Hygiene Knowledge, Attitudes, and Practices (KAP) of Retailers and Their Association to *E. coli* Contamination in Pork Sold in La Trinidad, Benguet

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Abstract

A cross-sectional study was conducted to evaluate the correlation between the meat hygiene knowledge, attitudes, and practices (KAP) of pork retailers and the *Escherichia coli* (*E. coli*) load of pork sold in La Trinidad, Benguet. A total of 72 pooled pork samples (60 grams per sample) were collected from all 72 registered meat stalls in the La Trinidad Public Market and the satellite markets across the municipality's 16 barangays. These samples were analyzed for *E. coli* presence and load, while face-to-face interviews using a KAP questionnaire assessed the pork vendors' knowledge, attitudes, and practices regarding meat hygiene. The results revealed a significant negative correlation ($r = -0.73$, $p<0.01$) between the vendors' KAP scores and the *E. coli* load in pork, indicating that barangays with higher KAP levels had lower levels of *E. coli* load. Further, 99% (71/72) of the pork samples tested positive for *E. coli*, with all samples exceeding the allowable limit (<10 cfu/g). The meat vendors demonstrated knowledge at 75.50%, attitude at 85.76%, and practice at 81.67%, resulting in an overall KAP score of 80.83%, classified as good. These findings suggest that while vendors demonstrate sufficient knowledge and satisfactory attitudes and practices concerning meat hygiene, significant gaps remain, as evidenced by the high levels of *E. coli* contamination and load. This study highlights the urgent need for targeted interventions to address these gaps, ensuring improved meat hygiene practices and reduced microbial contamination and load in pork sold in La Trinidad.

Introduction

Pork is a major source of protein for many populations, including those in La Trinidad, but its widespread consumption underscores the critical need for stringent hygiene practices to prevent contamination and safeguard public health. Improper handling and processing of pork can facilitate the growth of pathogenic bacteria, including coliforms, which serve as indicators of potential fecal contamination and the presence of harmful microorganisms. Such contamination poses a considerable risk for foodborne illnesses, emphasizing the critical importance of adhering to proper meat handling protocols to safeguard public health.

Meat handlers play a pivotal role in maintaining meat safety, as improper handling practices are a major contributing factor to contamination (Campos et al., 2009). Previous studies have shown that pathogens such as *Escherichia coli* and *Staphylococcus aureus* are often found on the hands of meat handlers (Lues & Van Tonder, 2007), with multi-drug-resistant strains of *S. aureus* being detected in meat intended for human consumption (Waters et al., 2011). Despite the availability of international guidelines like Hazard Analysis and Critical Control Point (HACCP) and Good Manufacturing Practices (GMP) (Hassan Ali et al., 2010), there remains a significant gap in understanding local food safety practices and the perceptions of meat handlers in La Trinidad. This underscores the need for locality-specific research on food safety practices.

To address this gap, this study adopts the Knowledge, Attitudes, and Practices (KAP) framework, a widely recognized approach in public health research, to assess the awareness, beliefs, and behaviors of meat handlers regarding food safety (You & Han, 2020). The KAP methodology is advantageous due to its simplicity, effective data interpretation, and relevance to addressing context-specific issues (Muleme et al., 2017). The results from KAP surveys can provide insights into areas where interventions are needed to improve food safety practices (You & Han, 2020; Muleme et al., 2017; Dauda Goni et al., 2019).

For this study, *E. coli* was chosen as an indicator of pork microbial quality due to its global recognition as a reliable marker of fecal contamination, which plays a pivotal role in assessing food safety. The presence of *E. coli* in food, particularly in raw pork, is directly linked to a heightened risk of foodborne illnesses (Vergara et al., 2008; National Meat Inspection Service, 2021). Although previous studies have extensively examined microbial quality and antimicrobial resistance (AMR) in farm animals and slaughterhouses, there is a significant lack of data on the microbial safety of raw retail pork available to consumers. This study seeks to address this research gap by evaluating the microbial quality of retail pork in La Trinidad and examining the correlation between *E. coli* load and the Knowledge, Attitudes, and Practices (KAP) of meat handlers. The findings of this study will be instrumental in formulating targeted risk management strategies to enhance food safety and mitigate the incidence of foodborne illnesses.

Materials and Methods

Sample Collection and Processing

The pork samples were collected from all the operating registered meat stalls in the central public market (i.e., New La Trinidad Public Market) and the satellite markets of all the barangays of La Trinidad, Benguet. Complete enumeration was done to remove sampling errors which would make the inferences from the observed data more accurate (Arnab, 2017).

About 20g of pork measuring 1.5 in³ was taken from three pieces of pork. The first sample was randomly selected from the pile found on the right side of the stall table, the second was from the middle and the third was from the left side. A properly labeled sterile bag was prepared to which the collected samples were placed. These samples were put in an icebox with refrigerants to maintain a constant temperature of 0 to 4°C while being transported to the College of Veterinary Medicine Microbiology Room for processing. These samples were used to isolate and identify and count *E. coli* following the procedures in the Bacterial Analytical Manual (BAM, 2017), an internationally accepted conventional culture method for foodborne pathogens using special media for bacterial isolation, identification and counting.

Experimental Phase

Isolation and Identification of E. coli

Approximately 60g of collected pork samples were homogenized for 2 minutes to ensure uniform distribution of bacteria. A 25g portion of the homogenized sample was then pooled and diluted in 225ml of Buffered Peptone Water (BPW). The suspension was agitated 25 times in a 30cm arc and incubated for 24 hours at 37°C to promote bacterial growth. Following incubation, the suspension was serially inoculated into various selective and differential media for isolation and identification of *E. coli*.

A loopful of the suspension was first inoculated into 10ml of Lactose Fermentation Broth (LFB) and incubated at 37°C for 24 hours. Gas production and turbidity in the LFB confirmed a positive result. One milliliter of the LFB was then transferred to 10ml of Brilliant Green Lactose Bile Fermentation Broth (BGLBFB) and incubated at 37°C for 24 hours. Positive results in the BGLBFB were indicated by gas production and a change in color or turbidity. A loopful of the incubated BGLBFB was streaked onto a MacConkey Agar plate using a quadrant streak method and incubated for 24 hours at 37°C. Colonies exhibiting a bright pink hue on the MacConkey Agar plate were presumptive indicators of *E. coli*.

A loopful of a suspected *E. coli* colony from the MacConkey plate was further streaked onto Eosin Methylene Blue (EMB) agar and incubated at 37°C for 24 hours. The EMB agar was examined for colonies with a characteristic metallic sheen, which is indicative of *E. coli*. Isolated colonies with these characteristics were then streaked onto Triple Sugar Iron (TSI) slants using the stab and streak method and incubated for 24 hours at 37°C. Simultaneously, another colony from the EMB agar was subjected to Gram staining following the procedure outlined by Quinn et al. (2002).

The TSI slants were observed for the appearance of a yellow slant and butt, with or without gas production, to confirm *E. coli* fermentation patterns. Confirmed colonies were then streaked onto nutrient agar and incubated aerobically at 37°C for 24 hours for purification. After incubation, the colonies on the nutrient agar were Gram-stained and examined under a microscope to identify the presence of Gram-negative bacilli characteristic of *E. coli*.

The purified *E. coli* colonies were subjected to further biochemical testing. The isolates were inoculated into slants of indole, methyl red, Voges-Proskauer, and Simmons Citrate media and incubated for 48 hours at 37°C. After incubation, five drops of methyl red solution were added to the methyl red slant, five drops of Barritt's reagent were added to the Voges-Proskauer slant, and five drops of Kovac's reagent were added to the indole slant. The slants were evaluated for color changes: a distinct red color in the methyl red slant, eosin pink color in the Voges-Proskauer slant, a red layer at the top of the indole test, and the development of turbidity in the Simmons Citrate slant, all of which indicate a positive reaction for *E. coli*.

Determining *E. coli* Load or Number

The *E. coli* load, expressed as the number of colony-forming units (cfu) of E. coli per gram of pork, was determined using the Aerobic Plate Count method, as outlined in the Bacterial Analytical Manual (BAM, 2017).

Presumptive Test. Three sets of test tubes (Set A, Set B, and Set C) were prepared, each containing three test tubes with Durham tubes and 10ml of lactose broth. From a 60g pooled sample, 0.10g was inoculated into the test tubes of Set A, 0.01g into Set B, and 0.001g into Set C. All lactose broth tubes were incubated at 37°C for 24 hours. After incubation, gas production and turbidity were observed. Tubes showing gas production, with or without turbidity, were considered presumptive positive, while tubes with turbidity but without gas formation were discarded. The number of presumptive positive tubes in each set was recorded.

Confirmatory Test. Three sets (Set A, Set B, and Set C) of Brilliant Green Bile Broth (BGLB) containing 10 ml of the media with Durham tubes were arranged. The number of tubes in each set was based on the number of presumptive positive tubes from the lactose broth. A loopful of the lactose broth showing gas production was inoculated into the BGLB tubes. The inoculated tubes were incubated for 24 to 48 hours at 37°C. After incubation, gas production was observed for confirmation of *E. coli*. The number of tubes with gas production in each set was recorded to calculate the colony-forming units (cfu) of *E. coli* per gram of pork.

Data Collection on Knowledge, Attitudes and Practices (KAP) of Pork Retailers

The questionnaire was developed following established guidelines and was approved by the Benguet State University Institute of Social Research Development (ISRD) to ensure its scientific integrity and ethical compliance. It underwent pre-testing and was subsequently refined based on feedback. The questionnaire

included sections on demographics, knowledge, attitudes, and practices related to meat hygiene, structured on a 10-point Likert scale.

The first part of the questionnaire was a brief summary of the research which included the introduction of the researcher, purpose of the questionnaire, confidentiality statement and a consent for voluntary participation. Informed consent and confidentiality statements were adapted from Food and Agriculture Organization (FAO) Publication Guidelines (2014), also called KAP manual. The questionnaire consists of the demographic profile of the respondents and statements about the Knowledge, Attitude and Practices of meat vendors. The topics under knowledge included the meat quality regulations, time and temperature control of microbes, antimicrobial and antibiotics, antimicrobial resistance, presence of microbes in meat, food hygiene, and safety. The attitude covers personal hygiene and health, food safety, proper handling, and cross-contamination. And lastly, for the practices, it covers proper storage, use of antimicrobials and preservatives, adequate preparation and quality control, adequate waste disposal and pest control.

Face-to-face interviews were conducted to all the meat vendors of the 72 registered meat stalls. All responses regarding the practices were validated by the researcher's observations.

The KAP survey sections were rated on a 10-point Likert scale ranging from 2 (strongly disagree/never- 2 points) to 10 (strongly agree/ always- 10 points). The total percentage for each category was referred to the study of Buang et al. (2019). The poor category was defined as <50%, fair as 51–69%, and good as >70%.

Data Analysis

Descriptive statistics were used to summarize the data, while Spearman rank-order correlation coefficients were calculated to evaluate the relationships between Knowledge, Attitudes, and Practices (KAP) scores and *E. coli* load. The correlation coefficient (r) ranges from +1 to -1, indicating the strength and direction of the relationship between two variables. A coefficient of +1 or -1 represents a perfect positive or negative correlation, respectively. Values between 0.8 and -0.8 suggest a strong positive or negative correlation, while values between 0.6 and -0.6 reflect a moderate positive or negative relationship. A coefficient of 0.5 or -0.5 indicates a moderately weak correlation, and values closer to 0 represent a weak correlation. A correlation coefficient of 0 implies no association between the variables (Da Silva Frost & Ledgerwood, 2020). Statistical significance was determined at a p-value of less than 0.05. All statistical analyses were conducted using Statistical Package for the Social Sciences (SPSS) version 21.0.

Results and Discussions

E. coli Contamination and Load of Pork Sold in La Trinidad Central Market and Registered Satellite Markets

Table 1 presents the prevalence and load of *Escherichia coli* (*E. coli*) contamination in pork samples from 72 stalls across various barangays of La Trinidad, highlighting a significant public health concern regarding food safety in the region. The overall prevalence of *E. coli* contamination was high, with 99% (71/72) of pork samples testing positive for *E. coli*. The contamination was widespread across the surveyed areas, with nine out of ten barangays reporting a 100% contamination rate. The New La Trinidad Public Market, though slightly better, still had a high prevalence of 91%, with only one pork sample testing negative. Moreover, all *E. coli*-contaminated pork samples had bacterial loads exceeding the acceptable limit of <10 cfu/g. It is important to note that these findings are based on data from nine barangays in La Trinidad, as the remaining seven barangays (Alapang, Alno, Baho,ng, Beckel, Bineng, Lubas, and Tawang) did not have registered meat stalls in operation at the time of the study.

Regarding the *E. coli* load, all pork samples with contamination exceeded the acceptable limit of <10 cfu/g, resulting in all samples being classified as "Rejected." Barangay-specific findings show that Ambiong, Cruz, Shilan, and Wangal had the highest contamination loads, all exceeding 1,100 cfu/g, which suggests significant issues with hygiene practices in slaughtering, processing, and handling of meat in these areas. On the other hand, Puguis had the lowest contamination load with a mean of 19.31 cfu/g, but it still far

Table 1

Prevalence of E. coli Contamination and Load in Pork Sold at La Trinidad Public Market and Satellite Markets (n= 72)

Barangay	No. of Stalls and Pork Samples	Prevalence of *E. coli* Contamination		*E. coli* Load	
		No. of Positives	Prevalence (%)	Mean (cfu/g)	Interpretation
Ambiong	3	3	100	>1,100.00	Rejected
Balili	14	14	100	177.57	Rejected
Betag	6	6	100	951.66	Rejected
Cruz	1	1	100	>1,100.00	Rejected
Pico	13	13	100	782.57	Rejected
Poblacion	6	6	100	787.50	Rejected
Puguis	11	11	100	19.31	Rejected
Shilan	5	5	100	>1,100.00	Rejected
Wangal	2	2	100	>1,100.00	Rejected
New La Trinidad Public Market	11	10	91	39.16	Rejected
Total	72	71	99		

*Acceptable level of E. coli load: <10 cfu/g

exceeded the acceptable limit, emphasizing that corrective measures are needed even in relatively less *E. coli* load areas. The New La Trinidad Public Market, while reporting one negative sample, still had a mean *E. coli* load of 39.16 cfu/g, which underscores the ongoing need for improved hygiene practices, even in more centrally regulated locations.

The high prevalence and *E. coli* load in these pork samples pose serious public health risks, as *E. coli* contamination often indicates fecal or environmental contamination. This contamination is likely a result of poor hygiene practices during slaughter, processing, or retail handling, which can lead to foodborne illnesses, including severe gastrointestinal infections in consumers. Potential contributing factors include lapses in sanitation during slaughter, improper temperature control at meat stalls, and cross-contamination through contact with contaminated surfaces, tools, or handlers' hands.

Escherichia coli, a normal flora of the lower intestines of warm-blooded animals and humans, is a key indicator of fecal contamination (Tenaillon et al., 2010). Contamination of pork with *E. coli* can occur at various stages, from slaughterhouses to meat stalls, with previous studies indicating that fecal contamination during carcass handling at slaughterhouses is a major contributor (Gill, 2014). While testing for specific pathogenic strains such as *E. coli* O157 is prioritized (Bohaychuk et al., 2011), detecting generic *E. coli* remains crucial as its presence indicates fecal or environmental contamination (Gill, 2014). Ideally, *E. coli* should be absent from raw meat, although very low levels (<10 cfu/g) are considered acceptable.

Globally, fecal *E. coli* has been commonly isolated from pork carcass samples, with prevalence rates ranging from 42% to 71% in North America (Bohaycguk et al., 2011), Asia (Kim & Dong, 2016), and Africa (Luanda et al., 2016). However, the 99% contamination rate found in

La Trinidad is extremely high based on the report of the European Food Safety Authority's report (EFSA, 2017). This high contamination rate and bacterial load suggest serious deficiencies in hygiene and sanitation practices across various stages of the meat supply chain, which include: (1) Fecal contamination: High *E. coli* contamination levels may indicate direct contamination from the animal's gastrointestinal tract or from the surrounding environment during processing; (2) Inadequate temperature control: *E. coli* thrives at room temperature, and the high contamination levels reflect poor temperature management at meat stalls, where refrigeration was not consistently used; (3) cross-contamination: Insufficient cleaning or disinfection of equipment and surfaces could contribute to the transfer of bacteria between carcasses; and (4) Public health risks: E. coli, particularly pathogenic strains like *E. coli* O157:H7, pose significant threats to public health. Ingesting contaminated pork can result in foodborne illnesses, ranging from mild gastrointestinal symptoms to severe conditions such as hemolytic uremic syndrome.

These findings emphasize the urgent need for rigorous hygiene protocols, proper meat handling practices, and improved temperature control throughout the pork supply chain. The observed high *E. coli* load highlights systemic failures in hygiene and sanitation that require immediate corrective measures. Contributing factors to microbial contamination include multiple steps in the slaughtering process, exposure to animal feces and skin, contaminated equipment, and poor personal hygiene of handlers (Boukhors et al., 2012). Addressing these gaps is essential to reduce microbial contamination and safeguard public health.

Knowledge of Pork Vendors

Table 2 provides insights into the knowledge of pork vendors on meat hygiene based on responses from 72 vendors. The data reveals varying levels of understanding and familiarity among the vendors regarding meat safety, hygiene practices, and the risks associated with improper meat handling.

Majority of the meat vendors (48.68%) recognized the health risks posed by antibiotic residues in animal products, such as antibiotic resistance, allergies, and other health issues.

However, a notable portion (31.94%) remained neutral, suggesting a need for greater awareness of the long-term consequences of consuming antibiotic-contaminated meat. The meat vendors also demonstrated a strong understanding of how to identify food unfit for consumption, as 71.05% strongly agreed that changes in meat color, taste, and smell are indicators of spoilage. This highlights that meat vendors are generally capable of recognizing visibly spoiled meat, an essential aspect of preventing foodborne illnesses caused by microbiological pathogens (McIntyre et al., 2013). Moreover, vendors acknowledged the regulations enforced by local authorities concerning meat safety and quality, with 84.2% of respondents confirming their awareness of these rules.

However, the study revealed significant gaps in knowledge regarding the use of antimicrobials in meat processing. Only 19.73% of vendors strongly agreed that antimicrobials can be applied at multiple stages of meat processing to reduce microbial contamination, while 37.5% remained neutral on the issue. This indicates a lack of understanding about the role of antimicrobials in ensuring meat safety during processing. Additionally, 30.26% of vendors correctly defined antimicrobials as substances that prevent the growth of microorganisms, yet 26.31% were unsure, suggesting that a substantial proportion of vendors may not fully understand the substances they use in meat handling and processing.

The study also uncovered a gap in knowledge regarding the role of chilling and refrigeration in inhibiting microbial growth. Despite the well-established importance of temperature control in preventing bacterial proliferation, 36.84% of vendors strongly disagreed with the idea that these methods are ineffective. This misunderstanding suggests a lack of appreciation for the critical role these preservation methods play in ensuring meat safety. Kabwang et al. (2019) identified the absence of refrigeration systems and improper storage practices as key risk factors contributing to microbial growth and resistance. Enhancing vendors' knowledge of proper storage practices can mitigate contamination risks and improve meat quality while reducing the development of antimicrobial resistance (Elsas et al., 2011; Jenpanich, 2015; Ko, 2013).

Table 2

Knowledge of Pork Vendors on Meat Hygiene (n =72)

Knowledge	Strongly Agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly Disagree (%)
Consumption of antibiotic residues in animal products may pose health risk to consumers including development of antibiotic resistance, allergy, reproductive disorder and hypersensitivity reaction	21.05	27.63	31.94	13.15	7.89
Food that is unfit for consumption always presents color, taste and smell changes	71.05	19.73	2.77	2.63	3.94
Antimicrobial can be used during multiple steps of meat processing to minimize microbial contamination	19.73	18.42	37.50	17.10	9.21
Antimicrobials are drugs that kill or prevent the growth of a variety of microorganisms, including bacteria, viruses, fungi and parasites	30.26	27.63	26.31	6.57	9.21
Chilling and refrigeration or heating cannot inhibit or kill microbial growth	11.84	15.7	22.36	13.15	36.84
Time and temperature are important factors in controlling microbial growth	40.78	43.42	14.47	1.31	0
Meat safety, quality and regulations of meat are implemented by local authorities	44.73	39.47	13.15	2.63	0

Conversely, a majority of vendors (84.2%) correctly identified time and temperature control as vital factors in controlling microbial growth, indicating a strong understanding in this area. Furthermore, the majority (84.2%) recognized the importance of local authorities in enforcing meat safety regulations, underlining their understanding of the role of official oversight in maintaining meat quality and safety.

These findings suggest that while vendors demonstrate strong knowledge in certain areas, such as identifying spoiled meat and the importance of time and temperature control, there are clear gaps in more specialized aspects of meat hygiene, such as antimicrobial use and proper storage practices. To address these gaps, targeted educational programs and regular training on meat safety protocols are essential. Such interventions will help improve hygiene practices, reduce contamination risks, and safeguard consumer health.

Attitude of Pork Vendors

The attitudes of pork vendors toward meat hygiene practices were evaluated using a survey of 72 respondents. The findings highlight both strengths and areas for improvement in the vendors' perceptions of meat hygiene practices (Table 3).

A combined 66.66% of respondents strongly agreed or agreed that using protective garments or equipment (e.g., gloves, facemasks, hairnets) can prevent meat contamination. However, a notable 18.42% were neutral, and 5.25% disagreed, suggesting that some vendors may lack full awareness or appreciation of the importance of protective gear in reducing contamination risks.

A significant majority, 83.33%, strongly agreed or agreed that sick vendors (e.g., those with cough, colds, flu, or hand injuries) should not handle meat. This indicates strong recognition of the

Table 3

Attitude of Pork Vendors on Meat Hygiene (n=72)

Attitude	Strongly Agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly Disagree (%)
Using protective garments or equipment routinely (gloves, facemask, hairnet, etc) can prevent contamination of meat	47.22	19.44	18.42	3.94	1.31
Sick vendors (having cough, colds and flu, cuts on hand) should not handle meat	59.72	23.61	15.78	2.63	2.63
Improper meat storage can lead to contamination or even spoilage	63.88	37.50	3.94	0	0
Meat should be sold free from diseases	86.11	15.78	2.63	0	0
Meat should come from an approved slaughter house for its quality	72.36	21.05	5.26	1.31	0
Wearing unnecessary accessoriesor jewelleries such as bracelets and rings while handling meat should be avoided	38.15	25.00	23.68	10.52	2.63
Washing of hands and materials before, during and after handling meat can limit contamination	48.68	34.21	10.52	3.94	2.63

health risks posed by unwell handlers. However, the remaining 16.04% were neutral or disagreed, indicating a need for further education on the impact of vendor health on meat safety.

The highest level of consensus was observed for the statement regarding improper meat storage leading to contamination or spoilage, with 100% of respondents strongly agreeing or agreeing. This demonstrates a widespread understanding of the importance of appropriate storage conditions in preventing meat contamination.

The attitude that meat should be sold free from diseases received overwhelming support, with 86.11% strongly agreeing and 15.78% agreeing. Similarly, 93.41% of respondents strongly agreed or agreed that meat should come from approved slaughterhouses, reinforcing the vendors' acknowledgment of quality assurance measures.

Responses were more varied regarding the avoidance of unnecessary accessories (e.g., bracelets, rings) during meat handling. While 63.15%

strongly agreed or agreed, a substantial portion (23.68%) were neutral, and 13.15% disagreed. This variation suggests that some vendors may not fully understand the contamination risks posed by accessories.

A majority, 82.89%, strongly agreed or agreed that washing hands and materials before, during, and after handling meat can limit contamination. However, 13.15% were neutral or disagreed, indicating that handwashing practices may not be consistently emphasized or practiced.

Overall, the findings indicate that pork vendors generally have positive attitudes toward key meat hygiene practices, with high levels of agreement on the importance of proper storage, disease-free meat, and approved slaughterhouses. This is notable since it is found that good attitude is a crucial factor that may influence food safety behavior and practice, decreasing the occurrence of foodborne diseases (Jenpanich, 2015). Salih et al. (2019) also stated that positive attitudes of workers were an important issue in reducing the risk of food contamination as well as food safety during their study on the

evaluation of the levels of KAP of workers in an export slaughterhouse in Khartoum, Sudan. Good attitude towards food prevents antibiotic-resistant organisms from spreading the same way as other foodborne illnesses (Centre for Disease Control [CDC], 2020) while high levels of attitude indicate a positive impact of knowledge on attitude (Shah et al., 2019).

However, in this study, areas such as the consistent use of protective garments, awareness of the risks posed by accessories, and strict adherence to handwashing require further emphasis. Targeted interventions, such as training programs and hygiene workshops, could address these gaps and promote uniform adherence to best practices in meat handling.

Practices of Pork Vendors

The practices of pork vendors regarding meat hygiene were evaluated based on eight key activities crucial to ensuring food safety. The results reveal both strengths and significant areas needing improvement (Table 4).

Annual Physical Examination

A combined 68.41% of vendors ("Strongly Agree" and "Agree") recognize the importance of undergoing annual physical examinations. This practice helps ensure that vendors handling meat are free from communicable diseases. However, notable 14.47% "Strongly Disagree," indicating a lack of awareness or access to health services. This resistance may pose a risk of disease transmission to consumers and co-workers.

Use of Protective Clothing

Only 40.78% ("Strongly Agree" and "Agree") consistently use protective garments (e.g., aprons, caps, masks, gloves) during work. A significant 35.52% remain neutral, and 23.68% ("Disagree" and "Strongly Disagree") do not adhere to this practice. The lack of protective clothing increases the risk of contamination from hair, skin, or respiratory droplets, highlighting the need for stricter enforcement of protective gear use. This is note-worthy since the none-wearing of personal protective equipment is a risk factor

Table 4

Practices of Pork Vendors on Meat Hygiene (n=72)

Practices	Strongly Agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly Disagree (%)
Taking physical examination yearly	55.26	13.15	13.15	3.94	14.47
Using protective clothes (apron, cap, mask and gloves) at work daily	28.94	11.84	35.52	18.42	5.26
Washing hands before and after handling meat, especially after going to the toilet	71.05	14.47	9.21	2.63	2.63
Conducting pest control methods in the workplace	25.00	26.31	25.00	13.15	10.52
Segregating and disposing waste properly	67.10	17.10	15.78	0	0
Disinfecting the materials used (knives, chopping board, table stall before and after placing the meat products on for selling	26.63	36.84	34.21	1.31	0
Using chemicals such as antimicrobials and preservatives in the meat before selling	7.89	0	0	7.89	84.21
Storing meat in the chiller or refrigerator separated from other products	43.42	19.73	25.00	10.52	1.31

for cross contamination to the meat being sold. Lack of awareness may also contribute to the result of food handling practices that increase the risk of bacterial food-borne contamination (Worsfold, 1995).

Handwashing Practices

Most vendors (85.52% "Strongly Agree" and "Agree") wash their hands before and after handling meat, particularly after using the toilet. This high compliance reflects a strong understanding of hand hygiene's role in preventing cross-contamination and foodborne illnesses.

Pest Control in the Workplace

Only 51.31% ("Strongly Agree" and "Agree") actively implement pest control, while 25% remain neutral and 23.67% do not. Inadequate pest control increases the risk of meat contamination by rodents, insects, or other pests. Efforts to standardize pest control practices across stalls are essential.

Waste Segregation and Disposal

Nearly all vendors (84.2%) segregate and dispose of waste properly, with no respondents disagreeing with this practice. Proper waste management minimizes environmental contamination and supports overall hygiene in the market environment.

Disinfection of Tools and Surfaces

A combined 63.47% of vendors disinfect knives, chopping boards, and work surfaces before and after placing meat, though 34.21% remain neutral. Neutral responses may indicate inconsistent adherence to disinfection protocols, leaving room for improvement to reduce cross-contamination risks.

Use of Chemicals in Meat

A majority of vendors (84.21%) "Strongly Disagree" with using antimicrobials or preservatives in meat, with only a small minority (7.89%) in favor. This widespread rejection is aligned with ethical practices and enhances consumer trust in the safety and natural quality of pork. Nevertheless, practice of using a ntimicrobials raises concerns, as the CDC

(2020) has linked the indiscriminate use of antimicrobials to the development of antimicrobial resistance (AMR).

Meat Storage Practices.

Over 63.15% ("Strongly Agree" and "Agree") store meat in a chiller or refrigerator separate from other products. However, 25% remain neutral, and 11.83% ("Disagree" and "Strongly Disagree") do not follow this practice. Given the critical role of temperature control in preventing bacterial growth, targeted interventions are needed to improve compliance.

The results that there is high adherence to handwashing and waste segregation practices reflects an awareness of basic hygiene principles. However, there is low compliance in using protective garments and inconsistent disinfection of tools and surfaces expose gaps in hygiene practices that can lead to meat contamination. Moreover, pest control and temperature management require stronger emphasis and enforcement to ensure safe meat handling.

By addressing these gaps and leveraging existing strengths, La Trinidad markets can significantly enhance meat safety and reduce public health risks.

Knowledge, Attitude, and Practices (KAP) of Pork Vendors

Table 5 summarizes the KAP scores of meat retailers across different barangays in La Trinidad. The data provides insight into the overall food hygiene standards among meat vendors and highlights variations across barangays.

The KAP (Knowledge, Attitude, and Practices) scores of meat retailers in La Trinidad highlight the current state of meat hygiene among vendors, revealing both strengths and areas requiring improvement. On average, meat retailers demonstrated "Good" performance, with a total KAP score of 80.83%. Among the components, attitude scored the highest at 85.76%, reflecting a strong awareness and positive beliefs about meat hygiene practices. Knowledge and practices followed with scores of 75.50% and 81.67%, respectively, indicating satisfactory levels of understanding and application of hygiene protocols.

Table 5

Knowledge, Attitude, and Practices of Meat Retailers of La Trinidad (n=72)

Barangay	Knowledge Score (%)	Attitude Score (%)	Practices Score (%)	KAP Score (%)
Shilan	67.43	80.57	84.00	77.33
Ambiong	77.14	90.48	85.83	84.48
Balili	78.37	83.27	77.32	78.00
Betag	82.38	88.57	59.17	76.71
Cruz	65.71	85.71	87.50	79.64
Wangal	75.71	88.57	86.25	83.51
Puguis	68.57	72.99	68.86	70.14
Pico	73.33	89.88	86.56	83.26
Poblacion	86.19	96.67	97.92	93.59
New La Trinidad Public Market	80.17	80.89	83.29	81.64
Total Score	75.50	85.76	81.67	80.83

Interpretation: Poor (<50%), Fair (51-69%), Good (>70%)(Buang et al., 2019)

The good level of KAP of the pork vendors might be attributed to their level of education, length of work experience in selling pork and the trainings that they have attended. Profile showed that all of the pork vendors have formal schooling with majority (58%) having finished or earned undergraduate units, and at least 50% have attended trainings related to meat handling and hygiene. While 55% of the respondents have worked in the pork industry for 1 to 5 years, 45% have worked as pork sellers for 6 to more than 31 years. Researchers have shown that there is significant positive correlation between educational level and KAP among food handlers in Malaysia (Abdul-Mutalib et al., 2012) and Brazil (da Vitória et al., 2021). Researchers also found that food safety training increases KAP regarding food safety issues (Lynch et al., 2003). In addition, improving food safety practices requires training and education which is an effective tool to increase food safety knowledge and awareness of hygiene among food handlers (Gillespie, et al., 2000). Studies have found that food safety training is positively associated with self-reported changes in food safety practices (Clayton et al., 2002). Further, other studies have found that training helps to improve the overall employee knowledge about food safety (Costello et al., 1997).

The barangay-level analysis reveals notable variations in KAP scores. Poblacion emerged as the highest-performing barangay with an overall KAP score of 93.59%, driven by exemplary attitudes (96.67%) and practices (97.92%). Its urban setting and closer proximity to regulatory oversight likely contributed to its high scores. Ambiong also performed well with a balanced score of 84.48%. In contrast, Puguis recorded the lowest overall KAP score of 70.14%, with knowledge and practices categorized as "Fair." Similarly, Shilan exhibited low knowledge scores (67.43%), though its practices score was relatively high (84.00%), suggesting a reliance on experiential knowledge rather than formal training.

Knowledge scores varied significantly, with Poblacion achieving the highest score (86.19%), while Cruz (65.71%) and Shilan (67.43%) scored the lowest, falling into the "Fair" category. Attitude scores were consistently "Good" across all barangays, with Poblacion (96.67%) and Ambiong (90.48%) leading. However, Puguis (72.99%) scored the lowest in this category, indicating a need to strengthen the prioritization of hygiene. Practices scores also showed discrepancies; while Poblacion (97.92%) and Cruz

(87.50%) excelled, Betag recorded the lowest practices score (59.17%), classified as "Fair." This indicates challenges in translating knowledge and attitude into actionable hygiene practices.

The findings underscore the correlation between KAP components, as barangays with higher knowledge and attitude scores, such as Poblacion and Ambiong, tended to exhibit stronger practices. However, discrepancies in barangays like Betag, which had high knowledge and attitude scores but lower practices, point to gaps in the application of hygiene principles. Variability across barangays highlights the need for localized interventions, particularly in rural areas like Puguis and Shilan, where knowledge and practices need improvement.

The consistently high attitude scores indicate that most vendors are positively inclined toward adopting proper hygiene practices, presenting an opportunity to leverage these attitudes for further improvements. However, gaps in practical implementation, as evidenced by some barangays' practices scores, emphasize the need for infrastructure support, such as refrigeration facilities and protective gear, as well as routine monitoring and inspections.

Moreover, while the overall KAP scores reflect a satisfactory level of meat hygiene among vendors, the variability across barangays and the gaps in practices highlight the need for targeted interventions. By addressing these challenges, La Trinidad can ensure safer meat handling practices and improved food safety for its community.

Correlation of KAP and *E. coli* Load

The findings in Table 6 reveal a significant negative correlation between Knowledge, Attitude, and Practices (KAP) scores of meat retailers in La Trinidad and the *E. coli* load in pork. The correlation coefficient (r=−0.73) indicates a "Strong Correlation," while the p-value (0.00139) confirms the statistical significance of this relationship. These results suggest that higher KAP scores among meat retailers are associated with lower levels of *E. coli* load, emphasizing the importance of improving KAP to enhance food safety.

The negative correlation highlights the impact of KAP components on contamination levels.

Table 6

Correlation of KAP of Meat Retailers in La Trinidad and E. coli Load (n=72)

	Correlation (r-value)	Significance/ p-value (two-tailed)	Descriptive equivalent
KAP	-0.73	0.00139*	SC

Legend:
* - significant	ns – not significant
+ 1.00	Perfect Correlation (PC)
+ 0.81 – + 0.99	Very Strong Correlation (VSC)
+ 0.61 – + 0.80	Strong Correlation (SC)
+ 0.41 – + 0.60	Moderately Strong Correlation (MSC)
+ 0.21 – + 0.40	Weak Correlation (WC)
+ 0.01 – + 0.20	Very Weak Correlation (VWC)
0.00	Negligible Correlation (NC)

Enhanced knowledge of meat hygiene equips vendors with the necessary understanding to reduce contamination risks. Positive attitudes toward hygiene reinforce the importance of maintaining high standards, while better practices—such as washing hands, using protective gear, and proper meat storage—directly contribute to lower contamination levels. The barangays with higher KAP scores, such as Poblacion and Ambiong, consistently had lower *E. coli* loads compared to barangays with lower KAP scores, like Puguis and Shilan. This indicates that targeted improvements in knowledge, attitudes, and practices are key to reducing contamination risks. These results indicate that good levels of KAP towards meat handling have a great impact on meat quality including prevention of cross contamination of microorganisms (CDC, 2020). Furthermore, Kabwang et al. (2019) concluded in their study that lack of knowledge, attitude and practice of hygiene in meat handling by retail meat vendors appears to be a real threat to food safety and public health. This was further explained in the study of Jairoun et al. (2019) wherein the overall KAP was poor (56%) regarding antibiotic use and associated factors, which in turn increases the risk of antimicrobial meat contamination, adverse effects, and economic health burden.

These findings also aligned with the statement to McIntyre et al. (2013) that knowledge will help the food handlers to have better understanding of the risks associated with contamination of food

with microbiological pathogens. Jenpanich, (2015) and Elsas et al. (2011) also suggested that increasing knowledge about food like meat reduces the risk of contamination and improves meat quality thus, reducing the risk of contamination in meat. It further corresponds to the study of Kabwang et al. (2019) describing that lack of KAP in meat hygiene and handling by retail meat vendors appears to increase the threat to food safety and public health.

Although the level KAP of the vendors is good at 80.83%, there is a high level (99%) of *E. coli* contamination of the pork sold in La Trinidad central public market and satellite markets. This suggests that the contamination might not have only occurred during the handling of meat but also during the slaughtering process. Researchers have established that slaughter houses are nonsterile and pose a high risk of pathogenic microbial contamination (Diyantoro & Wardhana, 2019).

These findings have practical implications. Strengthening education and training programs for meat retailers, especially in areas with lower KAP scores, can equip vendors with the skills and knowledge needed to maintain proper hygiene. Regular monitoring and assessments of hygiene practices and contamination levels can help track progress and enforce compliance with food safety standards. Additionally, providing infrastructure support—such as refrigeration units, protective gear, and waste disposal systems—can facilitate better hygiene practices.

Conclusions

The findings of this study highlight a critical hygiene issue in the pork sold at La Trinidad markets, with a high level of *E. coli* load (all exceeding the acceptable *E. coli* load of <10 cfu/g) and *E. coli* contamination (99%). While these findings underscore significant contamination, it is crucial to note that *E. coli* contamination primarily serves as an indicator of hygiene lapses rather than a comprehensive reflection of all aspects of meat quality, such as nutritional value or sensory attributes. This distinction prevents overgeneralization and allows for targeted interventions focusing on improving hygiene practices.

The study revealed a strong negative correlation (r=-0.73, p<0.001) between the Knowledge, Attitudes, and Practices (KAP) scores of meat vendors and the *E. coli* load in pork. This indicates that higher levels of vendor awareness and adherence to proper meat hygiene practices significantly reduce contamination levels. This finding emphasizes the importance of targeted education and practical training for meat vendors, alongside infrastructural support and stricter enforcement of food safety protocols. By addressing these hygiene-related gaps, microbial contamination can be minimized, thereby safeguarding public health and enhancing consumer trust in pork products.

Recommendations

The high levels of E. coli load and contamination in pork sold at La Trinidad's central public market and satellite markets, despite vendors demonstrating good Knowledge, Attitudes, and Practices (KAP) scores (80.83%), highlight the multifactorial nature of meat contamination. This finding suggests that contamination is not solely a result of poor handling and storage practices at the retail level but likely originates earlier in the supply chain, particularly during the slaughtering process. Research has shown that slaughterhouses are inherently nonsterile environments, posing significant risks for pathogenic microbial contamination (Diyantoro & Wardhana, 2019). To mitigate these risks, registering and accrediting all slaughterhouses in La Trinidad with the National Meat Inspection Services (NMIS) under the Department of Agriculture is critical. Accreditation would ensure compliance with national standards for meat safety and hygiene. Additionally, equipping municipal slaughterhouses with facilities for chilling carcasses immediately after dressing can significantly reduce the initial microbial load, while washing carcasses with potable cold water at market locations before sale can further decrease contamination.

At the retail level, the lack of refrigeration facilities is a major systemic issue that exacerbates contamination risks. Many meat vendors rely on unrefrigerated stalls, leaving pork exposed to ambient temperatures that facilitate bacterial proliferation. Providing refrigeration

units or cold storage systems at public markets should be prioritized to maintain the freshness of meat and reduce microbial growth. Investments in market infrastructure, supported by municipal or provincial government programs, can help address this critical gap.

Vendor training programs represent another systemic issue that needs urgent attention. Although vendors in La Trinidad generally demonstrate good Knowledge, Attitudes, and Practices (KAP) scores, this has not translated into consistent compliance with food safety standards. Training programs should be expanded and enhanced to focus on practical, actionable steps that vendors can take to improve hygiene and handling practices. Regular workshops, on-site demonstrations, and follow-up evaluations should be implemented to ensure that training is not only delivered but also applied effectively. These programs should emphasize the importance of refrigeration, proper cleaning of equipment, prevention of cross-contamination, and the safe handling of raw meat. Special attention should be given to low-performing barangays to address specific barriers that hinder compliance.

Consumer education must also be integrated into broader interventions. Many consumers lack awareness of proper meat handling and cooking practices, which can exacerbate food safety risks at the household level. Public campaigns should focus on educating consumers about the importance of proper storage, avoiding cross-contamination, and cooking meat to safe internal temperatures. These campaigns can empower consumers to make informed decisions and demand higher standards from vendors and regulatory bodies.

Routine microbial testing should also be institutionalized to monitor contamination levels, evaluate the effectiveness of interventions, and ensure compliance with food safety standards. This data-driven approach can guide continuous improvements in meat safety protocols. Furthermore, consumer awareness campaigns are essential to empower buyers to demand higher hygiene standards. Educated consumers can serve as a driving force for vendors to maintain proper hygiene practices, creating a positive feedback loop that reinforces adherence to safety measures.

There is also a need for further studies to address critical issues such as cross-contamination risks in retail environments. Research should explore how contamination spreads within market stalls, from equipment, surfaces, or improper handling practices, to identify and mitigate these risks. Additionally, consumer education campaigns are essential to raise awareness about proper meat handling and cooking practices. Educating consumers on practices such as avoiding cross-contamination in the kitchen, thoroughly cooking pork to safe internal temperatures, and proper storage can significantly reduce the risk of foodborne illnesses at the point of consumption.

Further research should investigate the antimicrobial resistance (AMR) profiles of *E. coli* strains present in pork sold in La Trinidad. This data is vital for developing targeted interventions to address both immediate safety concerns and the broader public health risks associated with AMR. Expanding these recommendations to include studies on retail and consumer practices ensures a comprehensive approach to mitigating contamination risks and protecting public health.

Finally, stronger regulatory enforcement and policy changes are necessary to ensure meat safety. Regulatory agencies should implement mandatory training and certification for meat vendors, establishing clear standards for meat handling and hygiene. Stricter inspections of slaughterhouses and markets should be enforced regularly to ensure compliance with established food safety protocols. Collaborative efforts involving regulatory agencies, municipal authorities, market operators, vendors, and consumers are essential for implementing systemic changes to improve meat safety and protect public health.

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