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Microbial assessment of locally registered slaughterhouses in La Union, Philippines

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Abstract

This study was conducted to assess the microbial quality of meat and hygiene practices in selected slaughterhouses in the Province of La Union, Philippines from January 28 to February 28, 2025. Swab samples from food contact surfaces including were collected and analyzed for microbial contamination for potential pathogens including Aerobic Plate Counts (APC), *Staphylococcus aureus*, *Escherichia coli*, *Salmonella* spp., and Coliforms. Results revealed varying levels of microbial contamination, with some samples exceeding acceptable safety limits, indicating potential risks to public health. Poor sanitation, improper handling, and inadequate facilities contributed to contamination levels. The study highlights the need for stricter enforcement of hygiene protocols, improved slaughterhouse infrastructure, and regular microbial monitoring to ensure meat safety. Findings can guide local authorities in developing policies to enhance food safety standards and protect consumers.

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Introduction

Meat Establishments like slaughterhouse or abattoir play an important guide in monitoring, managing, and eliminating animal diseases, as well as in controlling, reducing, and preventing foodborne risks that impact public health. Proper hygiene practices should be maintained throughout the slaughtering and processing stages to avoid foodborne hazards and cross contamination of carcasses. Thus, the hygiene of meat establishments facilities plays an important role in determining the final microbiological condition of chilled carcasses, as well as in preventing and lessen consumer exposure to foodborne risks linked to meat consumption (Nastasijevic *et al.*, 2011).

Poor personal and environmental hygiene, along with unhygienic conditions can spread foodborne infections in slaughterhouse across sub-Saharan Africa. To evaluate the hygiene and sanitation practices in selected abattoir in sub-Saharan African nations, as well as the bacterial contaminants present in these facilities. Due to insufficient hygiene, lack of formal occupational health and safety training, inadequate worker knowledge, and the use of substandard infrastructure and basic tools Pathogenic microorganisms of public health concern are commonly found in these abattoirs. These circumstances create an environment conducive to the growth, survival, transmission, and spread of foodborne pathogens such as bacteria, parasites, and viruses. To handle these challenges, it is essential to evaluate issues like poor personal and environmental hygiene among butchers and other abattoir workers, limited access to clean water, unsuccessful waste management practices, and the absence of proper infrastructure and technology—all of which facilitate the presence of harmful microorganisms. Sustainable solutions should involve the implementation of regulations or rules supported by legal frameworks (Ovuro *et al.*, 2023).

Monitoring carcass surface contamination along the slaughter line is critical for confirming hygiene practices and compliance to manufacturing standards. The most commonly describe foodborne diseases globally and one of the major sources of human nontyphoidal salmonellosis is pork. The findings of this study highlight the need for ongoing improvements in slaughtering operations and the implementation of good manufacturing practices to ensure the safety of pork production in Portugal (Alvez *et al.*, 2022).

The meat handlers who trained in proper hygiene practices serve as the first line of defense against contamination of food throughout the supply chain. The spread of harmful microorganisms can be minimized or lessen through basic hygiene practices, such as proper handwashing. The palms of food handlers can carry a variety of microorganisms and contaminants like *Escherichia coli* O157:H7, *Shigella* spp., *Salmonella Typhi*, nontyphoidal *Salmonella*, Norovirus, and Hepatitis A virus, and all are derived from human fecal matter and environment. Additionally, handling raw food materials can lead to the transfer of bacteria, such as *Salmonella* spp. and *E. coli* O157:H7 through the hands. These pathogens and microorganisms can then easily spread from the food handler's palms to the food during handling or preparation (El-Nemr *et al.*, 2019).

Meat or carcasses has been valued for its nutritional content, which helps explain its widespread consumption around the world. The protein in the meat contains amino acids that are considered of high quality, as it includes all the essential amino acids needs by the body. A significant part of the global population depends on meat as a primary food source. Nonetheless, eating or consuming half raw meat can lead to infections in humans, as certain enteric bacteria species can cause sickness (Olaoye, 2011).

The meat is rich in protein and fat, low carbohydrates, and with adequate water activity, gives an ideal environment for the growth of both pathogenic bacteria and spoilage. The common spoilage in raw meat and poultry include *Enterobacteria* spp., *Salmonella* spp., as well as *Pseudomonas* and *Staphylococcus* bacteria. Yeasts

and molds grow much more slowly on freshly slaughtered meat compared to bacteria and are therefore not major contributors to spoilage (Doyle, 2007). As mentioned by Olaoye *et al.* (2011), meat is more vulnerable to spoilage and is frequently associated with the spread of foodborne illnesses, as various biochemical changes and microorganisms are introduced during slaughter, processing, and preservation stages. According to Okonko *et al.* (2010), roughly 69% of Gram-negative bacteria are known to cause foodborne diseases. Also, foodborne pathogens and microorganisms can spread from contaminated meat to surfaces, further increasing the risk of infection. The Food and Agriculture Organization (FAO) and the World Health Organization (WHO) state that diseases caused by unhygienic food are among the most widespread health issues and a major contributor to reduced economic productivity (Käferstein, 2003).

Raw meat or half cooked meat can harbor a variety of pathogenic microbes making it a major risk to human health. Without hygienic and proper handling and control of these pathogens, foodborne illnesses can occur (Norrung *et al.*, 2009). Top contributors to bacterial contamination of meat are the hygienic conditions of slaughterhouses or abattoirs and their surrounding (Gill *et al.*, 2000). During the transportation, storage, and handling at the meat shops continues the contamination risk.

Strict adherence to food safety protocols is very much needed to stop foodborne illnesses and control the microbial load in raw meat. Nevertheless, in developing countries like the Philippines, the poor sanitary conditions of meat establishments, as well as insufficient transportation and storage facilities, not only lead to contamination but also promote the growth of both spoilage and pathogenic bacteria in meat (Ahmad *et al.*, 2013).

The meat industry produces large amount of high-strength byproducts and waste from slaughterhouses, which, if untreated, can cause significant impact on the environment in China. These waste products are rich in protein and lipids, which could be successfully used for energy and nutrient recovery (Wang, 2024).

With all the animal products like meat, fish, and fishery products often described as high-risk commodities due to their potential for harboring pathogens, natural toxins, and other contaminants, food security is a complicated issue (Yousuf *et al.*, 2008). Depending on the quantity of contaminated food consumed and the individual's exposure to the pathogens, foodborne diseases, caused by consuming of different harmful bacteria, toxins, and microbial cells, differ in severity (Clarence *et al.*, 2009). Foodborne contamination contributes significantly to healthcare burdens in the industrialized nations, (Adak *et al.*, 2005).

According to Pereira *et al.* (2024) slaughterhouse and abattoirs activities is an alert to environmental and public health issues due to the large volume of effluents produced. As mentioned by Kebede *et al.* (2023), in abattoirs, the majority of respondents (87.5%) concur that there were some challenges in achieving slaughtering in the working environment. Food borne infections and diseases is a vital international health problem with consequent economic depletion is a major cause of illness and death worldwide (Adak *et al.*, 2005). Recognizing this, the World Health Organization (WHO) developed its Global Strategy for Food Safety (Adak *et al.*, 2005). In the developing world, food-borne contamination leads to the death of many children and the on children's growth as well as on their physical and cognitive development (Adak *et al.*, 2005).

Lagrimas *et al.* (2020) noted that *Trichinella* spp. one of the major prevalent food-borne zoonotic parasites worldwide, posing danger to human health, pig farming, and food safety.

However, in the livestock production in the Philippines, there are still lacking researches. Immunoglobulin G (IgG) antibodies in the province of Bulacan and exploring the relationship between its

presence and common animal husbandry practices. The study was done in selected abattoirs, where pigs were randomly chosen for sampling. Overall, the findings in Bulacan, Philippines shows that *Trichinella* spp. antibodies has a very low prevalence. The study highlights a valuable early screening method for *Trichinella* in hogs, without the need to sacrifice animals for testing. These outcomes suggest the need for broader screening and further investigation of *Trichinella* spp. in pigs across other provinces in the Philippines.

According to Auditors of Moroccan Court, the standards they required for slaughterhouses do not meet the basic conditions. Bacteriological results indicate a need to improve the available slaughter facilities and develop an appropriate slaughter process strategy to minimize the risk of carcass contamination (Muhammed *et al.*, 2022).

The disinfection procedure was partly effective in reducing of microbial contamination of the environment, significantly reducing bacterial diversity and favoring some genera such as *Psychrobacter* and *Weissella confusa* (Sui *et al.*, 2023). The predominant factors led to the contamination of beef meat and seriously compromise the quality of the meat products are poor personal hygiene along with low educational status, lack of training on food handling, personal and environmental hygiene, poor sanitation of the butcher shops and slaughterhouses, no veterinary laboratory, sterilization facilities, hot water service, and hazard analysis and critical control point (Codex Alimentarius Commission, 2020).

According to Chelea *et al.*, 2019 training on Good Manufacturing Practices and implementation of HACCP principles is an urgent need for the slaughterhouse personnel. To control the food-borne illnesses and to keep the microbial load of raw meat in check, the food safety requirements should be followed strictly in accordance with HACCP (Hazard analysis critical control point), but in developing countries like Pakistan, the abattoir environment, its sanitary level, and transportation and storage conditions because it can not only contaminate but also enhance the growth of different types of spoilage as well as pathogenic bacteria in meat (Ahmad *et al.*, 2013).

As reported by Reta *et al.*, 2023 chickens are the main reservoirs of Salmonella and the slaughterhouse is the sites for cross-contamination of pathogens. Regardless of the sample weight, time of contact, and amount of inoculum, cross-contamination were occurred.

In accordance with Aenedo *et al.* (2019) cross-contamination during the transportation and slaughter process is very important but Campylobacter spp. infected flocks may be a source of these bacteria in the corresponding carcasses.

The proliferation of bacteria, particularly Campylobacter, and the contamination of broiler carcasses by the bacteria found in the intestinal material during processing could lead to monitoring hygienic status (Khalefa and Laban *et al.*, 2023). Cabral and Pansanhagen (2017) noted that it is imperative to enforce sanitary inspections in slaughterhouses and to apply good manufacture practices to assure the safety of the produced pork. The monitoring of critical points, slaughterhouse equipment, good slaughtering practices, and effective washing and disinfection are the keys to obtaining good microbiological results (Delhalle *et al.*, 2008).

Equipment frequently comes into direct contact with the carcass is critical to thoroughly remove the microorganisms through accurate cleaning to prevent the spread of microbial contamination on the carcasses (Nakamura *et al.*, 2022).

The major sources of gut AMR bacteria on slaughtered meat were cross contaminated during the slaughter process (Wu *et al.*, 2022). The spread of antimicrobial resistance (AMR) is an impending crisis highlighted by the emergence of multidrug-resistant (MDR) pathogenic foodborne bacteria, like MDR

Salmonella enterica due to the misuse and overuse of antibiotics in agricultural and livestock industries Hence, quick, and accurate identification of AMR and resistance genes are of utmost importance to treat infections, monitor or safeguard food production, and trace the sources of AMR outbreaks. Conventional methods of antimicrobial susceptibility testing (AST) such as disk diffusion assays are relatively inexpensive but are labor-intensive, slow, and limited to phenotypic detection. Conversely, modern AST methods include DNA sequencing and polymerase chain reaction (PCR) sequencing that provide more accurate genotypic detection and more faster. This study sought to detect resistance genes in *S. enterica* isolated from swine from Philippine slaughterhouses through various protocols of conventional and modern AST methods. Resistance to five antibiotic classes was examined. It was found that 50% (14/28) of the isolates were MDR, and resistance to tetracycline was found in all isolates. The most common genes detected from the isolates were tet(A) (39.3%), followed by tet(C) (28.6%), and tet(E) (25%). Also, 25% (7/28) and 25% (7/28) of isolates were resistant to one and two antibiotic classes, respectively. PCR methods were used only for detection of tetracycline resistance genes, as a model for molecular investigation. The results of this study demonstrated the growing prevalence of MDR in the agricultural industry and the necessity for improvement of its detection (Pagoso *et al.*, 2024).

Sui *et al.*, 2023 emphasizes the importance of disinfection in the slaughterhouses and scientific suggestions for implementing effective disinfection. Improper slaughterhouse waste disposal may contaminate the environment with infective forms of parasites and pathogens (Besana *et al.*, 2020).

Sabiniano (2015) recommended that control measures be implemented to reduce the risk, such as chilling of carcass to 7°C, loading the carcass in refrigerated vans, and application of proper cooking time and temperature on the pork belly. According to the section 12 of the National Meat Inspection Code of the Philippines (R.A. 9296) (2005), the local government units should endeavor to improve meat facilities in order to comply with the national standards. Furthermore, these unaccredited slaughterhouses may increase the consumers' exposure to pathogens due to non-compliance to the meat hygiene program (Maranan *et al.*, 2008). The microbial populations of pork and chicken meats both increase during storage for 12 hours at ambient temperature, while pH and %TA of the meats are not significantly affected by this storage.

Relationships between APC and physicochemical characteristics of both meats are weak.

Therefore, developing microbial spoilage indicators based on either pH or %TA for meat may not be feasible, and based on this study, the only way to determine the shelf-life of meat is to conduct microbiological analysis. In terms of a suitable pork shelf-life is attained when the local regulation of maximum holding time of 8 h at ambient temperature is conformed with, while some chicken meat can reach the end of its shelf-life in as little as 3 h storage at ambient temperature, showing non-conformity. Research related to shelf-life determination of newly slaughtered meat, particularly chicken, at ambient temperature is very scanty and rare. This may be due to the fact that holding fresh meat at ambient temperature is not widely accepted in other countries.

According to Monica Manalo (2020) the microbial populations of pork and chicken meats both increase during storage for 12 hours at ambient temperature, while pH and %TA of the meats are not significantly affected by this storage. Abattoir hygiene has an important impact on final microbiological status of chilled carcass, as well as prevention and minimization of consumers exposure to foodborne hazards associated with meat consumption (Nastasijevic *et al.*, 2022).

In general, the study will assess the microbial load of the equipment and other food contact surfaces (scalding vat, Butcher's knife, ax or splitting saw,

meat hook and butcher's hand), pork carcass (belly, jowl and ham) in four (4) Locally Registered Slaughterhouses in the Province of La Union, Philippines. Specifically, it aims to: (1) determine the common food-borne pathogens (e.g. *E. coli*, *Salmonella*, and *Staphylococcus* sp.) present in the samples; and (2) determine the microbial load per microbial species in the swab samples taken from different LRME Slaughterhouses in La Union.

Materials and methods

Research design

For this study, the researcher used the gold standard method as described by Official Methods of Analysis or as stated in the Bacteriological Analytical Manual (BAM) for Aerobic Plate Count (APC) by Larry Maturin and James T. Peeler, (January 2001). Experimental design used in the study was Observational Study Design since the results of the Microbial Analysis are not exact numbers or data.

Receipt of samples

The collected swab samples by the researcher were submitted to the meat laboratory as soon as possible. The analyst should note its general physical condition upon arrival of the samples at the laboratory. Swab samples should be stored properly if cannot be analyzed immediately.

Procedures

Preparation of the materials

The materials used in the collection of swab samples were prepared before conducting the collections process. Sampling Materials for Personnel includes head cap, mask, sterile gloves, hand soap, laboratory gown and rubber boots while sampling materials for the Carcass and facilities were Transport Medium (BPW in tubes), sanitizing solution – hypochlorite or 70% alcohol, cotton swab/sponge, tissue paper, cooler / ice box, forceps, coolant packs, scissors / knife, sterile cotton, sampling kit box, labelling, plastic bags and labelling tape.

Preparation of request letter

Request letter was present first to the Local Chief Executives of the selected four (4) Municipalities of La Union for them to be well- informed regarding the collection and testing of swab sample collection.

Carcass selection

Selection and identification of a carcass was randomly selected from predetermined point along the chain. Then count back five (5) carcasses and select the next carcass for sampling. The skipping prevents bias in selection.

Collection of swab samples

A sterilized, moistened cotton swab was used to collect samples from the ham, belly, and jowls of the pork carcasses and swab surface area like splitting saw or ax, meat hook, scalding vat, knives and butcher's hands. After swabbing, the samples were immediately placed in test tubes containing a sterile sampling solution (Buffered peptone water). The swab samples were agitated up and down in the tubes to help rinse the bacteria from the surface of the swabs. Identification tags were attached to the sampling tubes.

Storage and transport of swab samples

Swab samples were stored in a cooler with ice or ice-gel pack at 4°C (39.2°F) and immediately transported to the laboratory for analysis.

Collection of samples

Swab samples were collected from four (4) Locally Registered Slaughterhouses in the Province of La Union. Composite samples were taken from equipment and butchers' hands. For the equipment (such as splitting saw or ax, butcher's knife, scalding vat, and meat hook) and personnel (butchers' hands), swab samples were collected prior to the start of slaughtering operations. Meanwhile, swab samples from the pork carcasses specifically from the ham, belly, and jowls were collected after the slaughter process. After collection, the swab samples were placed in an insulated box with ice and immediately transported to the laboratory or within 24 hours for the conduct of various tests.

Data gathered

Aerobic plate count

This was executed on total plate count agar. The medium was autoclaved and maintained at 46°C. Samples were serially diluted and an aliquot of 1 ml of each of serial dilution will be transferred to the petri dishes (4-inch diameter) and molten agar (15-20 ml) were poured on it. Plates was gently swirled to uniformly mix the sample and incubated at 37°C for 24 hours. After incubation, APC was determined from appropriate plates.

Staphylococcus aureus enumeration

Baird Parker agar (Oxoid, England), a selective medium for the isolation and counting of coagulase positive *staphylococci* was used for the enumeration of *Staphylococcus aureus* as described by (Bhandare *et al.*, 2007).

Escherichia coli enumeration

This *was* enumerated on Eosin methylene blue agar by plating an appropriate dilution on plates followed by aerobic incubation at 37°C for 24hrs. After incubation *E. coli* were counted as colonies with distinct metallic sheen (Bhandare *et al.*, 2007).

Salmonella isolation and identification

This was established by pre-enrichment of meat sample in lactose broth followed by enrichment in tetra-thionate broth and final detection on Bismuth sulphite agar, XLD and *Salmonella-Shigella* agar as recommended by WHO procedures.

Coliforms

Enumeration can be done on a standard colony counter. Picking out individual colonies for interpretation can also be done because the top film can be lifted quite effortlessly to expose the gel. Unfortunately, if a sample is too dark in colour (e.g. mixed with chocolate or hot chocolate), enumeration becomes more difficult or impossible, since the stained colonies are less visible.

E. coli, *Staphylococcus aureus*, and *Salmonella* were identified by the following flowchart (Fig. 1-3) and basic slaughtering procedure (Fig. 4) given below.

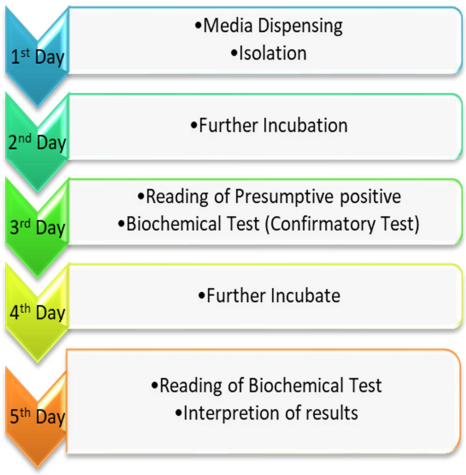

Fig. 1. *E. coli* identification

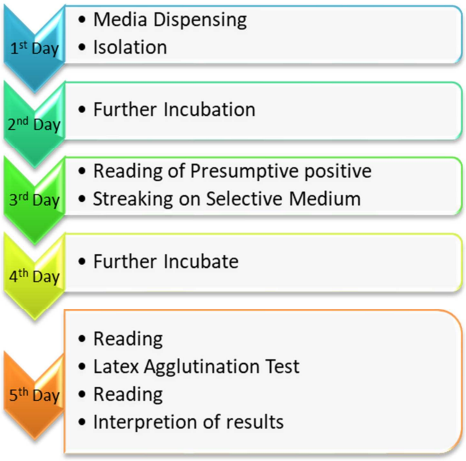

Fig. 2. *Staphylococcus aureus* identification

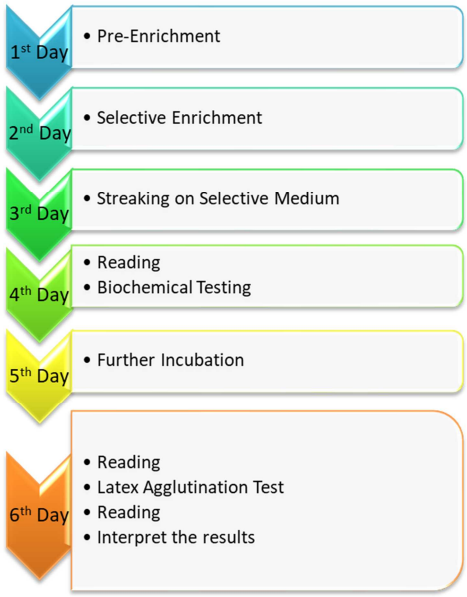

Fig. 3. *Salmonella* identification

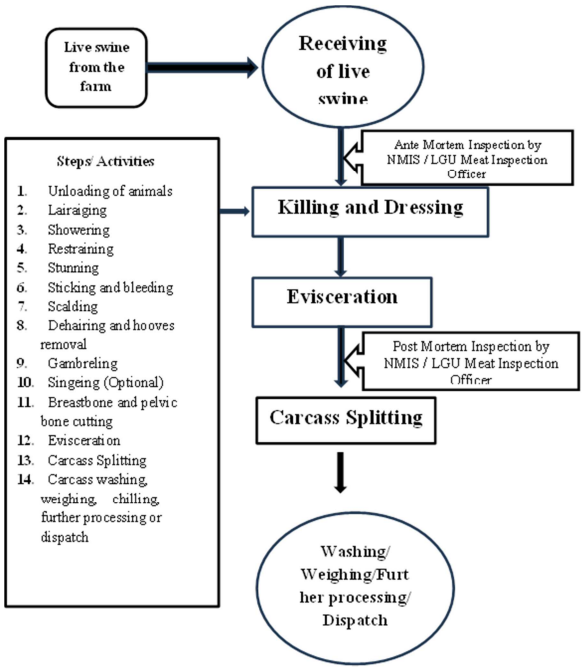

Fig. 4. Flow chart of basic slaughtering procedure

Microbial count

Guidelines for calculating and reporting aerobic plate count (Larry Maturin and James T. Peeler, 2001)

Report all aerobic plate counts computed from plates containing more than 250 colonies as estimated counts. Counts outside the normal 25-250 range may give erroneous indications of the actual bacterial composition of the sample. Dilution factors may exaggerate low counts (less than 25), and crowded plates (greater than 250) may be difficult to count or may inhibit the growth of some bacteria, resulting in a low count. Report counts less than 25 or more than 250 colonies as estimated aerobic plate counts (EAPC). Use the following guide:

Normal plates (25-250)

Select spreader-free plate(s). Count all colony forming units (CFU), including those of pinpoint size, on selected plate(s). Record dilution(s) used and total number of colonies counted.

Plates with more than 250 colonies

When number of CFU per plate exceeds 250, for all dilutions, record the counts as too numerous to count (TNTC) for all but the plate closest to 250, and count CFU in those portions of plate that are representative of colony distribution. Mark calculated APC with EAPC to denote that it was estimated from counts outside 25-250 per plate range.

Spreaders

Spreading colonies are usually of 3 distinct types: 1) a chain of colonies, not too distinctly separated, that appears to be caused by disintegration of a bacterial clump; 2) one that develops in film of water between agar and bottom of dish; and 3) one that forms in film of water at edge or on surface of agar. If plates prepared from sample have excessive spreader growth so that (a) area covered by spreaders, including total area of repressed growth, exceeds 50% of plate area, or (b) area of repressed growth exceeds 25% of plate area, report plates as spreaders. When it is necessary to count plates containing spreaders not eliminated by (a) or (b) above, count each of the 3 distinct spreader types as one source. For the first type, if only one chain exists, count it as a single colony. If one or more chains appear to originate from separate sources, count each source as one colony. Do not count each individual growth in such chains as a separate colony. Types 2 and 3 usually result in distinct colonies and are counted as such. Combine the spreader count and the colony count to compute the APC.

Plates with no CFU

When plates from all dilutions have no colonies, report APC as less than 1 times the corresponding lowest dilution used. Mark calculated APC with asterisk to denote that it was estimated from counts outside the 25-250 per plate range. When plate(s) from a sample are known to be contaminated or otherwise unsatisfactory, record the result(s) as laboratory accident (LA).

Computing and recording counts

To create accuracy when computing APC, report only the first two significant digits. Round off to two significant figures only by raising the second digit to the next highest number when the third digit is 6, 7,

8, or 9 and use zeros for each successive digit toward the right from the second digit. Round down when the third digit is 1, 2, 3, or 4. When the third digit is 5, round up when the second digit is odd and round down when the second digit is even.

Data analysis

Data were analyzed using the Descriptive - Quantitative Analysis where values obtained from the samples in each slaughterhouse / municipality was discussed.

Results and discussion

Aerobic plate count

Table 1 presents the aerobic plate count (CFU/cm²) for various food contact surfaces and pork cuts in locally registered slaughterhouses in the Province of La Union

In Slaughterhouse A, the splitting saw or bolo had minimal contamination, with counts below 10 CFU/cm², while the butcher's knife ranged from 10,000 to 220,000 CFU/cm². The scalding vat showed extreme contamination, reaching 1,890,000 CFU/cm² in one instance but remaining below 10 CFU/cm² in another. Meat hooks had low bacterial counts, mostly below 10 CFU/cm², whereas the butcher's hand ranged from below 10 CFU/cm² to 90,000 CFU/cm². Pork ham and pork belly were generally clean, with counts below 10 CFU/cm², but pork jowls exhibited contamination levels between 10,000 and 280,000 CFU/cm².

In Slaughterhouse B, the splitting saw or bolo was mostly below 10 CFU/cm², while the butcher's knife had values of either below 10 CFU/cm² or marked as "TNTC" (too numerous to count). The scalding vat followed a similar pattern, with some samples showing below 10 CFU/cm² and others marked as TNTC. The meat hooks ranged from below 10 CFU/cm² to 690,000 CFU/cm². However, the butcher's hand recorded values up to 810,000 CFU/cm². Pork ham had TNTC contamination levels, pork belly ranged from 120,000 CFU/cm² to TNTC, and pork jowls were also marked as TNTC in some samples.

Table 1. Aerobic plate count

Locally registered slaughterhouse	Aerobic plate count (CFU/cm²) <10(CFU/cm²) <10⁶							
	Splitting saw or bolo	Butcher's knife	Scalding vat	Meat hook	Butcher's hand	Pork ham	Pork belly	Pork jowls
A	<10	10000	1890000	<10	90000	<10	<10	10000
	<10	220000	<10	3000	70000	<10	<10	<10
	<10	20000	<10	<10	<10	<10	<10	280000
B	<10	TNTC	TNTC	690000	810000	TNTC	<10	1360000
	<10	<10	<10	<10	<10	TNTC	120000	TNTC
	100000	<10	TNTC	<10	TNTC	1660000	TNTC	TNTC
C	310000	10000	90000	80000	150000	10000	350000	TNTC
	<10	80000	10000	<10	10000	TNTC	170000	TNTC
	10000	90000	700000	1180000	20000	TNTC	TNTC	TNTC
D	<10	10000	TNTC	<10	<10	30000	70000	<10
	10000	1100000	40000	<10	<10	840000	70000	330000
	<10	TNTC	<10	<10	<10	210000	130000	260000

Slaughterhouse C showed high microbial loads on several surfaces. The splitting saw or bolo had values ranging from 10,000 to 310,000 CFU/cm², while the butcher's knife showed a wide range from 10,000 to 90,000 CFU/cm². The scalding vat varied between 90,000 and 700,000 CFU/cm².

Meat hooks showed particularly high contamination, reaching up to 1,180,000 CFU/cm². The butcher's hand had significant bacterial presence, with counts between 10,000 and 150,000 CFU/cm². Pork ham ranged from from 10,000 to TNTC. Pork belly was also heavily contaminated, with values between 170,000 and 350,000 CFU/cm². Pork jowls had TNTC contamination levels in multiple instances.

In Slaughterhouse D, the splitting saw or bolo had contamination levels of either below 10 CFU/cm²

or 10,000 CFU/cm². The butcher's knife exhibited high contamination, ranging from 10,000 to 1,100,000 CFU/cm². The scalding vat had microbial counts of 40,000 CFU/cm² in one instance but remained below 10 CFU/cm² in others. Meat hooks were mostly clean, with counts below 10 CFU/cm². The butcher's hand ranged from below 10 CFU/cm² to TNTC. Pork ham had values between 30,000 and 840,000 CFU/cm², while pork belly ranged from 70,000 to 130,000 CFU/cm². Pork jowls showed high contamination, with values between 260,000 and 330,000 CFU/cm².

These findings highlight significant bacterial contamination in several slaughterhouses, particularly in Slaughterhouse C and D, where high microbial counts were recorded on critical food contact surfaces such as butcher's hands, knives, and scalding vats. This implies that contamination poses a serious food safety risk that would lead to foodborne illness among consumers.

Staphylococcus aureus

Table 2 shows the aerobic plate count of *Staphylococcus aureus* (CFU/cm²) on various food contact surfaces in slaughterhouses located in the four (4) Locally Registered Slaughterhouses in the Province of La Union.

In Slaughterhouse A, bacterial counts ranged from <10 to 10,000 CFU/cm², with the highest contamination observed on pork jowls. The butcher's knife showed contamination at 1,000 CFU/cm², while other surfaces had minimal bacterial presence. In Slaughterhouse B, microbial levels were relatively lower, ranging from <10 to 5,000 CFU/cm², with pork jowls exhibiting the highest count. Slaughterhouse C showed the most significant contamination, with values ranging from <10 to 44,000 CFU/cm², particularly in the scalding vat, which recorded the highest microbial load. Other highly contaminated surfaces in San Fernando included pork belly (14,000 CFU/cm²) and pork jowls (9,000 CFU/cm²).

Table 2. Aerobic plate count of *Staphylococcus aureus*

Locally registered slaughterhouse	Aerobic plate count of *Staphylococcus aureus* (CFU/cm²) <1000							
	Splitting saw or bolo	Butcher's knife	Scalding vat	Meat hook	Butcher's hand	Pork ham	Pork belly	Pork jowls
A	<10	<10	TNTC	<10	<10	<10	<10	<10
	<10	1000	<10	<10	<10	<10	<10	<10
	<10	<10	<10	<10	<10	<10	<10	<10
B	<10	<10	<10	<10	<10	<10	<10	10000
	<10	<10	<10	<10	<10	TNTC	<10	4000
	<10	<10	<10	<10	<10	9000	<10	5000
C	<10	<10	44000	3000	1000	1000	4000	<10
	<10	1000	19000	<10	2000	<10	14000	<10
	<10	3000	TNTC	TNTC	<10	6000	<10	<10
D	<10	<10	<10	<10	3000	<10	<10	<10
	<10	<10	TNTC	<10	<10	11000	<10	1000
	<10	<10	<10	<10	<10	<10	8000	<10

In contrast, Slaughterhouse D recorded microbial counts between <10 and 11,000 CFU/cm², with pork ham and pork belly showing the highest contamination. Across all slaughterhouses, surfaces such as the splitting saw, meat hook, and butcher's hand exhibited relatively low microbial presence (<10 CFU/cm²). The high bacterial loads observed in certain areas, particularly the scalding vat and pork products, underscore the need for improved sanitation practices to ensure food safety and minimize potential health risks associated with *S. aureus* contamination. This implies that the four (4) slaughterhouses in La Union need to improved sanitation practices in slaughterhouses to reduce food safety risks.

Escherichia coli

Table 3 presents the microbial load of Escherichia coli on various food contact surfaces and pork cuts from locally registered slaughterhouses in the four (4)

Locally Registered Slaughterhouses in the Province of La Union was assessed, with results expressed in colony-forming units per square centimeter (CFU/cm²). Across all slaughterhouses, the aerobic plate count for *E. coli* on food contact surfaces—including the splitting saw or bolo, butcher's knife, scalding vat, meat hook, and butcher's hand—was consistently low, with values recorded at <10 CFU/cm².

However, variations were observed in pork meat samples, particularly in pork ham, belly, and jowls.

Table 3. Aerobic plate count of *Escherichia coli*

Locally registered slaughterhouse	Aerobic plate count of *Escherichia coli* (CFU/ cm²) <500							
	Splitting saw or bolo	Butcher's knife	Scalding vat	Meat hook	Butcher's hand	Pork ham	Pork belly	Pork jowls
A	<10	<10	<10	<10	<10	5000	<10	<10
	<10	<10	<10	<10	<10	<10	<10	<10
	<10	<10	<10	<10	<10	1000	<10	<10
B	<10	<10	<10	<10	<10	<10	<10	<10
	<10	<10	<10	<10	<10	1000	1000	1000
	<10	<10	<10	<10	<10	2000	<10	<10
C	<10	<10	<10	<10	<10	2000	5000	<10
	<10	<10	<10	<10	<10	<10	1000	<10
	<10	<10	<10	<10	<10	<10	<10	<10
D	<10	<10	<10	<10	<10	<10	8000	<10
	<10	<10	<10	<10	<10	<10	21000	7000
	<10	<10	<10	<10	<10	1000	<10	<10

Table 4. Aerobic plate count of *Salmonella* sp.

Locally registered slaughterhouse	Aerobic plate count of *Salmonella* sp. (Negative)							
	Splitting saw or ax	Butcher's knife	Scalding vat	Meat hook	Butcher's hand	Pork ham	Pork belly	Pork jowls
A	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative
	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative
	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative
B	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative
	Negative	Negative	Negative	Negative	Negative	Positive	Positive	Positive
	Negative	Negative	Negative	Negative	Negative	Positive	Positive	Negative
C	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative
	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative
	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative
D	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative
	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative
	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative

In Slaughterhouse A, pork ham exhibited microbial contamination ranged from 1000 to 5000 CFU/cm², whereas pork belly and jowls had minimal contamination (<10 CFU/cm²).

Slaughterhouse B reported lower counts, with pork ham showing 1000–2000 CFU/cm², while pork belly and jowls remained at or below 1000 CFU/cm². Slaughterhouse C displayed microbial loads of 2000 CFU/cm² for pork ham, while pork belly and jowls ranged from <10 to 5000 CFU/cm². The highest microbial contamination was found in Slaughterhouse D, where pork ham ranged from 1000 to 8000 CFU/cm², pork belly reached a significant 21,000 CFU/cm², and pork jowls had up to 7000 CFU/cm².

These findings suggest that while food contact surfaces maintained a consistently low microbial load, pork products, especially in Slaughterhouse D, exhibited significantly higher *E. coli* counts, highlighting potential hygiene and handling concerns during meat processing. The result implies that there is a need for stricter food safety measures, improved hygiene protocols to minimize health risks due to microbial contamination of pork.

Table 5. Aerobic plate count of coliform

Locally registered slaughterhouse	Aerobic plate count of Coliform (CFU/ cm²) <500							
	Splitting saw or bolo	Butcher's knife	Scalding vat	Meat hook	Butcher's hand	Pork ham	Pork belly	Pork jowls
A	<10	<10	<10	<10	<10	2000	2000	<10
	<10	14000	<10	<10	<10	<10	2000	<10
	<10	<10	<10	<10	<10	<10	<10	1000
B	<10	TNTC	<10	TNTC	<10	<10	<10	TNTC
	TNTC	<10	<10	<10	<10	TNTC	7000	TNTC
	36000	<10	<10	<10	<10	5000	49000	TNTC
C	TNTC	<10	<10	11000	10000	2000	1000	TNTC
	<10	<10	<10	<10	1000	TNTC	<10	TNTC
	<10	<10	<10	<10	<10	TNTC	TNTC	TNTC
D	<10	<10	<10	<10	12000	<10	5000	<10
	<10	TNTC	TNTC	<10	<10	1000	4000	19000
	<10	TNTC	<10	<10	<10	<10	4000	1000

Salmonella sp.

Table 4 presents the aerobic plate count of *Salmonella sp.* from various food contact surfaces in locally registered slaughterhouses in La Union.

In Slaughterhouse A, all tested surfaces, including the splitting saw or ax, butcher's knife, scalding vat, meat hook, butcher's hand, and pork products (ham, belly, and jowls), were consistently negative for *Salmonella sp.* Similarly, Slaughterhouse C and D exhibited complete negativity across all tested surfaces, reflecting stringent hygiene and sanitation measures.

However, in Slaughterhouse B, while equipment and butcher-related surfaces remained negative, pork ham, pork belly, and pork jowls tested positive for *Salmonella sp.* This variation highlights the need for stricter handling and sanitation protocols, especially in meat processing and packaging stages, to prevent microbial contamination in consumer products. This result implies that there is a possible post-slaughter contamination in Slaughterhouse B.

Coliform

Aerobic plate count of coliform (CFU/cm²) across various food contact surfaces in four (4) locally registered slaughterhouses presented in Table 5. The acceptable limit for coliform contamination is set at <500 CFU/cm².

Results show that, In Slaughterhouse A, most surfaces have coliform counts below 10 CFU/cm², except for the butcher's knife, which recorded a high count of 14,000 CFU/cm². Pork ham and pork belly also exceeded the acceptable limit, with values reaching 2,000 CFU/cm². Slaughterhouse B exhibited significantly high coliform counts, with the splitting saw reaching 36,000 CFU/cm² and pork belly at 49,000 CFU/cm². Several surfaces, including the splitting saw or bolo, butcher's knife, meat hook, and pork jowls, were labeled as "TNTC" (Too Numerous to Count), indicating extreme contamination levels. Slaughterhouse C had generally lower contamination levels, with most surfaces below 10 CFU/cm². However, the butcher's hand and meat hook registered counts of 10,000 CFU/cm² and 1,000 CFU/cm², respectively. Pork ham and pork belly also showed contamination, with values of 1,000 CFU/cm², 2,000 CFU/cm² and TNTC respectively. Slaughterhouse D showed moderate to high contamination, with most surfaces falling below 10 CFU/cm². However, the butcher's hand had the highest count at 12,000 CFU/cm². Pork belly and pork jowls were notably contaminated, recording values of 4,000 CFU/cm² and 19,000 CFU/cm², respectively.

Overall, the data suggests that certain food contact surfaces, particularly the butcher's hand, knife, and pork products, are highly susceptible to contamination. This result implies that there training on proper sanitation measures must be reinforced to ensure compliance with food safety standards.

Conclusion

The following conclusions were drawn based on the findings of the study. (1) Based on the submitted samples, the common food borne pathogens present were *E. coli, Staphylococcus aureus, Salmonella sp.,* and Coliforms. (2) The microbial load across the different food contact surfaces and pork products in slaughterhouses located in the Province of La Union, highlights significant concerns regarding hygiene and food safety.

Aerobic plate count (APC): The data reveals a wide variation in microbial contamination, with the highest microbial loads observed in Slaughterhouse C and D. Surfaces such as butcher's knives, scalding vats, and butcher's hands in these areas exhibited substantial contamination, ranging from tens of thousands to over a million CFU/cm². Pork jowls also showed consistent contamination across all slaughterhouses, while other pork cuts, such as pork ham and belly, were generally less contaminated. These findings suggest that hygiene practices, especially in the handling and processing stages, may be inadequate in some areas, contributing to high bacterial contamination levels.

Staphylococcus aureus

Slaughterhouse A exhibited relatively low contamination levels for *S. aureus*, with pork jowls showing the highest counts. Slaughterhouse C had the most significant contamination, particularly on surfaces like the scalding vat and pork products. These high levels of contamination are concerning, as *Staphylococcus aureus* is a potential foodborne pathogen, and its presence on food contact surfaces increases the risk of cross-contamination during meat processing.

Escherichia coli

While food contact surfaces maintained low levels of *E. coli* contamination, pork products, especially in Slaughterhouse D, exhibited notably higher counts. The findings from Slaughterhouse A and B show occasional contamination, but Slaughterhouse D higher contamination levels, particularly on pork ham and belly, point to potential lapses in sanitation or handling procedures during meat processing and packaging.

Salmonella sp.

The results for *Salmonella sp*. were mostly negative across all tested surfaces, indicating effective control measures for this pathogen in most slaughterhouses. However, Slaughterhouse B showed positive results on pork products, which may suggest contamination occurring post-slaughter, underlining the importance of controlling microbial contamination at all stages of meat processing.

Coliforms

While most surfaces across the slaughterhouses had coliform counts below the acceptable limit of 500 CFU/cm², certain areas such as the butcher's knife, pork ham, and pork belly exceeded this limit. Particularly, Slaughterhouse B displayed alarmingly high coliform contamination, signaling a potential issue with sanitation, equipment cleanliness, or meat handling practices in that area.

Recommendations

In the light of the findings and conclusions, the following recommendations are offered: (1) Stricter sanitation measured and improved meat handling practices to ensure food safety. (2) Stricter enforcement of Personal Protective Equipment usage for butchers. (3) Installation of hand and tool dip sanitizer inside the slaughterhouse. (4) Assigned butcher in every station of the production process of slaughtering to prevent cross-contamination. (5) Follow the standard process flow of slaughtering as required by the National Meat Inspection Service.

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