Trends in the occurrence and characteristics of Campylobacter jejuni and Campylobacter coli isolates from poultry meat in Northern Poland

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ABSTRACT
The aim of this study was to investigate the occurrence of Campylobacter spp. in poultry meat available in retail stores in the northern part of Poland during a five-year period (2009–2013). A total of 742 poultry meat samples were collected from butcher shops and supermarkets including the following types of samples: chicken breast files (n = 133), turkey breast files (n = 112), chicken wings (n = 135), chicken leg quarters (n = 128), chicken drumsticks (n = 115), and chicken giblets (n = 119).

The results indicated that 41.6% of the samples were positive for Campylobacter spp., and Campylobacter jejuni was predominant in this study. The prevalence of Campylobacter spp. changed during the study period, decreasing from 60.2% in 2009 to 32% in 2013.

The characterization of the isolates revealed a high prevalence of Campylobacter virulence genes. All Campylobacter spp. isolates from poultry meat contained the cadF gene, which is responsible for adherence. The flaA gene, which is involved in motility, was present in all C. jejuni and Campylobacter coli strains. The cdtB, which is associated with toxin production, was present in 93.3% of C. jejuni strains and 89.6% of C. coli strains. The iam gene, which is associated with the invasiveness of Campylobacter spp., was predominant in C. coli strains (95.6%) compared to C. jejuni strains (84.5%).

Resistance to four antimicrobials was also examined. The prevalence of resistance among the obtained C. jejuni and C. coli isolates was as follows: ciprofloxacin (62.8% and 72.2%, respectively), tetracycline (42.3% and 42.6%, respectively), erythromycin (3% and 1.7%, respectively) and azithromycin (1%). Multidrug resistance was more frequent among C. jejuni isolates (29.8%) than among C. coli isolates (18.2%).

In conclusion, the results of this study demonstrated the importance of poultry meat as a source of Campylobacter spp., especially macrolide-resistant strains. The trend of decreasing Campylobacter spp. occurrence in retail poultry meat in this region of Poland requires further investigation, and monitoring.

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1. Introduction

Food-borne diseases are currently recognized as one of the most serious public health concerns, and remain a significant burden on society, impacting quality of life and causing medical costs (Whyte et al., 2004). Campylobacteriosis has been the most commonly reported zoonosis in humans in the EU since 2005. The number of reported confirmed cases of human campylobacteriosis in the EU in 2012 was 214,268. The EU notification rate was 55.49 per 100,000 population in 2012 (Anonymous, 2014a).

The original reservoir of Campylobacter strains is numerous species of domestic and wild animals, among which poultry plays an important role (Lin, 2009). Campylobacter jejuni and, less commonly, other species are components of the gastrointestinal microflora in older poultry (Reich, Atanassova, Haunhorst, & Klein, 2008). While numerous potential vehicles of transmission exist, commercial chicken meat has been identified as one of the most important food vehicles for these organisms (Bardon, Kolar, Karpiskova, & Hricova, 2011; Lynch, Cagney, McDowell, & Duffy, 2011). In 2012, fresh broiler and other poultry meat were the foodstuffs in which Campylobacter was most frequently reported (Anonymous, 2014a).

The poultry sector is a dynamically developing food industry worldwide. Poultry meat is now one of the most popular food products, and the consumption of this product is increasing in the

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countries of the European Union (Anonymous, 2012). Microbiological quality control programs are applied throughout the chain of food production to minimize the risk of infection for consumers. This activity focuses on two issues: reducing the number of bacteria in the digestive tract of poultry for slaughter and reducing Campylobacter spp. in the slaughter environment. To achieve these goals, a reduction of the age of slaughter chickens, the use of protective screens against insects and stricter hygiene standards are advised. Actions that can reduce the prevalence of Campylobacter spp. by up to 90% include pouring water at a temperature of 80 °C on poultry carcasses for 20 s, two-to-three-day meat freezing and food irradiation (Anonymous, 2014b; Nagel, Bauermeister, Bratcher, Singh, & McKee, 2013).

Antimicrobial resistance is the main undesirable side effect of antimicrobial use in both humans and animals and causes the selection of resistant bacterial clones. The trend of increasing antimicrobial resistance in Campylobacter spp. isolates, which is attributed to the wide use of antibiotics in veterinary medicine and agriculture, is an alarming problem (Anonymous, 2014b). The poultry reservoir is accepted to be the source of human fluoroquinolone-resistant Campylobacter isolates (Wieworek, Kania, & Osek, 2013). Epidemiological studies of the prevalence of Campylobacter in poultry meat are limited. The purpose of this work was to analyze the invasiveness. Epidemiological studies of the prevalence of Campylobacter in poultry meat are limited. The purpose of this work was to analyze the invasiveness.

2. Materials and methods

2.1. Sample collection

A total of 742 poultry meat samples were collected in Northern Poland over a five year period (2009–2013). The samples were purchased from supermarkets and butcher shops to provide the element of representativeness. The sites were also selected based on their geographical location. The number of samples collected during each year of the study is shown in Table 1. Raw poultry meat samples that were sold unpackaged were collected six times during each year of the study; these samples were collected in January, March, May, July, September and October to define seasonality. The following types of poultry meat were included in the study: chicken filets (n = 133), turkey filets (n = 112), chicken wings (n = 135), chicken leg quarters (n = 128), chicken drumsticks (n = 115), and chicken giblets (n = 119). Each month, the similar number of samples was collected. The samples were transported to the laboratory in cooler boxes on ice and analyzed immediately.

2.2. Isolation of Campylobacter

Thermotolerant Campylobacter spp. were isolated in accordance with ISO 10272-1:2006 method, with micro-aerobic conditions generated by a Generbox microaer (BioMerieux, Marcy l’Etoile, France). Meat samples (25 g) were transferred to 225 ml of Bolton broth (Oxoid, Basingstoke, United Kingdom). Next, a bacterial suspension in Bolton enrichment broth was spread on Charcoal Cephoperazone Desoxycholate Agar (CCDA) (Oxoid, Basingstoke, United Kingdom). The plates were incubated at 42 °C for 48 h under micro-aerobic conditions. Characteristic growth from the CCDA plates was transferred to a blood plate (i.e., Columbia agar containing 5% cattle blood) (Oxoid, Basingstoke, United Kingdom) and incubated overnight at 42 °C. Colonies suspected of being Campylobacter spp. were examined for cell morphology using the Gram staining method and for motility. The catalase and oxidase reactions were performed using available tests (Oxoid) in accordance with the manufacturer’s instructions. The identification of C. jejuni strains was based on positive hippurate hydrolysis reactions with a 3.5% ninhydrin solution (Hendriksen, Wagenaar, & Bergen, 2003). The strains were stored at −80 °C in Microbanks (Pro-Lab Diagnostics, United Kingdom).

2.3. DNA extraction

Bacterial chromosomal DNA was isolated from 24-h cultures on Columbia agar with 5% sheep blood using a conventional boiling method (de Lamballerie, Randotti, Vignoli, Bollet, & de Micco, 1992). A 100 μl sample of a bacterial suspension in PBS with 45 μl of Chelex 100 chelating resin (BioRad, USA) was boiled for 10 min prior to centrifugation at 13,000×g for 10 min.

2.4. Species identification

Species identification was confirmed using PCR with specific primers, as described elsewhere (Linton, Lawson, Owen, & Stanley, 1997; On & Jordan, 2003). PCR was performed in a 25 μl volume containing 2.5 μl of 10× PCR buffer (Fermentas, Vilnius, Lithuania), 2.5 μl of 25 mM MgCl2 (Fermentas, Vilnius, Lithuania), 1.0 μl of each PCR primer (10 μM) (Oligo, Warsaw, Poland), 1.0 μl of 10 mM deoxynucleoside triphosphate mix (Fermentas, Vilnius, Lithuania), 0.5 μl of Dream Taq DNA Polymerase (1 U/μl) (Fermentas, Vilnius, Lithuania), 1.0 μl of template and 13.0 μl of DNA-free purified water (Fermentas, Vilnius, Lithuania). PCR was then performed using the cycling conditions specified by the original authors. The amplicons were analyzed via electrophoresis in a 1.5% agarose gel. The DNA bands were visualized via staining with the Midori Green Stain (Nippon Genetics, Duren, Germany) and photographed using the IG/L-E InGenius L documentation system (Syngene, Cambridge, United Kingdom). The size of the PCR amplicons was compared to a 100 bp DNA marker (Fermentas, Vilnius, Lithuania).

2.5. Amplification of virulence genes

The presence of the cadF, flaA, cdtB and iam genes was evaluated using the PCR method with previously described primers and cycling conditions (Bang et al., 2001; Carvalho et al., 2001; Konkel, Gray, Kim, Garvis, & Yoon, 1999; Nachamkin, Bohachick, & Patton, 1993). All PCR reactions were performed in 25 μl volumes containing 2.5 μl of 10× PCR buffer (Fermentas, Vilnius, Lithuania), 2.5 μl of 25 mM MgCl2 (Fermentas, Vilnius, Lithuania), 1.0 μl of each PCR primer (10 μM) (Oligo, Warsaw, Poland), 0.5 μl of 10 mM deoxynucleoside triphosphate mix (Fermentas, Vilnius, Lithuania), 0.5 μl of Dream Taq DNA Polymerase (0.5 U/μl) (Fermentas, Vilnius, Lithuania), 1.0 μl of template and 13.0 μl of DNA-free purified water (Fermentas, Vilnius, Lithuania). PCR products were analyzed via electrophoresis in a 1.5% agarose gel. The DNA bands were visualized via staining with Midori Green Stain and photographed using the IG/L-E InGenius L documentation system. The size of the PCR

### Table 1: Prevalence of Campylobacter spp. in retail poultry meat from 2009 to 2013.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total no. of samples</th>
<th>No. of positive samples</th>
<th>No. of C. jejuni</th>
<th>No. of C. coli</th>
<th>Prevalence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>161</td>
<td>97</td>
<td>61</td>
<td>36</td>
<td>60.2</td>
</tr>
<tr>
<td>2010</td>
<td>148</td>
<td>68</td>
<td>43</td>
<td>25</td>
<td>45.9</td>
</tr>
<tr>
<td>2011</td>
<td>140</td>
<td>54</td>
<td>29</td>
<td>25</td>
<td>38.6</td>
</tr>
<tr>
<td>2012</td>
<td>143</td>
<td>42</td>
<td>31</td>
<td>11</td>
<td>29.3</td>
</tr>
<tr>
<td>2013</td>
<td>150</td>
<td>48</td>
<td>30</td>
<td>18</td>
<td>32.0</td>
</tr>
<tr>
<td>2009–2013</td>
<td>742</td>
<td>309</td>
<td>194</td>
<td>115</td>
<td>41.6</td>
</tr>
</tbody>
</table>
amplicons was compared to a 100 bp DNA marker (Fermentas, Vilnius, Lithuania).

2.6. Antimicrobial susceptibility testing

The susceptibility of *Campylobacter* isolates to erythromycin, azithromycin, tetracycline and ciprofloxacin was determined using E-test (AB Biodisk, Solna, Sweden) on Mueller–Hinton agar with 5% defibrinated horse blood (bioMerieux, Marcy l’Étoile, France). The E-tests were used in accordance with the manufacturer’s instructions. The plates were incubated at 37 °C for 48 h under microaerophilic conditions. The following Clinical and Laboratory Standards Institute (CLSI, 2008) interpretative criteria for the *Enterobacteriaceae* family were used as break points for *Campylobacter* resistance: erythromycin, 32 μg/mL; tetracycline, 16 μg/mL; azithromycin, 8 μg/mL; and ciprofloxacin, 4 μg/mL.

2.7. Reference strains

The following positive control strains were included in the study: *C. jejuni* ATCC 33291, *C. jejuni* ATCC 33560, and *Campylobacter coli* ATCC 33559.

2.8. Statistical analysis

Statistical analysis was performed using the Statistica 10.0 program (StatSoft Poland, 2011). Statistical differences in the prevalence of *Campylobacter* spp. in individual years, the presence of *Campylobacter* spp. in individual meat types, and the occurrence of virulence genes and antimicrobial resistance in *C. jejuni* and *C. coli* were analyzed using the two-proportion test. The null hypothesis that no difference exists between the percentages of counted cases was compared to the alternative hypothesis that the difference between the percentages is significant. A significance level of *p* = 0.05 was accepted as verification of these hypotheses.

3. Results

3.1. Prevalence of *Campylobacter* spp. in poultry meat

During the study period, a total of 742 poultry meat samples were tested. The results indicated that 309 (41.6%) of the samples were positive for *Campylobacter* spp. The frequency of *C. jejuni* in the examined samples was 62.8%. *C. coli* was found in 37.2% of retail poultry products. The prevalence of *Campylobacter* spp. changed during the study period, decreasing from 60.2% in 2009 to 30.2% in 2013 (Table 1). Statistical differences between the incidence of positive results between 2009 and 2013 are shown in Table 2.

The number of *Campylobacter*-positive samples from different parts of chicken and turkey, and the diversity of the detected species are shown in Table 3. The two-proportion test revealed that *Campylobacter* spp. occurred significantly more often in chicken leg quarters (60%) than in other chicken parts and turkey breast filets (*p* = 0.0002, *p* = 0.0084, *p* = 0.0001, *p* = 0.0073, and *p* = 0.0022).

The results demonstrate a high prevalence of *Campylobacter* spp. in turkey breast filets (42.8%). The lowest contamination with the examined bacteria was observed in the chicken wings (35.1%).

In our studies, the highest numbers of positive results were observed in March and July. Statistically significant differences were observed between these months and October, in which the number of *Campylobacter*-positives samples was the lowest (March vs. October, *p* = 0.0239, July vs. October, *p* = 0.0238). The seasonal prevalence of *Campylobacter*-positive poultry meat samples is shown in Fig. 1.

3.2. Prevalence of virulence genes

*Campylobacter* strains were analyzed for the presence of 4 virulence genes. All *Campylobacter* spp. isolates from poultry meat had the *cddf* gene, which is responsible for adherence. The *flaA*, which is involved in motility, was detected in all *C. jejuni* and *C. coli* strains. The *cdtB* gene, which is associated with toxin production, was present in 93.3% and 89.6% of *C. jejuni* and *C. coli* strains, respectively (*p* = 0.2486). The *iam* gene, which is linked to invasiveness in *Campylobacter* spp., was more prevalent in *C. coli* strains (95.6%), compared to 84.5% in *C. jejuni* strains. Significant differences in the occurrence of these genes were detected between isolates (*p* = 0.003).

3.3. Antimicrobial resistance

Antimicrobial susceptibility testing demonstrated that 66.3% of the strains isolated in this study were resistant to ciprofloxacin. For 42.3% of the strains, resistance to tetracycline was confirmed. Only 2.6% of *Campylobacter* strains were resistant to erythromycin. The lowest antimicrobial resistance was observed for azithromycin. Only 0.6% of the isolated strains were resistant to this drug. The results of antimicrobial susceptibility testing in individual years are summarized in Table 4.

Higher levels of resistance to fluoroquinolones were found within the *C. coli* group. As many as 72.2% of *C. coli* strains were resistant to ciprofloxacin, compared to 62.8% of *C. jejuni* strains. The rates of resistance to tetracycline were 48.9% for *C. jejuni* and 32.2% for *C. coli*; this difference was statistically significant (*p* = 0.0004). Only 3.0% of *C. jejuni* strains and 1.7% of *C. coli* strains were resistant to erythromycin. This study revealed that two isolates of *C. jejuni* (1%) and none of the tested *C. coli* strains were resistant to azithromycin. None of the tested isolates were resistant to both erythromycin and azithromycin. Multidrug resistance, which is defined as resistance to at least two different antimicrobial agents, was more common among *C. jejuni* (29.8%) strains than *C. coli* (18.1%) strains.

4. Discussion

Among the 742 samples collected from different types of fresh poultry meat, *Campylobacter* spp. were isolated from 309 (41.6%) of samples tested (%).

### Table 2

<table>
<thead>
<tr>
<th>Year</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>0</td>
<td>0.0041</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>2010</td>
<td>0.0041</td>
<td>0.2102</td>
<td>0.0035</td>
<td>0.0139</td>
<td>0.139</td>
</tr>
<tr>
<td>2011</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0085</td>
<td>0.2396</td>
<td>0.6164</td>
</tr>
<tr>
<td>2012</td>
<td>0.0000</td>
<td>0.0035</td>
<td>0.0085</td>
<td>0.6164</td>
<td>0.6164</td>
</tr>
<tr>
<td>2013</td>
<td>0.0000</td>
<td>0.0139</td>
<td>0.2396</td>
<td>0.6164</td>
<td>0.6164</td>
</tr>
</tbody>
</table>

### Table 3

<table>
<thead>
<tr>
<th>Food category</th>
<th>Number of <em>Campylobacter</em> spp. isolated</th>
<th>Number of <em>Campylobacter</em> positive samples/number of samples tested (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chicken breast filet</td>
<td><em>C. jejuni</em> (30), <em>C. coli</em> (19)</td>
<td>49/133 (36.8)</td>
</tr>
<tr>
<td>Turkey breast filet</td>
<td><em>C. jejuni</em> (28), <em>C. coli</em> (20)</td>
<td>48/112 (42.8)</td>
</tr>
<tr>
<td>Chicken leg quarters</td>
<td><em>C. jejuni</em> (46), <em>C. coli</em> (24)</td>
<td>70/123 (60)</td>
</tr>
<tr>
<td>Chicken wings</td>
<td><em>C. jejuni</em> (28), <em>C. coli</em> (17)</td>
<td>45/128 (35.1)</td>
</tr>
<tr>
<td>Chicken drumstick</td>
<td><em>C. jejuni</em> (26), <em>C. coli</em> (23)</td>
<td>49/115 (42.6)</td>
</tr>
<tr>
<td>Chicken giblets</td>
<td><em>C. jejuni</em> (36), <em>C. coli</em> (12)</td>
<td>48/119 (40.3)</td>
</tr>
</tbody>
</table>
the samples. According to the EFSA report, the incidence of *Campylobacter* in fresh retail broiler meat sampled in 2012 ranged from 0 to 80.6%. Differences in these results may occur due to meat type, sampling techniques, methodology or seasonal effects (Zendehbad et al., 2013). The prevalence of *Campylobacter* spp. reported in this study is comparable to data reported by Williams and Oyarzabal (2012), Mackiw, Rzewuska, Stoś, Jarosz, and Korsak (2011), Madden, Moran, Scates, McBride, & Kelly, 2011.

Our data revealed that although we maintained identical methods of isolation and identification, the prevalence of *Campylobacter* in samples of retail poultry meat changed during the study period. In 2013, 32.0% of examined food samples were positive for *Campylobacter*. In 2009, the results indicated that 60.2% of samples were contaminated with the examined bacteria. There are also reports on the prevalence of *Campylobacter* spp. in retail poultry meat in Italy, where a decreasing temporal trend was revealed (i.e., 81% of poultry meat samples exhibited *Campylobacter* contamination in the study performed by Pezzotti et al. in 2003, and 51% of poultry meat samples exhibited *Campylobacter* contamination in study performed by Sammarco et al. in 2010, followed by a prevalence of 20.7% in 2013 in studies performed by Nobile et al.). However, the prevalence of *Campylobacter* spp. in retail broiler meat in the USA failed to change during a seven-years study performed by Williams and Oyarzabal (2012).

Species identification indicated that the majority (62.8%) of the positive samples were contaminated with *C. jejuni* species. Most authors of previous studies confirmed the predominance of *C. jejuni* strains in poultry meat (Anonymous, 2012; Bardon et al., 2011; Madden, et al., 2011).

Poland and other countries of the European Union are required to eradicate, control and monitor certain animal diseases and zoonoses. The trend of decreasing isolation of *Campylobacter* spp. from retail poultry meat from 2009 to 2013 could be associated with the implementation of the recommendations of this program in Poland, improving the sanitary and hygienic slaughtering, storage, cutting, processing and packing of poultry meat. More research is needed to verify this positive trend of decreasing *Campylobacter* prevalence in retail poultry meat in this region of Poland.

Limited data are available concerning the existence of *C. jejuni* and *C. coli* in individual parts of chicken and turkey meat samples. The obtained results concerning the prevalence of *Campylobacter* in chicken giblets (40.3%) are similar to those reported in the studies of Mackiw et al., in which as many as 47.3% of chicken giblet samples were contaminated with the bacteria. The data obtained for turkey filets stand in contrast to the results reported in the studies of Calmak and Erol (2012), in which *Campylobacter* spp.-positive samples were detected in 61.1% of turkey breast meat samples. The analysis of the prevalence of the bacteria in different parts of chicken carcasses in the study performed by Wieczerzk, Szewczyk, and Osek (2012) revealed that the legs were the part that was most frequently contaminated with *Campylobacter*, but the level of contamination in that study was higher (89.1%) than the level obtained in the current study.

Human *Campylobacter* infections are related to the season of the year, with a higher incidence in warmer months due to consumer behavior and dietary habits (Bardon et al., 2011). An association between the prevalence of *Campylobacter* spp. in retail samples and the season of the year was documented previously. Seasonal variation in the *Campylobacter* contamination of broiler chicken meat was confirmed in the studies of Boysen, Vigre, and Rosenquist (2011). The season significantly affected the occurrence of *Campylobacter* in retail chicken meat, which peaked during the warm summer period. In our research, seasonality was not observed for every year of the study. In the years from 2009 to 2013, the number of *Campylobacter*-positive samples was highest in July and March. A statistically significant increase in the isolation of *Campylobacter* spp. was observed in these months in comparison to October, in which the number of observed positive samples was lowest. In the studies of Bardon et al. (2011), no strong association was observed between the prevalence of *Campylobacter* in retail samples and the season of the year.

The complex pathogenesis process of *Campylobacter* species is not yet well defined, although motility, adherence, invasion and cytotoxin production appear to be essential virulence factors. The prevalence of virulence genes responsible for pathogenicity (i.e., the flaA gene responsible for motility, the cadF gene responsible for adhesion, the cdtB gene responsible for toxin production, and iam gene responsible for invasiveness) among the *Campylobacter* strains isolated in the study was generally similar to other reported data.

The flaA gene was present in all *Campylobacter* spp. isolated from poultry meat. The obtained results are identical with the work of other authors (Datta, Niwa, & Itoh, 2009; Ripabelli, Tamburo, Minelli, Leone, & Sammarco, 2010; Thorsness, Sherwood, Danzeisen, Doetkott, & Logue, 2008). The prevalence of the cadF gene in products of animal origin was the subject of studies performed by Datta et al. in 2003, Różynek et al. in 2005. The results of those studies are consistent with the results presented in this study. In material collected from poultry meat, the marker iam was more likely to occur among *C. coli* strains than among *C. jejuni* strains (95.6% and 84.5%, respectively). Similar results were obtained by Różynek et al. (2005). The invasion-associated marker iam was detected in 54.7% of *C. jejuni* strains and 100% of *C. coli* strains collected in this study. The results revealed a lower incidence of the cdtB gene than reported by other authors (Datta et al., 2009; Hamidian et al., 2011).

Monitoring the progress of *Campylobacter* resistance is a growing public health issue. According to the EFSA report (Anonymous, 2014b), the ciprofloxacin resistance levels in *C. jejuni* and *C. coli* isolates from poultry meat in the EU were estimated to be 59.5% and 82.7%, respectively. The research presented in this study confirmed a high level of fluoroquinolone resistance among *Campylobacter* species, especially in *C. coli* isolates (72.2%). The frequency of resistance to tetracycline among *Campylobacter* spp. was estimated to be 42.3% in this study. The obtained results are

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**Table 4**

<table>
<thead>
<tr>
<th>Antimicrobial</th>
<th>Table 4</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2009–2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ciprofloxacin</td>
<td>0.75</td>
<td>0.75</td>
<td>0.80</td>
<td>0.75</td>
<td>0.80</td>
<td>0.75</td>
<td>0.75</td>
</tr>
<tr>
<td>Erythromycin</td>
<td>0.75</td>
<td>0.75</td>
<td>0.80</td>
<td>0.75</td>
<td>0.80</td>
<td>0.75</td>
<td>0.75</td>
</tr>
<tr>
<td>Azithromycin</td>
<td>0.75</td>
<td>0.75</td>
<td>0.80</td>
<td>0.75</td>
<td>0.80</td>
<td>0.75</td>
<td>0.75</td>
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<tr>
<td>Tetracycline</td>
<td>0.75</td>
<td>0.75</td>
<td>0.80</td>
<td>0.75</td>
<td>0.80</td>
<td>0.75</td>
<td>0.75</td>
</tr>
</tbody>
</table>

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*Fig. 1. Seasonal prevalence of *Campylobacter* spp. in retail poultry meat from 2009 to 2013 (the data are presented as the number of positive samples in individual months).*
similar to those of the previous studies (Noormohamed & Fakhr, 2012; Wieczorek et al., 2012), although the EFSA report indicated a higher level of resistant \textit{C. coli} strains among bacteria isolated from broiler meat (57.3%). Recent studies focused on the increasing problem of macrolide-resistant strains isolated from poultry, as contaminated food can be a vehicle for the transmission of these strains to humans. In this study, resistance to erythromycin and azithromycin was also confirmed. Similar results were described by Rozynek et al. (2013), although resistance to erythromycin was only observed in \textit{C. coli} isolates and was estimated to have a prevalence of 4.7%. A higher level of resistance to erythromycin among \textit{C. coli} strains than among \textit{C. jejuni} strains isolated from chicken meat was also reported by the EFSA (16.5% and 1.8%, respectively).

In conclusion, due to the increasing number of \textit{Campylobacter} cases in humans, the importance of poultry as a source of infection and the growing concerns about antimicrobial resistance, additional comparable data related to the prevalence of \textit{Campylobacter} spp. in poultry meat are needed. Further studies are necessary to determine whether hygienic measures on farms and control measures during carcass processing reduce \textit{Campylobacter} numbers in retail poultry products.

Acknowledgments

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