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Diagnostic Test Methods to Identify Campylobacter Species from Animal Samples

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Abstract

Campylobacter species are a leading cause of bacterial foodborne infections in both developed and developing countries. Considering the presence of the "emerging" and re-emerging of a human pathogenic Campylobacter species in the food and their production environment, it is prudent to include them when developing detection methods. Various diagnostic methods have been developed to detect Campylobacter in animal samples, including culture-based methods, Immunological assays, and molecular techniques. However, there is a lack of consensus on the most reliable and sensitive method for Campylobacter detection in animal samples. Different methods have limitations and advantages. So, Since Campylobacter species in the sample were desiccate and needs fast preparation time and process, the DNA-based methods for a fast screening of positive samples were recommended.

Keywords: Campylobacter, foodborne infections, Immunological assays, and molecular techniques

1. Introduction

Campylobacter spp. are a leading cause of bacterial foodborne infections in both developed and developing countries (Igwaran and Okoh, 2019; Kaakoush *et al.,* 2015). The annual incidence of foodborne campylobacteriosis has increased in the US, and Europe with 64.9 and 130 cases per 100,000 populations in these countries, respectively (EFSA*et al.,* 2019; Tack *et al.,* 2019).

The clinical symptoms of campylobacteriosis include gastrointestinal manifestations such as bloody diarrhea, inflammatory bowel disease (IBD), esophageal diseases, periodontal diseases, celiac disease, colorectal cancer, and extra-gastrointestinal manifestations such as Guillain-Barre syndrome, Miller-Fisher syndrome, bacteremia and septicemia, cardiovascular complications, meningitis, and reactive arthritis (Kaakoush et al., 2015). In a review article, Teunis *et al.* predicted the infectious dose to be <100 Colony Forming Units (CFU), depending on the *Campylobacter jejuni* strain (Teunis *et al.*, 2018).

Campylobacter species can colonize the mucosal surfaces of the gastrointestinal tracts of humans and a wide variety of wild and domesticated birds and mammals, including food animals. To date, the genus *Campylobacter* consists of 32 spp. and 9 subspecies (Costa and Iraola, 2019); most human infections are attributed to *C. jejuni* and *C. coli*. However, campylobacteriosis may also be caused by the "emerging" *Campylobacter* spp., including *C. concisus*, *C. sputorum*, *C. lari*, *C. upsaliensis*, *C. hyointestinalis*, *C. ureolyticus*, *C. curvus*, *C. fetus*, *C. gracilis*, *C. helveticus*, *C. insulaenigrae*, *C. mucosalis*, *C. rectus*, *C. showae*, *C. ureolyticus* and *C. volucris*, which have been associated with clinical presentations such as gastroenteritis and/or bacteremia (Costa and Iraola, 2019; Kaakoush *et al.*, 2015; Man, 2011).

The main sources attributed to foodborne campylobacteriosis outbreaks from 2015 through 2019 include raw milk (51.9%), chicken (31.1%), and seafood (4.9%) (Interagency Food Safety Analytics Collaboration, 2021). The recovery of *Campylobacter* isolates from poultry and beef that were genetically identical to isolates recovered from humans directly links this spp. to human illness, demonstrating their impact on public health (Duffy, 2010).

The predominant *Campylobacter* spp. found in fresh fruits and vegetables include *C. jejuni*, *C. coli*, and *C. fetus* (Chai *et al.*, 2007; Mohammadpour *et al.*, 2018; Wijnands *et al.*, 2014). Possible sources for *Campylobacter* contamination in fresh produce include irrigation water, composted animal manure, fecal contamination from wild or domestic animals, post-harvest processes, and cross-contamination at the retail level as well as at home (Keller and Shriver, 2014; Lawton *et al.*, 2018; Rodrigues *et al.*, 2019). Considering the presence of the "emerging" human pathogenic *Campylobacter* spp. in food and their production environment (Garcia-Sanchez *et al.*, 2018), it is prudent to include them when developing detection methods.

Therefore, a comprehensive review of the available diagnostic methods for Campylobacter identification in animal health settings is necessary to assess their effectiveness, accuracy, and practicality. Such a review will also help identify the limitations and challenges associated with each method and highlight areas for future research. Overall, this review manuscript aims to provide an up-to-date resource for researchers and practitioners in the animal health sector to improve the diagnosis and management of Campylobacter infections in animals,

2. Literature review

Various diagnostic methods have been developed to detect Campylobacter in animal samples, including culture-based methods, Immunological assays, and molecular techniques. However, there is a lack of consensus on the most reliable and sensitive method for Campylobacter detection in animal samples.

2.1 Culture-based methods

Culture-based methods are considered the gold standard for Campylobacter detection, but they are time-consuming, laborious, and require specialized media and incubation conditions (Seliwiorstow *et al*., 2021).

Media can be divided into blood-based, charcoal based and others. Charcoal cefoperazone deoxycholate (CCDA) is the most commonly used selective plate medium worldwide (Bolton and Coates, 1983; Bolton and Robertson, 1982). Although Campylobacter colonies have unique characteristics on charcoal plate, the dark background is a challenge for identification to the untrained scientist. However, for those with sufficient experience, CCDA offers an easy identification of Campylobacter spp. and contaminants. On CCDA incubated at 42 °C for 36–48 hr, Campylobacter species usually appear as gray, flat, swarming colonies. We particularly consider this agar medium as one of the best choices based on simplicity and cost.

In general, there are no differences in the isolation rate of naturally occurring Campylobacter species from carcass rinses between charcoal based and blood-based media. However, Campy-Line plates appear to be selective against Campylobacter species and yield a lower isolation rate from carcass rinses and poultry fecal material (Oyarzabal *et al.*, 2005; Potturi-Venkata *et al.*, 2007). Few other media have been developed and marketed in the last 10 years. One of the newer plates is CampyFood ID agar.

Habib*et al.*, (2008) found that CampyFood ID performed similarly to CCDA when testing artificially contaminated samples. However, CampyFood ID was less effective for the detection of naturally contaminated samples, where non-Campylobacter colonies had similar color and were undistinguishable from Campylobacter colonies. The same authors later reported that this plate performed similarly to CCDA for direct counting of Campylobacter spp. in naturally contaminated chicken meat samples (Habib *et al.*, 2011). Recently, a C. jejuni/C. coli Chromogenic Plating Medium has been introduced into the market. However, there are no scientific publications on this new medium and therefore its incorporation in food microbiology laboratories will depend on validation studies and cost.

Most selective plate media have several antimicrobial agents, such as cefoperazone and vancomycin, as the primary inhibitor of enteric bacterial flora. However, the incorporation of filter membranes has allowed us to reduce the number and amount of antimicrobials. Currently, the addition of 33 mg of cefoperazone and 4 mg of amphotericin B per liter of medium appears to be the best combination to isolate Campylobacterspp. from retail broiler meat (Williams and Oyarzabal, 2012).

Amphotericin B performs similarly to cycloheximide for the isolation of Campylobacter spp. Frompoultry products and can be used in enrichmentand plate media (Oyarzabal *et al.*, 2005). The incorporation of either of these compounds appears to be a matter of cost. The use of filters also improves the performance of blood media, such as Campy-Cefex, which appears to have low selectivity and isolation rate because of the growth of competing microorganisms (Chon *et al.*, 2012).

2.2 Latex agglutination tests

Latex agglutination tests for rapid identification of Campylobacter species have been in use for approximately 20 years. The principle behind this test is the use of polyclonal antibodies to detect flagellar or outer membrane proteins. The latex particles are coated with immunoglobulin's that are raised against antigen from several Campylobacter species, primarily C. jejuni, C. coli and C. lari. Several studies have assessed previous latex tests, but as of 2013 there are only two commercial latex tests available in the US market: Microgen M46 Campylobacter (Microgen Bio-products Ltd., Camberley, Surrey, United Kingdom), which reacts with most of the Campylobacter spp., and SCIMEDXCAMPY (jcl) ™ (Scimedx Corp., Denville, NJ), which reacts only with C. jejuni, C. coli and C. lari (Miller *et al.*, 2008).

Although several studies have assessed previous latex tests, only one commercial latex test is available in the market. Of present importance, a latex agglutination immunoassay, and/or the use of phase contrast microscopy are considered confirmatory tests in the suggested methodology for isolation, identification and enumeration of Campylobacter spp. from poultry rinses and sponge samples by the U.S. Department of Agriculture (Anonymous, 2013a). It is important to remember that positive controls must be run with any latex agglutination test.

2.3 Enzyme-linked immunosorbent (ELA) assays

Similarly to the latex test, there were several ELA assays commercially available for the identification of Campylobacter species in foods, but most of these tests have been discontinued. Currently, commercial tests include mainly the

VIDAS® Campylobacter (bioMerieux, Marcy l'Etoile, France), which is an automated ELA system that has undergone several validations and has been in use in several countries for numerous years (Liu *et al.*, 2009; Reiter *et al.*, 2010).

There are currently four non-automated ELA assays for clinical samples: the Premier™ CAMPY microplate ELA and the Immuno Card STAT! CAMPY by Meridian Bioscience, Inc. (Cincinnati, OH) (Granato*et al.*, 2010); the ProSpecT™ Campylobacter assay by Remel Inc. (Lenexa, KS) (Granato*et al.*, 2010;Tribble*et al.*, 2008); and the Ridascreen® Campylobacter by RBiopharm AG (Germany) (Bessede*et al.*, 2011). These assays have a sensitivity of 105–6 CFU (colony forming units) per ml−1 (Oyarzabaland Battie, 2012). A recent evaluation of these assays showed that ELA assays are quite variable and that these assays alone should not be used for direct identification of Campylobacter spp. in stool samples. In addition, ELA assays are not sufficient for confirmation and therefore laboratories should confirm positive ELA results by culture methods(Fitzgerald *et al.*, 2011).

2.4 Molecular techniques

Molecular techniques, such as polymerase chain reaction (PCR) and loop-mediated isothermal amplification (LAMP), offer rapid and sensitive detection of Campylobacter in animal samples (Karami *et al.*, 2019). Molecular identification methods are fast and specific for the identification of Campylobacter species. Besides detecting specific segments of DNA or RNA, sequencing protocols are now providing a fast way to detect specific segments of the DNA that are unique for identification to the species and sometimes subspecies level.

Currently, these methods provide reliable tools for rapid screening of presumptive positive samples. However, the two regulatory agencies in charge of food safety in the USA, the Food and Drug Administration of the Department of Health and Human Services, and the Food Safety and Inspection Services of the U.S. Department of Agriculture, do not consider these molecular tests "confirmatory" and therefore the actual culture has to be obtained from presumptive positive samples for confirmation purposes.

Polymerase chain reaction (PCR) and multiplex PCR (mPCR) assays, since the first polymerase chain reaction (PCR) assay for the identification of Campylobacter species more than 20 years ago (Oyofo *et al.*,1992), PCR has become one of the most commonly used platforms for the identification of these foodborne pathogens. Genes unique to Campylobacter species have been used as targets for PCR assays to identify different Campylobacter spp. Manufacturers of PCR-based methods include enrichment protocols to recover injured or stressed cells and to increase the number of cells to detection level. The sensitivity of PCR assays is in the range of 103 CFU per ml in pure cultures, but the sensitivity is reduced considerably when testing food matrices.

The enrichment step also serves as a calibration to increase the probability of confirming a presumptive positive by cultural methods. Until 8–10 years ago, PCR assays were single PCR reactions, meaningthat they detected only one bacterial species. But in recent years a seriesof multiplex PCR (mPCR) assays have been designed to detect the presence of two or more species in the same sample. For instance, PCR assays have helped us understand that both C. jejuni and C. coli multiply to detection numbers during the enrichment of naturally contaminated retail broiler meat (Oyarzabal *et al.*, 2007).

Although the presence of both Campylobacter spp. was suggested in enriched poultry meat, it is extremely difficult to isolate both species from the enrichment with current plate media. Several multiplex PCR assays have been successfully used for testing a large number of commercial retail broiler meats(Cloak and Fratamico, 2002; Linton *et al.*, 1997; Oyarzabal *et al.*, 2005, 2007; Persson and Olsen, 2005; Zhou *et al.*, 2011) and therefore these protocols assist in providing rapid identification of Campylobacter species.

The platform for the detection of amplified product has already moved to real time detection protocols. There are two commercial real time PCR (qPCR) assays in the market: BAX® System for C. jejuni/coli/ lari (DuPont, Qualicon, Wilmington, DE) and iQ-Check™Campylobacter (Bio-Rad, Hercules, CA). More assays based on real time platforms, and its variations, will continue to appear in the market in the near future. Recently, a multiplex qPCR assay that targets the ceuEenterochelin gene for iron acquisition in C. jejuni (accession X82427) and C. coli(accession X88849) was developed and a total of 166 strains were tested in inclusivity and exclusivity studies (Gharst *et al.,* 2013). This qPCR protocol was able to detect 100% of 59 Campylobacter strains mexamined, which included 34 C. jejuni strains and 25 C. coli strains. Analysis of 107 strains for the exclusivity studies resulted in no false positives using this qPCR assay.

3. Discussion and Recommendations

Campylobacter is a significant foodborne pathogen associated withthe consumption of undercooked poultry or raw milk. In poultry products, the only Campylobacter spp. are C. jejuni and C. coli. In samples with low number of cells, the enrichment for 48 h under aerobic conditions is recommended to achieve a detectable number of Campylobacter cells. The samples collected are more sensitive forthe recovery and requires less time for preparation and processing of the samples. The dark background of CCDA is a challenge for identification to the untrained scientist. But, this agar medium is one of the best choices based on simplicity and cost. Latex agglutination requires positive controls must be run with any latex agglutination test. A recent evaluation of Enzyme Linked immunosorbent Assay assays (ELA) are quite variable and that these assays alone should not be used for direct identification of Campylobacter spp. in stool samples. In addition, ELA assays are not sufficient for confirmation and therefore laboratories should confirm positive ELA results by culture methods. Several multiplex PCR assays have been successfully used for testing a large number of and therefore these protocols assist in providing rapid identification of Campylobacter species. Analysis of 107 strains for the exclusivity studies resulted in no false positives using this qPCR assay. So, we recommend the DNA-based methods for a fast screening of positive samples.

References

Anonymous, 2013a. Isolation, identification, and enumeration of method for the enumeration of Campylobacter jejuni/coli/lari from poultry rinse, sponge and raw poultry product samples. USDA FSIS Microbiology Laboratory Guidebook, Chapter 41.02. (Available at http://www.fsis.usda.gov/wps/wcm/connect/0273bc3d-2363-45b3-befb-1190c25f3c8b/MLG 41.pdf?MOD=AJPERES).

Bessede, E., Delcamp, A., Sifre, E., Buissonniere, A.,Megraud, F., 2011. Newmethods for detection of campylobacters in stool samples in comparison to culture. J. Clin.Microbiol. 49, 941–944.

Bolton, F.J., Coates, D., 1983. Development of a blood-free Campylobacter medium: screening tests on basal media and supplements, and the ability of selected supplement to facilitate aerotolerance. J. Appl. Bacteriol. 54, 115–125.

Bolton, F.J., Robertson, L., 1982. A selective medium for isolating Campylobacter jejuni/coli.

broths and 3 selective agars for the detection of Campylobacter species in whole chicken

carcass-rinse samples. Poult. Sci. 2012 (91), 2382–2385.

Chai, L. C., Robin, T., Ragavan, U. M., Gunsalam, J. W., Bakar, F. A., Ghazali, F. M., ...& Kumar, M. P. (2007). Thermophilic Campylobacter spp. in salad vegetables in Malaysia. *International journal of food microbiology*, *117*(1), 106-111.

Chon, J.W., Hyeon, J.Y., Park, J.H., Song, K.Y., Seo, K.H., 2012.Comparison of 2 types of broths and 3 selective agars for the

detection of Campylobacter species in wholechicken carcass-rinse samples.Poult. Sci. 2012 (91), 2382–2385.

Cloak, O.M., Fratamico, P.M., 2002. A multiplex PCR for the differentiation of Campylobacter jejuni and C. coli from a swine processing facility and characterization of isolates by PFGE and antibiotic resistance profiles. J. Food Prot. 65, 266–273.

Costa, D., & Iraola, G. (2019).Pathogenomics of emerging Campylobacter species. *Clinical microbiology reviews*, *32*(4), e00072-18.

European Centre for Disease Prevention and Control (ECDC), European Food Safety Authority (EFSA), & European Medicines Agency (EMA). (2021). Third joint inter-agency report on integrated analysis of consumption of antimicrobial agents and occurrence of antimicrobial resistance in bacteria from humans and food-producing animals in the EU/EEA: JIACRA III 2016-2018. *EFSA Journal*, *19*(6), e06712.

European Food Safety Authority (EFSA), Aerts, M., Battisti, A., Hendriksen, R., Kempf, I., Teale, C., ...&Belœil, P. A. (2019). Technical specifications on harmonised monitoring of antimicrobial resistance in zoonotic and indicator bacteria from food-producing animals and food. *EFSA Journal*, *17*(6), e05709.

Fitzgerald, C., Patrick,M., Jerris, R.,Watson, R., Tobin-D'Angelo, M., Gonzalez, A., Polage, C.,

García-Sánchez, L., Melero, B., &Rovira, J. (2018).Campylobacter in the food chain. *Advances in food and nutrition research*, *86*, 215-252.

Gharst, G., Bark, D.H., Newkirk, D., Guillen, L., Wang, Q., Abeyta, C., 2013. Evaluation and single laboratory verification of a proposed modification to the U.S. Food and Drug Administration method for the detection and identification of Campylobacter jejuni or Campylobacter coli from raw silo milk. J. AOAC Int. (accepted for publication).

Granato, P., Chen, L., Holiday, I., Rawling, R., Novak-Weekley, S., Quinlan, T., Musser, K., 2010. Comparison of premier CAMPY enzyme immunoassay (EIA), ProSpecT Campylobacter EIA, and ImmunoCard STAT! CAMPY tests with culture for laboratory diagnosis of Campylobacter enteric infections. J. Clin. Microbiol. 48, 4022–4027.

Habib, I., Sampers, I., Uyttendaele, M., Berkvens, D., De Zutter, L., 2008.Performance characteristics and estimation of measurement uncertainty of three plating procedures for Campylobacter enumeration in chicken meat.Food Microbiol. 25, 65–74.

Igwaran, A., & Okoh, A. I. (2019). Human campylobacteriosis: A public health concern of global importance. *Heliyon*, *5*(11), e02814.J. Clin. Pathol. 35, 462–467.

Kaakoush, N. O., Castaño-Rodríguez, N., Mitchell, H. M., & Man, S. M. (2015).Global epidemiology of Campylobacter infection. *Clinical microbiology reviews*, *28*(3), 687-720.

Karami, N., Wysok, B., Skowron, K., and Rzewuska, M. (2019).Loop-mediated Isothermal amplification (LAMP) as a reliable and practical method for bacterial detection and identification—a review.Analytical and bioanalytical chemistry, 411(12), 2411-2427.

Keller, J. I., & Shriver, W. G. (2014).Prevalence of three campylobacter species, C. jejuni, C. coli, and C. lari, using multilocus sequence typing in wild birds of the Mid-Atlantic region, USA. *Journal of wildlife diseases*, *50*(1), 31-41.

Lawton, S. J., Weis, A. M., Byrne, B. A., Fritz, H., Taff, C. C., Townsend, A. K., ... & Boyce, W. M. (2018). Comparative analysis of Campylobacter isolates from wild birds and chickens using MALDI-TOF MS, biochemical testing, and DNA sequencing. *Journal of Veterinary Diagnostic Investigation*, *30*(3), 354-361.

Linton, D., Lawson, A.J., Owen, R.J., Stanley, J., 1997. PCR detection, identification to species level, and fingerprinting of Campylobacter jejuni and Campylobacter coli direct from diarrheic samples. J. Clin. Microbiol. 35, 2568–2572.

Liu, L., Hussain, S.K., Miller, R.S., Oyarzabal, O.A., 2009. Research note: efficacy of mini VIDAS for the detection of Campylobacter spp. from retail broiler meat enriched in Bolton broth with or without the supplementation of blood. J. Food Prot. 72, 2428–2432.

Lynch, O. A., Cagney, C., McDowell, D. A., & Duffy, G. (2010). A method for the growth and recovery of 17 species of Campylobacter and its subsequent application to inoculated beef. *Journal of microbiological methods*, *83*(1), 1-7.

Man, S. M. (2011). The clinical importance of emerging Campylobacter species. *Nature reviews Gastroenterology &hepatology*, *8*(12), 669-685.

Miller, R.S., Speegle, L., Lastovica, A.J., Oyarzabal, O.A., 2008. Letter to the Editor.An evaluation of three commercial latex agglutination tests for the identification of Campylobacter spp. J. Clin.Microbiol. 46, 3546–3547.

Mohammadpour, H., Berizi, E., Hosseinzadeh, S., Majlesi, M., &Zare, M. (2018). The prevalence of Campylobacter spp. in vegetables, fruits, and fresh produce: a systematic review and meta-analysis. *Gut pathogens*, *10*, 1-12.

Oyarzabal, O.A., Backert, S., Nagaraj, M., Miller, R.S., Hussain, S.K., Oyarzabal, E.A., 2007. Efficacy of supplemented buffered peptone water for the isolation of Campylobacter jejuni and C. coli from broiler retail products. J. Microbiol. Methods 69, 129–136.

Oyarzabal, O.A., Macklin, K.S., Barbaree, J.M., Miller, R.S., 2005. Evaluation of agar plates for direct enumeration of Campylobacter spp. from poultry carcass rinses. Appl. Environ. Microbiol. 71, 3351–3354.

Oyarzabal,O.A., Battie, C., 2012. Immunologicalmethods for the detection of Campylobacter spp. — current applications and potential use in biosensors. In: Abuelzein, E. (Ed.), Trends in Immunolabelled and Related Techniques. InTech. ISBN: 978-953-51-0570-1, pp. 203–226.

Oyofo, B.A., Thornton, S.A., Burr, D.H., Trust, T.J., Pavlovskis, O.R., Guerry, P., 1992.Specificdetection of Campylobacter jejuni and Campylobacter coli by using polymerase chain reaction. J. Clin. Microbiol. 30, 2613–2619.

Pérez-Rodríguez, F., &MercanogluTaban, B. (2019). A state-of-art review on multi-drug resistant pathogens in foods of animal origin: risk factors and mitigation strategies. *Frontiers in Microbiology*, *10*, 2091.

Persson, S., Olsen, K.E.P., 2005. Multiplex PCR for identification of Campylobacter coli and Campylobacter jejuni from pure cultures and directly on stool samples. J. Med. Microbiol. 54, 1043–1047.

Potturi-Venkata, L.P., Backert, S., Lastovica, A.J., Vieira, S.L., Norton, R.A., Miller, R.S., Pierce, S.J., Oyarzabal, O.A., 2007.Evaluation of different plate media for direct cultivation of Campylobacter spp. from live broilers.Poult. Sci. 86, 1304–1311.

Reiter, M.G., López, C., Jordano, R., Medina, L.M., 2010.Comparative study of alternative methods for food safety control in poultry slaughterhouses.Food Anal.Meth. 3, 253–260.

Seliwiorstow, T., Berkevens, D., Boon, N., and Verstraete, W. (2021). Cultivation-independent detection and characterization of Campylobacter species using culture-independent methods: a review. Critical reviews in microbiology, 47(2), 170-183

Tack, D. M., Ray, L., Griffin, P. M., Cieslak, P. R., Dunn, J., Rissman, T., ...& Payne, D. C. (2020). Preliminary incidence and trends of infections with pathogens transmitted commonly through food—Foodborne Diseases Active Surveillance

Network, 10 US Sites, 2016–2019. *Morbidity and Mortality Weekly Report*, *69*(17), 509.

Teunis, P. F., Marinović, A. B., Tribble, D. R., Porter, C. K., & Swart, A. (2018). Acute illness from Campylobacter jejuni may require high doses while infection occurs at low doses. *Epidemics*, *24*, 1-20.

Tribble, D., Baqar, S., Pang, L.,Mason, C., Houng, H., Pitarangsi, C., Lebron, C., Armstrong, A., Sethabutr, O., Sanders, J., 2008. Diagnostic approach to acute diarrheal illness in a military population on training exercises in Thailand, a region of Campylobacter hyperendemicity. J. Clin. Microbiol. 46, 1418–1425.

Wijnands, L. M., DELFGOU-van ASCH1, E. H., Beerepoot-Mensink, M. E., van der Meij-Florijn, A., Fitz-James, I., van Leusden, F. M., &Pielaat, A. (2014). Prevalence and concentration of bacterial pathogens in raw produce and minimally processed packaged salads produced in and for the Netherlands. *Journal of food protection*, *77*(3), 388-394.

Williams, A., Oyarzabal, O.A., 2012. Prevalence of Campylobacter spp. in skinless, boneless retail broiler meat from 2005 through 2011 in Alabama, USA.BMC Microbiol.12, 184.

Wymore, K., Gillim-Ross, L., Sadlowski, J., Monahan, J., Hurd, S., Dahlberg, S., DeMartino, M., Pentella, M., Razeq, J., Leonard, C., Jung, C., Juni, B., Robinson, T., Gittelman, R., Garrigan, C., Nachamkin, I., Campylobacter diagnostics working group, 2011.Multicenter study to evaluate diagnostic methods for detection and isolation of Campylobacter fromstool.AnnualMeeting of theAmerican Society forMicrobiology, New Orleans, LA., (n.d.), 20 Sept.

Zhou, P., Hussain, S.K., Liles, M.R., Arias, C.R., Backert, S., Kieninger, J.R., Oyarzabal, O.A., 2011.A simplified and cost-effective enrichment protocol for the isolation of Campylobacter spp. from retail broiler meat without microaerobic incubation.BMC Microbiol.11, 175.

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