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OCCURRENCE OF *CAMPYLOBACTER SPP* AMONG GOATS IN KOTA BHARU, KELANTAN

By

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ABSTRACT

An abstract of the research paper presented to the Faculty of Veterinary Medicine, Universiti Malaysia Kelantan, in partial requirement of the course DVT 55204 – Research Project.

This thesis investigates the occurrence of *Campylobacter* species among goats in Kota Bharu, Kelantan. Given the significant role of goats as potential reservoirs for this pathogen, the study aims to provide insights into the prevalence and implications of *C. jejuni* in the local goat population. A total of 53 fecal swab samples were collected from various goat farms in Kota Bharu. The samples were cultured on modified charcoal cefoperazone deoxycholate agar (mCCDA) and subsequently analyzed using polymerase chain reaction (PCR) techniques to confirm the presence of *C. jejuni* and other *Campylobacter* species. The results revealed that 2 out of 53 samples tested positive for *C. jejuni*, yielding a prevalence rate of 3.77%. Statistical analysis indicated no significant association between the presence of *C. jejuni* and factors such as age ($p = 0.053$) and sex ($p = 0.819$). However, a significant relationship was observed between the occurrence of *C. jejuni* and management practices ($p = 0.016$) as well as previous medical treatments ($p = 0.044$). These findings underscore the importance of monitoring *Campylobacter* in goat populations to mitigate public health risks associated with zoonotic transmission through contaminated meat products.

Keywords : Goats, *Campylobacter jejuni*, Zoonotic transmission

ABSTRAK

Kertas penyelidikan ini dikemukakan kepada Fakulti Perubatan Veterinar, Universiti Malaysia Kelantan, sebagai sebahagian daripada keperluan kursus DVT 55204 – Projek Penyelidikan.

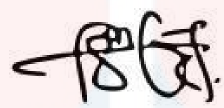
Tesis ini menyelidiki kejadian spesies *Campylobacter* dalam kalangan kambing di Kota Bharu, Kelantan. Memandangkan peranan penting kambing sebagai reservoir berpotensi bagi patogen ini, kajian ini bertujuan untuk memberikan maklumat mengenai prevalens dan implikasi *C. jejuni* dalam populasi kambing tempatan. Sebanyak 53 sampel swab najis telah dikumpulkan dari pelbagai ladang kambing di Kota Bharu. Sampel-sampel tersebut dikultur pada modified charcoal cefoperazone deoxycholate agar (mCCDA) dan seterusnya dianalisis menggunakan teknik tindak balas rantai polimerase (PCR) untuk mengesahkan kehadiran *C. jejuni* dan spesies *Campylobacter* lain.

Hasil kajian menunjukkan bahawa 2 daripada 53 sampel didapati positif untuk *C. jejuni*, memberikan kadar prevalens sebanyak 3.77%. Analisis statistik menunjukkan tiada hubungan yang signifikan antara kehadiran *C. jejuni* dengan faktor seperti umur (p = 0.0531) dan jantina (p = 0.8194). Walau bagaimanapun, terdapat hubungan yang signifikan antara kehadiran *C. jejuni* dengan amalan pengurusan (p = 0.0161) dan rawatan perubatan sebelumnya (p = 0.0444). Penemuan ini menekankan kepentingan pemantauan *Campylobacter* dalam populasi kambing untuk mengurangkan risiko kesihatan awam yang berkaitan dengan penularan zoonotik melalui produk daging yang tercemar

Kata kunci : Kambing, *Campylobacter jejuni,* Penyebaran zoonosis.

CERTIFICATION

This is to certify that we have read this research paper entitled **'Occurrence of *Campylobacter spp* in Goats from Kota Bharu, Kelantan'** by **Ahilya Vikneswaran**, and in our opinion, it is satisfactory in terms of scope, quality, and presentation as partial fulfillment of the requirements for the course DVT 55204 – Research Project.



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My parents

Lab assistance of FPV UMK

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Floppy, Biscuit, Nia, Batman & Bulan

Thank you

DEDICATIONS

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LIST OF ABBREVIATIONS

PCR	-	Polymerase Chain Reaction
DNA	-	Deoxyribose Nucleic Acid
AMR	-	Antimicrobial Resistance
mCCDA	-	modified Charcoal Cefoperazone Deoxycholate Agar
CCDA	-	Charcoal Cefoperazone Deoxycholate Agar

CHAPTER 1

1.0 Introduction

Campylobacter genus belongs to the family *Campylobacteriaceae*, order *Campylobacterales*, class *Epsilonproteobacteria,* and phylum *Proteobacteria*. The genus has a diverse and vast group comprising 27 species, nine subspecies, and three biovars (Hofreuter, 2020). *Campylobacteriosis* is a common disease that causes foodborne illnesses around the globe, with *Campylobacter jejuni* and *Campylobacter coli* being the predominant species in human infections. It is also a significant zoonotic pathogen that results in gastrointestinal infections in both humans and animals. In the poultry industry, chickens have been identified as a major reservoir of *Campylobacter*. It is also the main cause of enteritis in humans, whereas *C.jejuni* and *C.coli* are mostly responsible for infections in developing and developed countries (Man, 2011).

Studies have shown that *Campylobacter* is prevalent in goats worldwide including Malaysia. Yakubu, 2019 conducted a study and the findings stated that 41.7% of goat milk samples from various farms in Kelantan tested positive for *Campylobacter spp (*Yakubu, 2019*).* This highlights the importance of monitoring *Campylobacteria* in the goat population to ensure public health and food safety. Since Kota Bharu has a large goat population where many citizens have backyard farms rearing goats. Therefore, it is important to understand the prevalence of *Campylobacter* contamination in goats in Kota Bahru. This would aid in developing effective strategies to mitigate the risk associated with this pathogen. This pathogen, however, is poorly studied in all animals, which include goats, hence its epidemiology is still poorly understood.

1.1 Problem statement

Goats are known to harbor various zoonotic pathogens including *Campylobacter*. Their close contact with humans could result in opportunities for zoonotic transmission. Although the importance of understanding *Campylobacteriosis* has been addressed in some states of Malaysia, however, there is limited research that addresses the occurrence of *Campylobacter* in goats in Kelantan.

1.2 Research question

I. What is the level of occurrence of *Campylobacter sp* among goats in Kelantan?

II. Which species of *Campylobacter is most isolated* among goats in Kelantan?

III. What are the risk factors associated with the occurrence of *Campylobacter spp* among goats?

1.3 Research hypothesis

I. *Campylobacter spp* has a high occurrence among goats in Kota Bharu Kelantan

II. *Campylobacter coli* and *Campylobacter jejuni* are the most isolated species among goats in Kota Bharu Kelantan.

III. Risk factors that influence the occurrence of *Campylobacter spp* are, such as their age, sex, type of management practice, and if they received previous treatments.

1.4 Research objective

I. To determine the occurrence of *Campylobacter spp.* in goat populations from selected farms in Kelantan.

II. To identify the *Campylobacter spp* isolated from goat fecal swabs using microbiological and molecular techniques.

III. To identify the potential risk factors for the occurrence of *Campylobacter spp* in goats

CHAPTER 2

2.0 Literature review

2.1 Background of *Campylobacter spp*

Campylobacter spp is a major cause of foodborne gastroenteritis worldwide with *C .jejuni* and *C.coli* being the most pathogenic species identified (Ocejo et al., 2019). *Campylobacter spp* are gram-negative spiral, microaerophilic pathogens that grow optimally at temperatures of 42°C (Ansarifar et al ., 2023). *Campylobacter spp* has been identified in the gastrointestinal tract of many livestock animals including poultry, cattle, sheep, and goats (Chala et al., 2021). In 1968, researchers in Belgium successfully isolated *Campylobacter* from stool specimens of patients with diarrhea for the first time. This was achieved using the method of direct membrane filtration onto an agar medium containing various antibiotics (Tellez-Isaias & El-Ashram, 2022).

2.2 Transmission of *Campylobacter spp*

Goats are typically infected with *Campylobacter* from exposure to direct contact. It is transmitted directly from sick animals, by way of ingestion of contaminated feed or water, or even by licking or chewing on fomites infected by contaminated feces. The bacteria can spread asymptomatically by colonizing the gastrointestinal tract of these infected goats resulting in *Campylobacter spp* being shed in the feces hence leading to environmental contamination and the possibility of transmission to humans (Mohammad M. Obaidat et al., 2023). *Campylobacter* is then transmitted to humans who consume undercooked meat, unpasteurized dairy products, or in contact with infected animal feces (Cortés et al., 2006).

2.3 Clinical signs of Campylobacteriosis in goats

Campylobacter infection in goats is often asymptomatic. The infection could occasionally lead to clinical signs of diarrhea, abortion, and other gastrointestinal problems (Berhanu et al., 2021). Gastrointestinal signs exhibited are predominantly present depending on the species of *Campylobacter* infecting the animals. Considering it is asymptomatic, this infection often ends up undiagnosed resulting in the overgrowth of the bacteria in the goat's gut without causing over-clinical signs resulting in a continuous shedding and environmental spread (Mohammad M. Obaidat et al., 2023).

2.4 Clinical signs of Campylobacteriosis in humans

Humans infected with *Campylobacter spp.* from goats can develop acute gastroenteritis, characterized by diarrhea, abdominal pain, fever, and vomiting. The most commonly isolated species found among humans is *C.jejuni* which is now recognized as the leading cause of foodborne diseases in both developing and developed countries (Fischer et al., 2024). It is reported that *Campylobacter* infections could potentially lead to complications such as bacteremia, hepatitis, pancreatitis, miscarriages, reactive arthritis, and even neurological disorders like Gullain-barre syndrome which is an autoimmune-mediated demyelinating neuropathy among humans (Fischer et al., 2024).

Notably, cancer-related patients with reduced immunity would be at greater risk of developing *Campylobacteriosis*. Likewise, people who work closely with animals. Since *Campylobacter* can be transmitted through undercooked food, people who regularly consume lightly cooked or undercooked meat would be potentially at risk of developing campylobacterosis (Igwaran & Okoh, 2019).

2.5 Diagnosis of Campylobacteriosis

Diagnosing goats infected with *Campylobacteriosis* can be relatively difficult as they are more often than not asymptomatic (Québec, 2024). Apart from that, it is also challenging to isolate and identify *Campylobacter spp* as they are fragile. The gold standard in diagnosis would be to culture and isolate the bacteria using selective media under microerophilic conditions (Pezzanite et al., 2008). Samples from feacal, vaginal, and environment swabs and stomach content should be collected and transported in enrichment media for example Clark's medium as it would enhance the survival rate of *Campylobacter spp* (Bronowski et al., 2014). In more recent studies, several broths namely, Campylobacter enrichment broth, and Preston broth have also been used as enrichment media for the isolation of *Campylobacter spp* (Silva et al., 2011).

Samples collected should be directly streaked onto agar plates for the isolation of *Campylobacter spp*. The first selective agar medium designed specifically for the recovery of *C. jejuni and C. coli,* was a modified charcoal cefoperazone deoxycholate agar (mCCDA) medium (Chon et al., 2011). Currently, this method is the most extensively used in human and veterinary diagnostic medicine for the detection of species. Apart from that, diagnosis is often achieved through PCR assays and other molecular methods. However, fresh samples must be collected regardless if it is feces, faecal swabs, or blood cultures although it is rare that blood cultures are used as they rarely give an accurate diagnosis.

2.6 Treatment for Campylobacteriosis

Traditionally, antibiotic therapy is commonly used to treat goats infected with *Campylobacter* specifically with the cycline groups such as chlortetracycline or tetracycline (Prachanatasena et al., 2022). Since common clinical signs observed with animals infected with *Campylobacter spp*, is diarrhea, it is proven effective to provide supportive care to rehydrate infected animals (Johnson et al., 2017). However, antibiotic treatments have not been proven very effective as they do not prevent the disease from further spreading. Most animals would remain as asymptomatic carriers and continuously shed despite antimicrobial therapy (Johnson et al., 2017).

In recent years, alternative treatments have been done to reduce the colonization of *Campylobacter spp* for example, anti-campylobacter compounds like thyme extracts have been known to reduce adhesions of *C. jejuni* to intestinal cells that would help inhibit the colonization as well as the disease progression (Johnson et al., 2017). Other than that, anti-*Campylobacter* bacteriocins have been proven to be promising in reducing the incidences of *Campylobacter* colonization in poultry outbreaks as they target and inhibit the growth of these species(Svetoch & Stern, 2010) which begs the question if it would be able to help reduce the incidence in goats as well.

CHAPTER 3

3.0 Methodology

3.1 Ethics statement and permit approval

The IACUC approved this study of UMK to involve the use and care of animals with the ethics code: UMK/FPV/ACUE/FYP/015/2024.

3.2 Study design and area

This study was a cross-sectional study, conducted across several backyard farms around Kota Bharu Kelantan with the approval of the owners.

3.3 Sample collection

A total of 53 goats were sampled from the different farms. Rectal swabs were collected aseptically from the goats regardless of health status, age and gender, using disposable hand gloves and sterile cotton-tipped rectal swabs, sourced from farms located in Kota Bharu. Following collection, the samples were individually stored in sterile plastic bags to prevent any potential cross-contamination. Subsequently, they were promptly transported, utilizing Cary-Blair transport media, to the laboratory in a cooler box maintained at 4°C. Upon arrival at the laboratory, samples were immediately processed, within 2-4 hours of sampling (Aslantaş et al., 2019).

In addition, information was collected from the owners which included, the age of the subjects (categorized as young and adult), their sex (distinguishing between male and female), prior medical and vaccination history, and the type of management practices they are under (intensive vs extensive), were obtained prior to sample collection.

3.4 Sample preparation and bacteria isolation

Rectal swabs were directly streaked onto modified charcoal cefoperazone deoxycholate agar (mCCDA) supplemented with a CCDA selective additive for primary isolation. Strict aseptic techniques were employed to minimize the risk of contamination. The plates were incubated at 41.5ºC for 48 hours under microaerophilic conditions, maintained using anaerobic jars (Goni *et al*., 2017, Nachamkin *et al.*, 2017).

3.5 DNA extraction

After 48 hours of incubation, the agar was observed for any growth. Agar that had shown the presence of metallic greyish colonies was assumed to be positive for *Campylobacter sp* and DNA extraction was conducted (Carlos Abeyta et al., 2000). Out of the 53 samples, 14 showed the presence of metallic greyish colonies, which were then used to perform DNA extraction.

The boiling method was chosen for DNA extraction from the colonies due to its straightforward and effective nature. Since *Campylobacter* is a Gram-negative bacterium with a relatively thin peptidoglycan layer in its cell wall compared to Gram-positive bacteria, this method works well. Heating at 100°C disrupts the lipid membrane, causing cell lysis and releasing intracellular components, including DNA (Dawson et al., 2022).

To begin, each Eppendorf tube was labeled, and a single colony was transferred into a microcentrifuge tube containing 1 mL of sterile sodium chloride (NaCl) solution to remove residual media. The tubes were centrifuged at 12,000 rpm for 5 minutes to pellet the bacterial cells. The supernatant was then carefully removed, leaving the pellet intact. The pellet was resuspended in 200 µL of sterile distilled water and briefly vortexed to ensure proper mixing.

The tubes were placed in a water bath at 100°C for 10 minutes to lyse the bacterial cells and release DNA. To prevent further DNA degradation, the tubes were immediately cooled on ice for 5 minutes after boiling. The samples were centrifuged again at 12,000 rpm for 5 minutes to separate the cell debris. Finally, the DNA-containing supernatant was transferred into a new microcentrifuge tube, so as not to disturb the pellet (Ali A. Dashti et al., 2009).

3.6 Detection of *Campylobacter jejuni* and *Campylobacter coli* by PCR

Gene amplification was performed with a total of 25L reaction volumes, containing, 5.0µL of extracted DNA sample,12.5µL Thermo Scientific™ DreamTaq™ PCR Master Mix (2X),1.0µL of a reverse primer,1.0µL of a forward primer with the target genes as mentioned in Table 1 and 5.5µL of nuclease-free water.

DNA amplification was conducted using the following thermal cycling conditions: an initial denaturation at 95°C for 15 minutes, followed by 25 cycles of 30 seconds at 95°C for denaturation, 1.5 minutes at 58°C for annealing, and 1 minute at 72°C for extension. The process was completed with a final extension step at 72°C lasting 7 minutes.

The PCR products were then subjected to gel electrophoresis on a 1.5% agarose gel, run at 100V for 40 minutes. The separated DNA fragments were visualized using the Gel Doc EZ imaging system.

Table 1 : Primer sequence used for the PCR assay and the predicted sizes of PCR products (Yamazaki-Matsune et al., 2007).

Gene	Size(bp)	Target gene	Primer sequence
C.jejuni	735	hip gene	5′-GAA GAG GGT TTG GGT GGT G-3′ 5′-AGC TAG CTT CGC ATA ATA ACT TG-3′
C.coli	502	ceuE	5′-GGT ATG ATT TCT ACA AAG CGA G-3′ 5′-ATA AAA GAC TAT CGT CGC GTG-3′

3.7 Statistical analysis

Data was entered and analyzed using Microsoft Excel. Descriptive statistics were calculated for *Campylobacter* species prevalence and variable factors that could contribute to the presence of *Campylobacter spp* (age, gender, management, and previous treatment). Chi-square test was used as appropriate to test the association between the prevalence and risk factors for *Campylobacter* species occurrence and between strains isolated from different sources. A *p*-value of 0.05 was used as the level for statistical significance.

CHAPTER 4

4.0 Results

After a 48-hour incubation period on modified Charcoal Cefoperazone Deoxycholate Agar (mCCDA), 14 plates exhibited colonies with greyish, flat, and moist appearances, which are characteristic of *Campylobacter* species, suggesting a preliminary identification as seen in figure 1. The DNA from all 14 samples was analyzed using polymerase chain reaction (PCR) with primers specific to *Campylobacter jejuni* and *Campylobacter coli*.

Post-amplification, the PCR products were subjected to gel electrophoresis and visualized under UV light. Distinct bands as seen in Figure 2 were detected in samples C4 and C10 when tested with the *C. jejuni*-specific primers. However, no bands were observed in any samples using the *C. coli*-specific primers. These results indicate the probable presence of *C. jejuni* DNA, with no evidence of *C. coli* DNA. Table 2 also shows the variables associated with the two samples tested positive for *C.jejuni*.

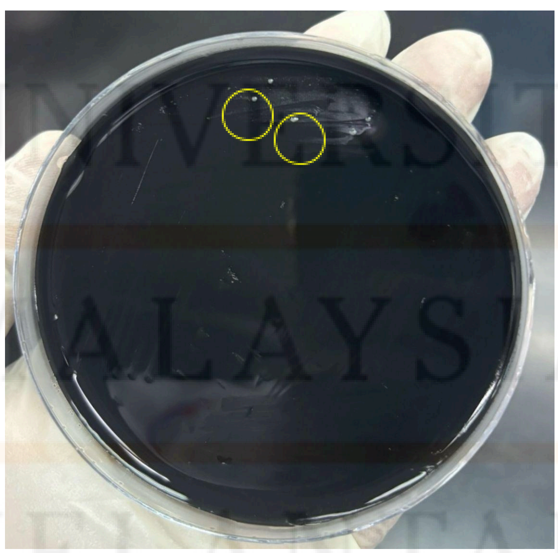


Figure 1: Yellow circles are indicative of* greyish, flat, moist growth, which was presumptively identified as *Campylobacter.

Table 2: Summary and information of samples that tested positive for *C.jejuni*

Variables	Sample C4	Sample C10
Age	Adult	Adult
Sex	Female	Female
Management	Extensive	Extensive
Previous treatment	No	No

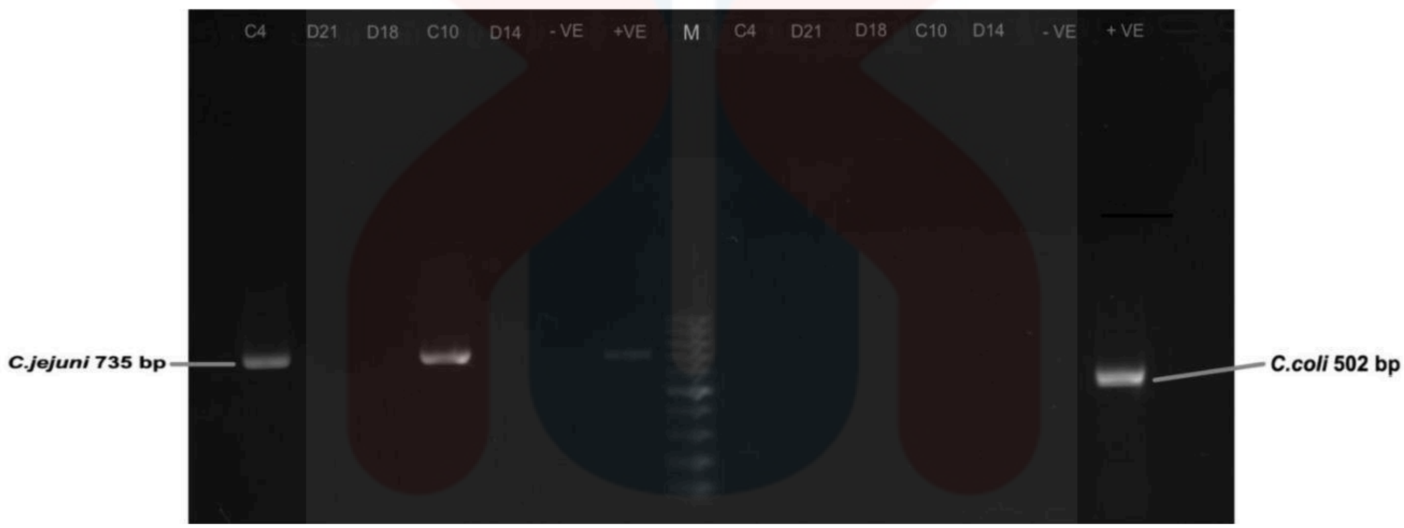


Figure 2 : PCR amplification of *Campylobacter jejuni* and *Campylobacter coli* isolated from goats.

4.1 Occurrence of *Campylobacter* in goats and associated risk factors

In this study, *C.jejuni* was detected in 2 out of 53 goats after confirmation by gel electrophoresis, resulting in a prevalence rate of 3.77%. Statistically as seen in Table 3, there was no significance reported between the presence of *C.jejuni* with age and sex with the p-values of 0.0531 and 0.8194 respectively. However, the association between *C.jejuni* between management practices and previous treatments was significant with p-values of 0.0161 and 0.0444 respectively. These findings align with previous research indicating that goats can serve as reservoirs for *C.jejuni*, contributing to potential zoonotic transmission through contaminated meat products (Kabwang et al., 2014). Given that a p-value less than 0.05 is generally considered statistically significant, our results underscore the importance of implementing effective management practices to mitigate *C.jejuni* infections in goat populations.

Table 3: Prevalence and p-values calculated using Microsoft Excel

Variables		n	Prevalence	p-value	95% CI
Age	**Juvenile**	8	0	0.0531	(0, 0.105)
	Adult	45	4.444		
Sex	**Male**	7	0	0.8194	(0, 0.1024)
	Female	46	4.3478		
Management	**Intensive**	40	0	0.0161	(0,0.35)
	Extensive	13	15.385		
Previous treatment	**Yes**	35	0	0.0444	(0,0.256)
	No	18	11.111		

CHAPTER 5

5.0 Discussion

Limited studies on the occurrence of *Campylobacteriosis* in goats have been conducted in Malaysia compared to chickens. In 2004, Saleha reported that more than 50% of broiler chickens across 10 farms were *Campylobacter* positive. Additionally, another study conducted in 2021, where the study area was the east coast of Peninsular Malaysia, reported that 65% of broiler chickens were positive for *C.jejuni* specifically. Although the prevalence among goats is low, *C.jejuni* is the most isolated species from this study which tallies with this study.

This study found that the occurrence of *Campylobacter* in goats in Kota Bharu, Kelantan, was significantly associated with its management practices and previous treatment history, with *C.jejuni* being the only species isolated. According to (Mohamed et al., 2021) *C.jejuni* is the main agent causing gastroenteritis in humans where food products are the main vector for this pathogen from farms to humans. Although there have been little to no studies regarding *Campylobacter* done in goats in Kota Bharu, a study that was conducted in southern Thailand found a prevalence rate of 11.33% among goats where *C.jejuni* is the most isolated species.

Based on this study as mentioned in Table 3, the occurrence of *C.jejuni* has the highest association with its management practices, which was an extensive farming system ($p=0.0161$). This implies the importance of farming methods in the transmission of this pathogen. Extensive farming systems lead to a higher stress level among animals and increase their contact with contaminated environments. The management practice of the farm that tested positive practiced extensive farming methods with no biosecurity measures practiced. The farm raised its goats, in a plot of land behind their house. The water and feeding troughs were poorly maintained which puts them at higher risk of contracting campylobacteriosis (USDA, 2019). *Campylobacter* spp. thrive in moist environments, making dirty troughs particularly problematic. This allows the continuous growth of *Campylobacter* in the farm potentially infecting other goats as well since they share the same troughs. Additionally, the feed was improperly stored, serving as a potential source of contamination. Rodents were also observed around the area, which is another contributing factor for *Campylobacteriosis*. Rodents often carry the bacteria and contaminate the feed through their droppings. Thus the goats are likely to contract this disease.

This particular farm reared chickens as well in the same vicinity making them a potential source of *Campylobacteriosis* since the prevalence among chickens is much higher than among goats (Jafari et al., 2021). The potential for *Campylobacter* to spread from chickens to goats exists primarily through environmental contamination and shared resources. This underscored the importance of maintaining good hygiene and biosecurity practices on farms. Furthermore, it is advised that goat farms and chicken farms be kept approximately 1 km apart to prevent disease transmission between the animals (Reichelt et al., 2022).

Other than management practices, there was also significance between *C.jejuni* and previous treatment histories where the farm that tested positive had never received any previous treatment. This would be mainly due to the goats not exhibiting any gastrointestinal signs. It has been said that goats infected by this pathogen more often than not, do not show any symptoms (*Campylobacteriosis in Animals*, n.d.). This is mainly due to the ability of their immune system to control the infection effectively. *C.jejuni* can establish itself as part of the gut flora mainly due to it being able to exist commensally allowing them to live and proliferate in the intestines without harming the host and not triggering an inflammatory response. Besides, the microbial communities in the goat's gut also help regulate the bacterial population to control the growth hence reducing the likelihood of the goat developing symptoms. This potentially could lead to an increase in morbidity rates of the herd.

Since the goats are raised in poor sanitary conditions, leading them to be susceptible to other diseases. This would result in them being immunosuppressed allowing the bacteria to proliferate in the intestines. Once in the intestines, the polar flagella provides *C.jejuni* with motility allowing it to navigate through the viscous mucus layer lining of the intestines and reach epithelial cells (Tikhomirova et al., 2024). The flagella play a role in chemotaxis that enables it to move towards favourable environments within the gut (Messaoudi et al., 2011). The bacterium can invade epithelial cells through a type IV secretion system, allowing it to evade immune responses and establish infection within the host (Uzal et al., 2021). *C.jejuni* has several virulence factors that include cytolethal distending toxin (CDT) and lipopolysaccharides (LPS), which contribute to inflammation and tissue damage within the gut (Tikhomirova et al., 2024). These factors enable *C.jejuni* to survive and proliferate in the hostile environment of the gastrointestinal tract. However, in an immunosuppressed goat, this ability is weakened allowing the proliferation and it is able to shed the bacterium in their feces contaminating the feed, water sources, and the environment(Gul et al., 2020) leaving other goats in the herd to become infected by ingestion.

It is said goats that have tested positive and never received prior medical treatment, may have a healthier gut microbiota. The normal microflora of the gut plays a big role in preventing colonization by pathogenic bacteria in this case, *C.jejuni*. Antibiotic treatments are said to disrupt the balance that causes them to be more susceptible to opportunistic pathogens. (Gensler et al., 2023).

Coincidentally, the immune response of these goats may also be more robust due to an intact microbiome and overall better health status. A healthy immune system is essential for effectively combating infections which include *Campylobacteriosis* (Chansiripornchai & Khemsuwan, 2022). According to the MSD Veterinary Manual, generally, goats that had not received antibiotic treatments that contract *C.jejuni*, generally exhibit milder symptoms compared to treated animals.

Since *C.jejuni* is persistent on this farm, it would be advisable for the owner to be more aware and retest the herd for a better diagnosis. (how often should sampling be done?)

Besides, they should be aware of the clinical signs that include diarrhea, abdominal discomfort, fever, lethargy, nausea, and vomiting (Chansiripornchai & Khemsuwan, 2022). Acknowledging these clinical signs would be helpful for the infected goats to receive treatment for *Campylobacteriosis as it* could leave the goats susceptible to other diseases due to being immunocompromised.

The presence of *C.jejuni* in goats has significant implications for animal health and welfare, as well as public health. As said previously, goats infected with *C.jejuni* mainly affect the gastrointestinal tract which leads to clinical signs like diarrhea that could manifest as watery or bloody, abdominal pain, fever, and lethargy(Uzal et al., 2021). Persistent diarrhea could lead to dehydration, particularly in young kids, and this could result in mortality if not addressed.

Although the mortality rates of this infection are not high, goats infected would experience reduced weight gain and low milk production due to illness and a decrease in feed intake (McKenna, J.P., et al. 2020). Based on a study done in Congo, where the prevalence of *C.jejuni* was found to be high, *Campylobacteriosis* resulted in economic loss due to increased veterinary costs and decreased marketability of infected animals (Mpalang et al., 2014).

Given the prevalence of *C.jejuni* in goat populations and its implications on human health, there is a pressing need for enhanced public health surveillance systems. Surveillance programs should focus on identifying sources of contamination within livestock populations and implementing interventions aimed at reducing the incidence of *Campylobacteriosis* linked to goat products (Chansiripornchai & Khemsuwan, 2022). Surveillance efforts play a crucial role in the early detection of outbreaks and guiding public health responses. Raising awareness among consumers about the risks associated with consuming undercooked goat products is essential for preventing *Campylobacteriosis* outbreaks. Public health campaigns should emphasize safe food operating practices, including thorough cooking of meat and avoiding unpasteurized dairy products (Uzal et al., 2021). Education efforts targeting farmers about biosecurity measures and proper management practices can also help reduce infection rates in goat populations.

However, this research does come with its limitations. Due to time constraints, cost considerations, and the logistical challenges associated with carrying out sampling on a larger scale, the study was limited to 53 faecal swab samples. This sample size may not adequately represent the broader goat population in Kota Bharu, Kelantan, which could affect the reliability of the prevalence estimates. A larger sample size would provide more robust data and enable more comprehensive statistical analyses.

Logistical challenges related to sample collection and processing may have introduced variability in handling and transportation conditions, potentially influencing bacterial viability and detection rates.

Additionally, the cross-sectional design of the study restricts the ability to draw causal inferences between management practices and the presence of *C.jejuni*. While significant associations were identified, longitudinal studies would be necessary to establish direct cause-and-effect relationships. The reliance on fecal swab samples may also overlook instances of *Campylobacter* infection in asymptomatic carriers, leading to an underestimation of prevalence.

CHAPTER 6

6.0 Conclusion and Recommendations

6.1 Conclusion

This thesis explored the prevalence of *Campylobacter* species, with a focus on *Campylobacter jejuni*, among goats in Kota Bharu, Kelantan. The study identified *C. jejuni* in 2 out of 53 fecal samples, indicating a prevalence rate of 3.77%. Statistical analysis showed no significant associations between the presence of *C. jejuni* and factors such as age or sex. However, significant relationships were observed between *C. jejuni* occurrence and management practices, as well as prior medical treatments.

These findings emphasize the need for routine monitoring of *Campylobacter* in goat populations to reduce public health risks associated with zoonotic transmission through contaminated meat products. As goat farming continues to grow in popularity in Malaysia, particularly in regions like Kota Bharu, understanding the epidemiology of *C. jejuni* is vital for devising effective strategies to minimize potential risks to human health.

While the study was limited by a small sample size and a cross-sectional design, it provides valuable insights into the prevalence of *Campylobacter* in Malaysian goats. The research highlights the importance of further studies with larger sample sizes and longitudinal approaches to deepen understanding of *Campylobacter* epidemiology in goats and its implications for food safety and public health. Enhanced management practices and surveillance measures are essential to safeguard goat products and mitigate the risk of zoonotic infections.

6.2 Recommendations and Future Work

To enhance the understanding and management of *Campylobacter* species in goats, particularly in Kota Bharu, and Kelantan, several recommendations are proposed. First, it is crucial to implement surveillance programs that regularly monitor *Campylobacter* prevalence in goat populations. Expanding the sample size and geographic coverage will provide a more comprehensive understanding of the distribution and risk factors associated with *C.jejuni* infections. This approach can help identify potential hotspots for contamination and targeted interventions can be implemented.

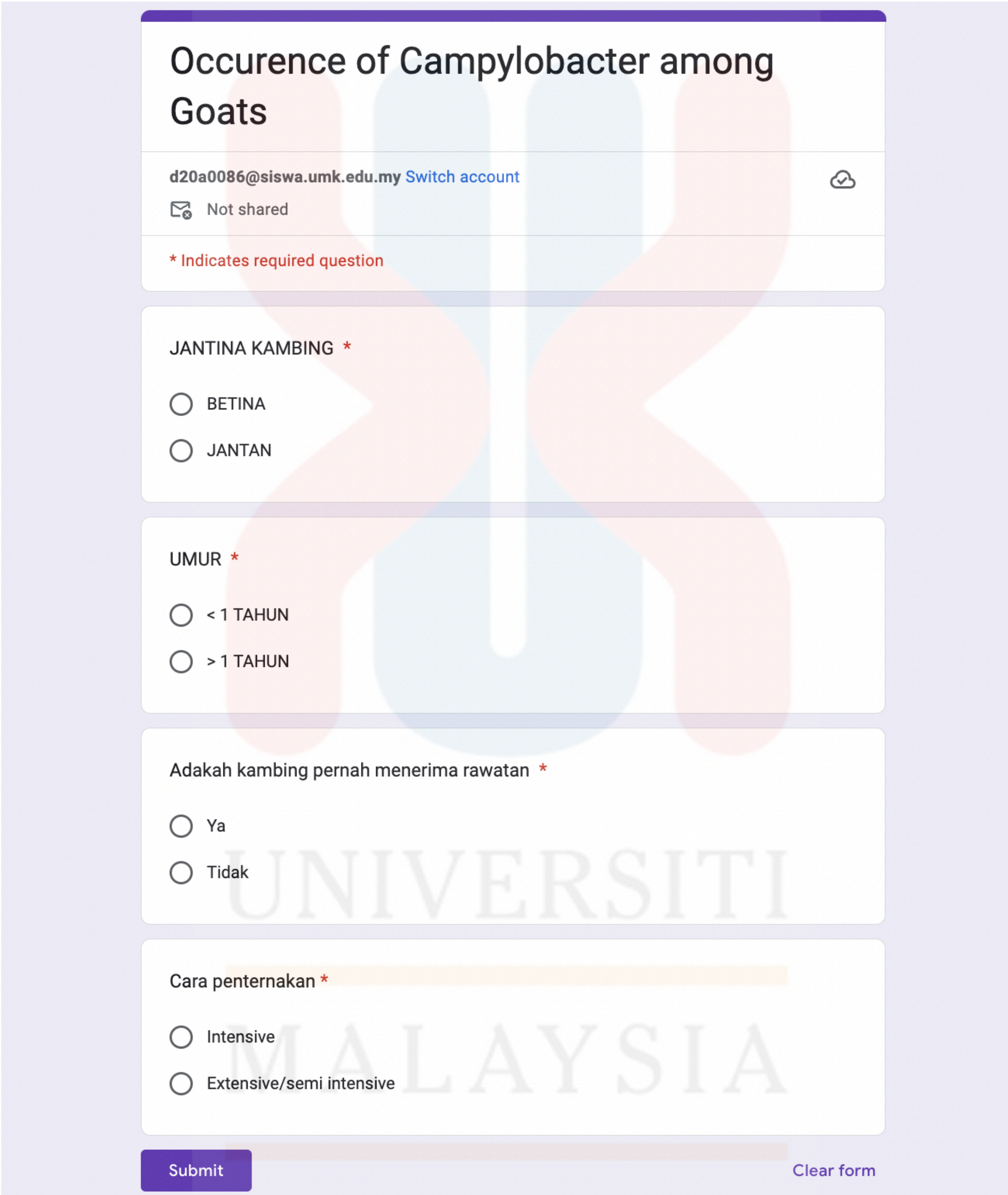
Public awareness campaigns are also recommended to educate consumers about the risks associated with consuming undercooked goat products. Emphasizing safe food handling practices, such as thorough cooking and avoiding unpasteurized dairy products, can help prevent zoonotic transmission of *C.jejuni*. Engaging local communities in these efforts will be crucial for fostering a culture of food safety.

Future research should focus on understanding the pathways of zoonotic transmission from goats to humans. Investigating environmental factors and potential reservoirs will provide valuable insights into how *C.jejuni* spreads within agricultural settings. Additionally, longitudinal studies are needed to establish causal relationships between management practices and the prevalence of *C.jejuni*, allowing for more effective risk mitigation strategies.

Lastly, exploring alternative treatments and interventions to reduce *Campylobacter* colonization in goats is warranted. Research into natural compounds, probiotics, or bacteriocins that inhibit *C.jejuni* could offer innovative solutions for managing infections without relying solely on antibiotics.

By addressing these recommendations and pursuing future research directions, stakeholders can significantly improve food safety, enhance animal health management practices, and reduce the risk of *Campylobacter*-related illnesses in humans.

7.0 Appendix



Occurence of Campylobacter among Goats

d20a0086@siswa.umk.edu.my Switch account

Not shared

* Indicates required question

JANTINA KAMBING *

- BETINA
- JANTAN

UMUR *

- < 1 TAHUN
- > 1 TAHUN

Adakah kambing pernah menerima rawatan *

- Ya
- Tidak

Cara penternakan *

- Intensive
- Extensive/semi intensive

Submit

Clear form

Figure 3: Google form for data collection

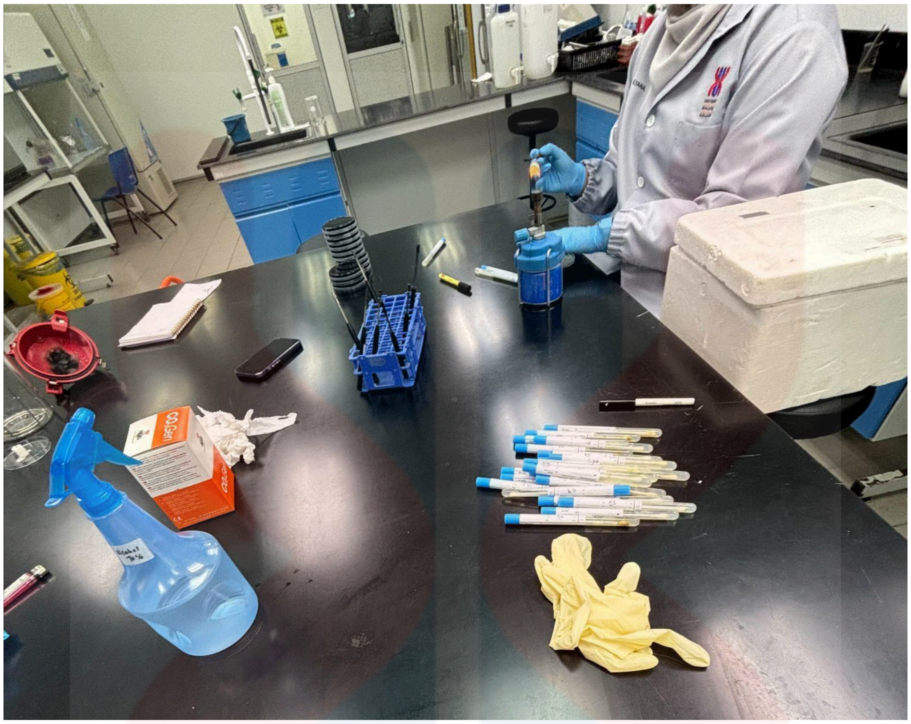


Figure 4 : Sample culture onto mCCDA agar

Figure 5 : cultures placed into an anaerobic jar before incubation

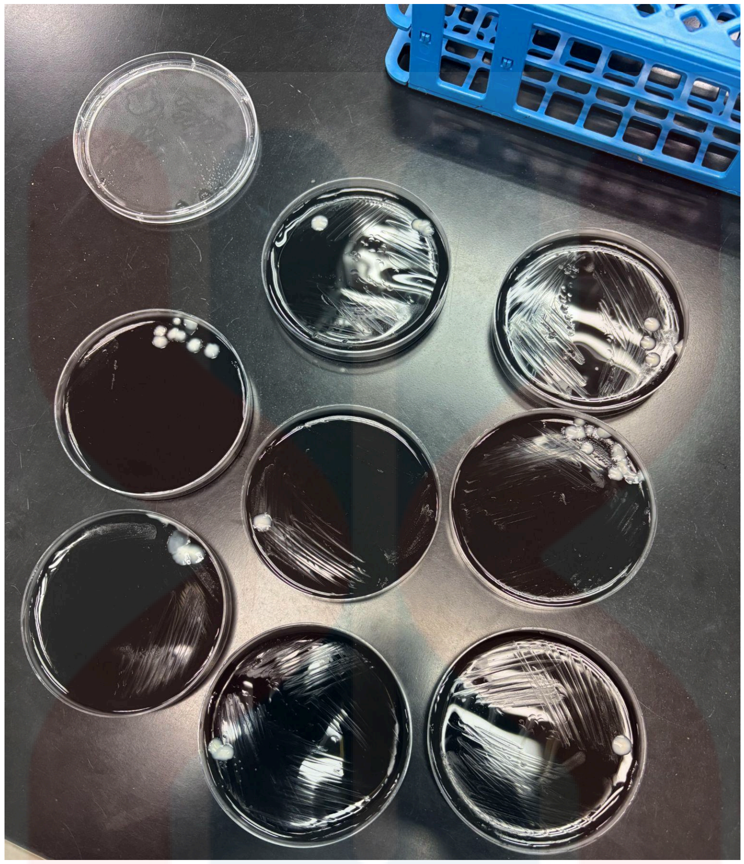


Figure 6 : Presumptive samples after 48 hours of incubation on mCCDA

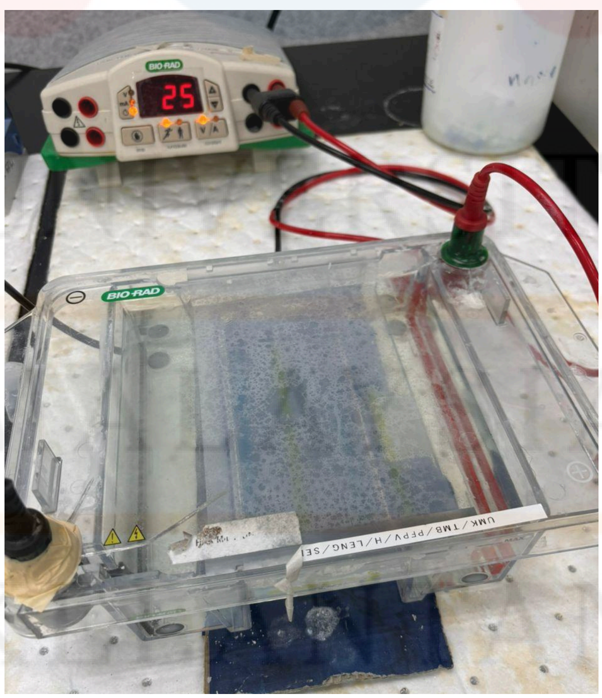


Figure 7 : Gel electrophoresis

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