regions to the drugs of choice and other relevant antibiotics used in human and veterinary medicine. The use and abuse of antimicrobial agents as feed additives or veterinary medicine have been recognized as a major determining factor in the dissemination and growth of resistance in most bacterial pathogens (Iovine 2013). The abuse of antibiotics in animals may cause an increase in resistance to their enteric flora. These resistant animal bacteria can be transferred to the human population by food products from animal sources or direct contact (Karikari et al. 2017; Khan et al. 2018).

Antimicrobial resistance in pathogenic microorganisms, such as *C. jejuni*, represents a global health challenge. The southern China researchers reported that multidrug-resistant *Campylobacter* strains make treatment a major health challenge and economic burden (Bai et al. 2021). Antimicrobial resistance in bacteria can be caused by excessive use of antibiotics by humans, antibiotics in animal feed or animal care, and increased industrial waste in the environment (Dameanti et al. 2023). Bacterial resistance to antimicrobials can develop in a variety of ways as in most situations, bacteria exposed to antibiotics find ways to evade or reject the antimicrobial agent (Jafari et al. 2020; Proietti et al. 2020; Al-Khresieh et al. 2022). Therefore, this study aimed to explore the antimicrobial resistance profile in *Campylobacter* species isolated from commercially sold steak (beef) and raw cow milk in Ebonyi State, Nigeria.

MATERIALS AND METHODS

Study area

The study area was Abakaliki; the capital city of Ebonyi state, Nigeria. Major areas in Abakaliki where raw cow milk and steak samples were collected include Ogbe Hausa, Kpiri-Kpiri, Vanco junction, and Sperandeo. Raw cow milk was only sold in Ogbe Hausa, while steak was found in all the other locations mentioned before, with more of its vendors at Ogbe Hausa.

Sample collection

Steak and raw milk were purchased from the various outlets mapped out for the study. One hundred and ten (110) steak samples and 20 pools of raw milk were collected for this study. Milk sample pooling was done according to the methods of Effendi et al. (2019), and for steak sampling, surface swabbing was performed. A sterile gauze pad pre-moistened with sterile maximum recovery diluents was used to swab the steak samples downward. Each gauze pad was placed in a sterile plastic bag. The air was taken out of the bag, tightly closed, labeled, and stored in an iced cool box before transportation to the laboratory for further analyses within a maximum of 48 hours. In each sampling pool for milk, 10 mL of raw cow milk was collected from various raw milk vendors in Ogbe Hausa and stored in the iced cool box before transportation to the laboratory for analysis.

Isolation and identification of *Campylobacter* species

Campylobacter species were isolated from the inspected samples recently described by Ghoneim et al. (2020) and Kashoma et al. (2015). 5 mL of homogenized milk was added to 10 mL of Preston enrichment broth containing *Campylobacter* growth supplements (Oxoid). The enrichment tubes were incubated for 48 hr at 42°C under microaerophilic conditions. Briefly, 10 g of each steak sample was homogenized in sterile thioglycollate broth and were incubated in a microaerophilic atmosphere for 48 hours at 42°C. A loopful of enrichment broth was streaked onto modified Charcoal Cefaperaxone Deoxycholate Agar (mCCDA) plates (Oxoid) and incubated under microaerophilic conditions at 42°C for 48 hours (Persson and Olsen 2005). The colonies were then examined microscopic to identify *Campylobacter* species (Vandamme et al. 2010). *Campylobacter* suspected colonies were sub-cultured onto 5% sheep blood agar once or more until monocultures were obtained. Biochemical tests were performed to identify the species of *Campylobacter*, including Gram stain, oxidase, catalase, hippurate hydrolysis, Nitrate reduction, and H_2S production in triple sugar iron medium.

Antimicrobial susceptibility test

The Kirby-Bauer disk diffusion method using Mueller-Hinton agar (Liofilchem-Italy) supplemented with 5% sheep blood was used for this study (Effendi and Harjiani 2017). Plates were inoculated with 0.5 Mcfarland suspension and incubated microaerophilically for 24 h at 48°C (Clinical and Laboratory Standards Institute, CLSI 2020). Drugs analyzed were sourced from OXOID (UK) and included: chloramphenicol (30 µg/disc), cefotaxime (30 µg/disc), kanamycin (30 µg/disc), erythromycin (15 µg/disc), gentamicin (10 µg/disc), ampicillin (10 µg/disc), nalidixic acid (30 µg/disc), tetracycline (30 µg/disc), cephalexin (30 µg/disc), trimethoprim-sulfamethoxazole (25 µg/disc), norfloxacin (10 µg/disc), ciprofloxacin (5 µg/disc) and imipenem (10 µg/disc). The recorded inhibition zones were interpreted according to CLSI (2020) breakpoints for *Campylobacter*. CLSI (2020) established breakpoints for Enterobacteriaceae to interpret the results of norfloxacin, trimethoprim-sulfamethoxazole, cefotaxime, and kanamycin.

RESULTS AND DISCUSSION

Results of isolation showed that only two species of *Campylobacter*, namely *Campylobacter coli* and *Campylobacter jejuni* were isolated from the milk. Out of the 20 pools of milk examined, 65% were positive for *Campylobacter coli*, and 20% were positive for *Campylobacter jejuni*, as shown in Figure 1 and Table 1. Concerning distribution in steak, 34.53% were positive for *C. coli*, while 19.10% of the steak samples collected were positive for *C. jejuni* (Table 2). Steak samples were collected from different parts of Abakaliki, while the raw milk samples were collected from Ogbe Hausa because that was the only place where it was readily available. Concerning location, Ogbe Hausa had the highest number of *C. coli* isolates in steak (31.58%), followed by Vanco junction (26.32%), Kpiri-Kpiri (23.68%) and Sperandeo (18.42%) (Table 3). Ogbe Hausa also had the highest frequency of *C. jejuni* (38.10%) in steak, followed by Kpiri-Kpiri (28.57%), Sperandeo (19.05%), and Vanco junction (14.29%) (Table 4).

The antibiotic susceptibility profile for *C. coli* isolated from raw cow milk ranged from 61.54% to 100%, especially for trimethoprim and cephalexin. Resistance ranged from 0.00 to 38.46%. The highest resistance was recorded for Tetracycline (Table 5). For *C. jejuni* isolated from cow raw milk, susceptibility ranged from 0.00% to 100% was recorded, especially for Cefotaxime, Imipenem, Cephalexin, and Nalidixic acid. Resistance ranged from 0.00% to 100%, especially for Chloramphenicol and Kanamycin (Table 6).

The antibiotic susceptibility profile for *C. coli* isolated from steak recorded susceptibility values ranged from 57.89% to 86.84%. Cephalexin had the highest effect on *C. coli* isolates from steak. Resistance values ranging from 13.16% to 42.11% were recorded with Nalidixic acid as the least effective antibiotic (Table 7). For *C. jejuni*, susceptibility values ranged from 28.57% to 85.71%, with imipenem presenting the highest effect. Resistance values ranged from 14.29% to 71.43%. Gentamycin had the least effect (Table 8).

Figure 1. The growth appearance of *Campylobacter* sp. on MacConkey agar show creamy colonies

Table 1. Distribution of *Campylobacter* species isolated from pools of raw milk sold in Abakaliki

Isolates obtained	No. of milk pools positive (%)	No. of milk pools negative (%)	Total pools (%)
C. coli	13 (65)	7 (35)	20 (100)
C. jejuni	4 (20)	16 (80)	20 (100)

Table 2. Distribution of *Campylobacter* species isolated from Steak sold in Abakaliki

Isolates obtained	No. of steak samples positive (%)	No. of steak samples negative (%)	Total steak samples (%)
C. coli	38 (34.55%)	72 (65.45%)	110
C. jejuni	21 (19.10)	89 (80.90)	110

Table 3. Distribution of *Campylobacter coli* species isolated from steak sold in Abakaliki with respect to locations

Location of steak outlets	No. of isolates obtained (%)
Ogbe hausa	12 (31.58)
Vanco junction	10 (26.32)
Sperandeo	7 (18.42)
Kpiri-kpiri	9 (23.68)
Total	38 (100)

Table 4. Distribution of *Campylobacter jejuni* species isolated from steak sold in Abakaliki with respect to locations

Location of steak outlets	No. of isolates obtained (%)
Ogbe hausa	8 (38.10)
Vanco junction	3 (14.29)
Sperandeo	4 (19.05)
Kpiri-kpiri	6 (28.57)
Total	21 (100)

Table 5. Antibiotic susceptibility of *Campylobacter coli* species isolated from raw cow milk sold in Abakaliki

Antibiotics (conc.10μg)	No. of isolates tested	No. of isolates resistant (%)	No. of isolates susceptible (%)
Ampicillin	13	2 (15.38)	11 (84.62)
Chloramphenicol	13	1 (7.69)	12 (92.31)
Ciprofloxacin	13	4 (30.77)	9 (69.23)
Kanamycin	13	2 (15.38)	11 (84.62)
Erythromycin	13	2 (15.38)	11 (84.62)
Gentamycin	13	3 (23.71)	10 (76.29)
Nalidixic acid	13	1 (7.69)	12 (92.31)
Tetracycline	13	5 (38.46)	8 (61.54)
Cephalexin	13	0 (0.00)	13 (100.00)
Trimethoprim	13	0 (0.00)	13 (100.00)
Norfloxacin	13	1 (7.69)	12 (92.31)
Cefotaxime	13	2 (15.38)	11 (84.62)
Imipenem	13	3 (23.71)	10 (76.29)

Table 6. Antibiotic susceptibility of *Campylobacter jejuni* species isolated from raw cow milk sold in Abakaliki

Antibiotics (Concentration)	No. of isolates tested	No. of isolates resistant (%)	No. of isolates susceptible (%)
Ampicillin	4	2 (50.00)	2 (50.00)
Chloramphenicol	4	4 (100.00)	0 (0.00)
Ciprofloxacin	4	2 (50.00)	2 (50.00)
Kanamycin	4	4 (100.00)	0 (0.00)
Erythromycin	4	1 (25.00)	3 (75.00)
Gentamycin	4	1 (25.00)	3 (75.00)
Nalidixic acid	4	0 (0.00)	4 (100.00)
Tetracycline	4	3 (75.00)	1 (25.00)
Cephalexin	4	0 (0.00)	4 (100.00)
Trimethoprim	4	3 (75.00)	1 (25.00)
Norfloxacin	4	2 (50.00)	2 (50.00)
Cefotaxime	4	0 (0.00)	4 (100.00)
Imipenem	4	0 (0.00)	4 (100.00)

Table 7. Antibiotic susceptibility of *Campylobacter coli* species isolated from steak sold in Abakaliki

Antibiotics (Concentration)	No. of isolates tested	No. of isolates resistant (%)	No. of isolates susceptible (%)
Ampicillin	38	12 (31.58)	26 (68.42)
Chloramphenicol	38	9 (23.68)	29 (76.32)
Ciprofloxacin	38	7 (18.42)	31 (81.58)
Kanamycin	38	15 (39.47)	23 (60.53)
Erythromycin	38	10 (26.32)	28 (73.68)
Gentamycin	38	11 (28.95)	27 (71.05)
Nalidixic acid	38	16 (42.11)	22 (57.89)
Tetracycline	38	14 (36.84)	24 (63.16)
Cephalexin	38	5 (13.16)	33 (86.84)
Trimethoprim	38	10 (26.32)	28 (73.68)
Norfloxacin	38	8 (21.05)	30 (78.95)
Cefotaxime	38	6 (15.79)	32 (84.21)
Imipenem	38	7 (18.42)	31 (81.58)

Table 8. Antibiotic susceptibility of *Campylobacter jejuni* species isolated from raw cow milk sold in Abakaliki

Antibiotics (Concentration)	No. of isolates tested	No. of isolates resistant	No. of isolates susceptible
Ampicillin	21	9 (42.86)	12 (57.14)
Chloramphenicol	21	6 (28.57)	15 (71.43)
Ciprofloxacin	21	12 (57.14)	9 (42.86)
Kanamycin	21	7 (33.33)	14 (66.67)
Erythromycin	21	14 (66.66)	7 (33.34)
Gentamycin	21	15 (71.43)	6 (28.57)
Nalidixic acid	21	10 (47.62)	11 (52.38)
Tetracycline	21	8 (38.10)	13 (61.90)
Cephalexin	21	5 (23.81)	16 (76.19)
Trimethoprim	21	9 (42.86)	12 (57.14)
Norfloxacin	21	10 (47.62)	11 (52.38)
Cefotaxime	21	4 (19.05)	17 (80.95)
Imipenem	21	3 (14.29)	18 (85.71)

Discussion

Campylobacteriosis is a zoonotic infectious disease. The natural reservoir is the digestive tract of mammals and birds, with the most important human pathogens being *C. coli* and *C. jejuni* (Hermans et al. 2012; Rukambile et al. 2019). The entry of *Campylobacter* into the food chain occurs mainly during livestock slaughter (Powell et al. 2012). The percentage of contaminated carcasses at slaughter is quite high and varies according to season. Powell and his co-authors (Powell et al. 2012), reported 80% of carcasses were contaminated with *Campylobacter* in March and October 2008 while in October, the percentage reached 97%. It has been identified as a significant risk factor that slaughter during the summer months previous depopulation of some livestock (Yun et al. 2016). In general, 20%-35% of diarrhea in humans is caused by *C. jejuni* (Rukambile et al. 2019). In most cases, no treatment is necessary because *Campylobacter* can usually be cured independently, except in patients with a weakened immune system who may require antibiotic therapy. This therapeutic option may be the main reason for the occurrence of antimicrobial resistance in *Campylobacter* (Nohra et al. 2019). Several methods are available to identify *Campylobacter* spp., such as biochemical, molecular, and serological reaction methods (Almashhadany 2021). The emergence of antimicrobial-resistant *Campylobacter* bacteria in food is a serious problem in veterinary and human medicine due to the indiscriminate use of antimicrobials in animal products; several studies have mentioned it as a public health problem (Rukambile et al. 2019).

Poultry is the main source of *Campylobacter* transmission to humans because it is a normal part of the flora in the poultry digestive tract (Hermans et al. 2012). *Campylobacter* spp., especially *C. jejuni*, can be found in high numbers in broiler chicken ceca at the farm level, on carcasses in poultry slaughterhouses, and in meat markets (Prachantasena et al. 2016). *Campylobacter* can be transmitted from animals by exposing humans to animal waste or by handling and consuming contaminated meat (Rukambile et al. 2019; Varga et al. 2019). Undercooked livestock meat, low cooking levels, hygienic standards, and cross-contamination (via knives, plates, etc.) in food preparation are crucial, especially in private households. A recent study correlated human enteritis cases with average temperature, indicating the seasonal occurrence of *Campylobacter* and *Salmonella*, and also indicating that barbeques are the main medium of contamination (Yun et al. 2016). Overuse of antibiotics in human and animal populations has increased the number of antimicrobial-resistant bacteria (Iovine 2013). Antimicrobial resistance poses additional risks because antibiotic-resistant *Campylobacter* infections lead to longer hospital stays, higher rates of treatment failure, and increased morbidity and mortality that compromise human health (Doyle 2015).

The frequent presence of *Campylobacter* in undercooked food and raw milk or dairy products indicates its risk of zoonotic transmission to humans (Chukwu et al. 2019). Transmission of *Campylobacter* from its natural reservoirs occurs mostly via contaminated food and water, person-to-person, and contact with infected animals. Around 80% of campylobacteriosis cases are transmitted by food (Karikari et al. 2017). In the present study, *Campylobacter coli* and *Campylobacter jejuni* were isolated from milk, which is consistent with findings from various studies that have reported raw milk-associated outbreaks of campylobacteriosis from various countries (Mungai et al. 2015; Burakoff et al. 2018).

Salihu et al. (2010) recorded a lower frequency of 4.8% of *C. jejuni* isolated from raw cow milk in Sokoto, Nigeria. In a study in Erbil, Iraq, Almashhadany et al. (2020) recorded that raw milk from cows had the highest distribution of *Campylobacter* species. They recorded an average frequency of 65.91% for *C. jejuni* isolated from raw milk, unlike in this study, where a frequency of 20% was recorded for *C. jejuni.* A frequency of 15.91% was recorded for *C. coli,* unlike in this study, where a frequency of 65% was recorded. Another study by Modi et al. (2015) in India recorded a low prevalence of *Campylobacter* species (2.91%) after analysis of raw milk samples from Cows and Buffalos.

Our findings disagree with Okunlade et al. (2015), who recorded a lesser frequency of 20.4% for *C. coli* from cattle in Ibadan, Nigeria; in their investigation, no *C. jejuni* was isolated. Another study in Sokoto, Nigeria, presented a frequency of 25% of *C. coli* isolated from cattle (Salihu et al. 2009). Another study by Premarathne et al. (2017) in Selangor, Malaysia, recorded an average frequency of 14.2% of *Campylobacter* species in raw beef, with *C. jejuni* presenting with 26% and *C. coli* presenting with 19%.

The results of this study revealed, especially regarding the frequency of *Campylobacter* in steak, was of utmost veterinary and medical importance. Most studies have analyzed at isolation of *Campylobacter* from raw beef or rectal swab samples, while in this study it was associated with processed (ready-to-eat) beef. Poor Handling, which entails poor hygiene from the vendors and improper washing and cooking (or roasting) of the beef, seems to make steak a veritable conduit for transmitting campylobacteriosis. Steak is readily enjoyed on most street corners of every typical Nigerian town. This study also found that campylobacteriosis can be spread by consuming unpasteurized (raw) cow milk. Aside from the incidence of *Campylobacter* as a normal flora, contamination especially by handlers is a decisive factor in the spread of campylobacteriosis. Poor sanitation, inadequate implementation of overall cleanliness, and practicing proper hygiene by the dairy farmers or the herders have been cited as very important criteria in issues concerning milk safety and contamination (Effendi et al. 2017).

Antibiotic resistance observed from this study agrees with that of Sammarco et al. (2010), who isolated *Campylobacter coli* from chicken and beef meat to be resistant to most antibiotics tested in Italy. Châtre et al. (2010) in France also documented a trend of increasing resistance of *Campylobacter* species isolated from cattle to commonly used antibiotics, notably quinolones, aminoglycosides, and penicillins. Okunlade et al. (2015), performed an antibiotic sensitivity test that revealed low susceptibility by *C. coli* to most of the 10 antibiotics studied; the cattle *C. coli* isolates exhibited low susceptibility to ciprofloxacin and erythromycin. Modi et al. (2015) recorded resistance by *Campylobacter* isolated from milk to nalidixic acid, tetracycline, and ciprofloxacin. Premarathne et al. (2017) also reported very high resistance of *Campylobacter* to tetracycline (76.9%) and ampicillin (69.2%); many isolates were relatively susceptible to chloramphenicol as resistance recorded was as low as 7.6%. Yanestria et al. (2023) reported the blaOxa-61 gene on *Campylobacter jejuni* detected in all 23 *C. jejuni* isolates from broilers in Indonesia, and also a total of 31 *Campylobacter jejuni* isolates were tested using PCR to detect the gyrA gene encoding fluorquinolone resistance and all (100%) detected the gyrA gene (Yanestria et al. 2024).

It was also observed that the indiscriminate use of antibiotics for dairy cows could be considered a contributory factor for antimicrobial resistance in *C. coli* and *C. jejuni*. It is suspected that in some climates cases of mastitis in dairy cows often use antimicrobial drugs, where mastitis is one of the most common infectious diseases in dairy cows. The bacteria involved in bovine mastitis are classified as infectious or environmental pathogens based on their epidemiological relationship to the disease. The increase in antibiotic resistance among bacterial populations is often due to the extensive use of antibiotics in medicinal and animal husbandry (Effendi et al. 2018; Ansharieta et al. 2021; Wibisono et al. 2021). There is an optimally high prevalence of *Campylobacter* species in steak and raw cow milk sold in various areas in Abakaliki, Nigeria. *Campylobacter* species isolated were resistant to various commercially available antibiotics. Some isolates showed complete resistance to chloramphenicol and kanamycin. The most effective antibiotics employed were the cephalosporin antibiotics (imipenem, cefotaxime, and cephalexin). The incidence of antimicrobial-resistant bacteria in animal proteins (Milk and Meat) has become a very important issue of both veterinary and medical importance, especially concerning the zoonotic transmission of these bacteria. Campylobacteriosis is known as one of the leading causes of gastroenteritis. Adequate sensitization on proper cooking practices and use of antibiotics, sanitation, and good hygiene practices are highly recommended for food handlers and herders to inhibit the spread of antibiotic-resistant *Campylobacter* species (Nohra et al. 2019).

In conclusion, *Campylobacter* is currently the most frequent causative agent of bacterial gastroenteritis and, therefore, represents a major challenge to human health, not only because of increasing antibiotic resistance. Although much research has been done to uncover this causative agent, the epidemiology of many *Campylobacter* infections remains unclear in many aspects. Despite increasing understanding of *Campylobacter* virulence factors, effective prevention methods must be improved. Obtaining data on antimicrobial resistance from *Campylobacter* helps raise public awareness about the misuse of antibiotics in infectious diseases. This is a prerequisite for effective phase variation and adaptation to different hosts and is currently an unexplored target for treating diseases caused by *Campylobacter* sp., especially to prevent the spreading of antimicrobial resistance by meat and milk in Abakaliki, Nigeria.

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