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MICROBIAL QUALITY OF BEEF AND HYGIENIC PRACTICES FROM ABATTOIR IN ABIA STATE, SOUTH-EAST, NIGERIA

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Abstract
In order to lessen the chance of microbiological contamination during meat processing in an abattoir, the study evaluated meat handling, hygiene/sanitation, and meat safety procedures. A cross-sectional study was carried out using a basic random sample technique among meat handlers at the Ubakala, Umuahia South abattoir. Qualitative and quantitative research designs were employed. A structured questionnaire (20 copies) and interviews were used to gather demographic data. Microbial counts were used to identify the table, floor, and scrapped meat items (three samples total; nine samples total). The serial dilution technique was used to isolate the bacteria, and standard techniques were used to identify the bacterial pathogens. Descriptive and inferential statistics were applied to the obtained data using SPSS version 20.0. According to the respondents' socio demographic profile, the majority of operators (85.0%) were men; the younger demographic came in at 50.0%. Features of the slaughterhouse show that 95.0% of the time, more than seven cows were killed every day, and 80.0% of the time, the abattoir was located next to a river or stream. According to hygiene status, 60.0% of people burn their waste, 65.0% dispose of waste often, and 85.0% wash their soiled aprons once a week. Based on an assessment of meat safety procedures, 80.0% of people know that handling meat should be done with cleanliness; 100.0% have never received any training; 65.0% wash their hands before handling meat; 25.0% tie their hair back; 30.0% wear cover garments; 20.0% wear jewelry; and 85.0% of people who handle meat also handle money. Ninety percent reported a lack of infrastructure, while only five percent reported the use of pest control devices; a hundred and fifty percent reported veterinary doctor inspections, and sixty-five percent mentioned medical examination and care given to employees who handle meat and exhibit symptoms like diarrhea, coughing, or skin infections (95.0%).The average pH level of 6.8—10-3 to 7.4×10-3 was found in table meat; 11.0×10-4 to 12.2×10-4 was found in floor meat; 3.3×10-5 to 6.0×10-5 was found in scraped meat, and the pH range of 6.3 to 7.2 was found in both. Four types of germs were identified as the most common in table meat, floor meat, and scrapping meat, respectively: Escherichia coli spp., Bacillus spp., Streptococcus spp., and Pseudomonas spp. High microbiological loads could be the result of cross-contamination via evisceration, dressing on an unclean floor, and inadequate personal hygiene. High levels of meat hygiene practices and low levels of bacterial contamination in beef were reported. In order to maintain good meat hygiene, the study suggests standardizing facilities, increasing the inspection of meat sold to the public, training meat handlers in hygiene maintenance, and conducting routine bacteriological monitoring.

Keywords: *Meat safety practices, Hygiene, Abattoir, Meat contact surfaces, Microbial quality*

Introduction

The world's expanding human population is frequently associated with an increase in the demand for foods derived from animals (Gutema *et al*., 2021). One of the biggest sectors in the world, the meat processing sector employs a sizable workforce and plays a crucial role in the economy and society of most urban regions (Swai and Schoonman, 2012). It is noteworthy that consumers, processors, and producers of meat place a higher value on meat safety (Shilenge *et al*., 2017). According to Zerabuk *et al*. (2019), meat is the primary source of protein, vitamins, and other nutrients needed for bodily cell growth and function. Foodborne illnesses are linked globally to eating damaged food, which can happen during processing; when contaminated, meat processing has been identified as the main cause of illness (Atlabachew and Mamo, 2021).Foodborne infections are common in underdeveloped nations because of inadequate sanitation and handling procedures, a lack of regulations governing food hygiene, a lack of money for equipment that is required, and a lack of education for food handlers (Abdullahi *et al*., 2016; Nyamakwere *et al*., 2017). Pathogenic bacteria including *Staphylococcus aureus, Salmonella species, Listeria monocytogenes, Escherichia coli O157:H7, and Campylobacter species* identified in infected meat are the primary causes of foodborne illnesses (Bersisa *et al*., 2019).

Consumer health risks may result from improper handling of meat (Haileselassie et al., 2013). Because butcheries have a significant risk of contamination, they are essential to the prevention of meat-borne illnesses. In order to offer fresh and nutritious meat for human consumption, it is imperative to practice and maintain adequate hygiene when handling meat (Khanal and Poudel, 2017). Meat workers who don't practice good personal hygiene run the risk of spreading microorganisms through their hands, cuts, lips, skin, and hair (Wambui *et al*., 2017; Ebuete *et al*., 2020). Bacterial contamination, meat loss, and post-harvest meat shortages can occur from neglecting to adhere to basic sanitation and hygiene practices, such as hand washing, donning protective clothes, and cleaning and sanitizing butchery equipment and utensils (Chepkemoi *et al*., 2015).Research carried out in Tanzania (Ntanga *et al*., 2014) and Ethiopia (Birhanu *et al*., 2017) have demonstrated that butcheries' meat and meat-contact surfaces have higher than permitted levels of bacteria. In impoverished nations, standard and hygienic methods for handling and processing meat are frequently disregarded (Rani et al., 2017). The World Health Organization estimates that foodborne infections resulted in 600 million cases, 420,000 deaths, and almost 33 million years of lost life globally in 2010. The continent of Africa experienced the highest death toll from these illnesses (Gutema *et al*., 2021; Havelaar *et al*., 2015).

Improved hygienic handling practices during preparation, distribution, storage, and retail sales are crucial to reducing microbial contamination (Gutema *et al*., 2021). For health and safety, wearing protective clothing and cleaning your hands before and after handling meat are essential (Ntanga, 2013). When handling meat, donning an apron or gown can help prevent the meat handler and the meat from coming into contact with foodborne germs (Sulleyman *et al*., 2018). The knowledge and practices surrounding meat safety have been the subject of numerous studies (Haileselassie *et al*., 2013; Khanal and Poudel, 2017; Al Banna *et al*., 2021). Other studies have looked at meat handling procedures along the beef supply chain (Chepkemoi *et al*., 2015; Sulleyman *et al*., 2018) and the bacteriological quality of meat from butcher shops and abattoirs across international borders (Sulleyman *et al*., 2018; Aburi, 2012).

The literature urgently needs to look at the routine procedures followed by food handlers in the course of their jobs and possible sources of microbiological pollutants that could have an impact on the quality of meat products (Shilenge *et al*., 2017). The transmission of infectious and zoonotic diseases is facilitated by inadequate emergency care and first aid facilities at slaughterhouses. Banjo (2013) points out that there must be enough first aid facilities available due to the hazardous nature of the work in the meat sector. Furthermore, predisposing risk factors in abattoirs are identified by Banjo *et al*. (2013). These include touching contaminated hands, breathing in infected aerosols when burning hides, and exposing mucosal membranes to blood and bodily fluid splashes.

According to Kinsella *et al*. (2006), the water activity of beef, which is roughly 0.99, promotes microbial development and allows bacteria to adhere to and multiply on meat. At slaughterhouses and retail establishments, the removal of hides, evisceration, processing, packaging, storage, and distribution are the main times when microbiological contamination of carcasses happens (Abdalla *et al*., 2009). According to Humphrey *et al*. (2007), these microbes commonly cause foodborne diseases in addition to causing spoiling. For meat and meat products, many nations advise using hygienic and quality control procedures, especially in food catering (Tavakoli and Razipour, 2008). According to Fasanmi *et al*. (2010), the use of contaminated water, careless handling techniques, contaminated tables for meat display, and the use of dirty blades and equipment during cutting operations are all common causes of meat contamination in abattoirs and retail establishments. Wooden boards, knives, and scales in retail store are frequently a source of bacterial contamination, particularly from *Shigella* and *Staphylococcus aureus* species (Ali *et al*., 2010). Consumer acceptability, functional and eating characteristics, and processing attributes are all impacted by low-quality meat (Ferguson and Warner, 2008). Foodborne infections are mostly caused by eating habits, unhygienic conditions in slaughterhouses, and hazardous food storage and transportation (Kebede *et al*., 2014).

The US Centers for Disease Control and Prevention estimate that foodborne infections linked to foods of animal origin may cause 76 million illnesses, 325,000 hospital admissions, and 5,000 deaths yearly (Aluko *et al*., 2014). There has not been enough work done to address these public health issues, particularly in poor nations (Otsuki *et al*., 2001). There is still little knowledge about the extent of risk exposure for particular communities, particularly with regard to bacterial diseases spread by eating meat (Otsuki *et al*., 2001). Public health is at danger from eating tainted meat and meat products due to slaughterhouse methods include butchering animals on bare floors tainted with blood and excrement (Cadmus *et al*., 2008; Nwanta *et al*., 2010). Meat microbiological testing may evaluate but also manage contamination from the slaughtering process. Meat's hygienic quality can be inferred from its microbiological quality (Bersisa *et al*., 2019; Tafida *et al*., 2013). Poor infrastructure, hygiene, and carcass handling practices in slaughterhouses are frequently the cause of high bacterial burdens on meat. To acquire meat free of pathogens, it is essential to slaughter only healthy animals in a hygienic setting (Oluwafemi *et al*., 2013; Rombout and Nout, 1994). According to studies conducted throughout Nigeria, the majority of the meat sold in retail stores and slaughterhouses is of unsatisfactory quality (Chuku *et al*., 2016; Eruteya *et al*., 2014; Okechukwu *et al*., 2018; Okonko *et al*., 2010; Tafida *et al*., 2013). It is crucial to design control methods and have knowledge of foodborne diseases (Oluwasfemi *et al*., 2013). To inform public health measures, thorough assessments of the sanitary state and handling procedures in abattoirs are necessary (Bersisa *et al*., 2019; Chuku *et al*. 2016, Okechukwu *et al*., 2018; Bersisa *et al*., 2019). The purpose of this study is to evaluate the level of microbial contamination in various beef components and meat-contact surfaces in municipal slaughterhouses. In addition to providing baseline data for upcoming studies on the hygiene of meat production, it aims to discover diseases of public health concern.

Study Area

The Umuahia South Local Government Area in Abia State, which includes Ubakala, was chosen as the research's study area. It was founded in August 1991 by the Nigerian Federal Government, and it has its offices at Apumiri Ubakala, which is across from the well-known Apumiri market (Ukandu *et al*., 2011). The Local Government Area (LGA) is located in the Equatorial Rain Forest Zone. It is bordered to the north by the Imo River, to the south and southeast by Isiala-Ngwa North Local Government, and to the northeast by the Ikwuano Local Government (Ukandu *et al*., 2011). The coordinates of its location are 5° 31.59’ N and 7° 28.59’ E. Ubakala has 138,570 people living there, spread across an area of about 140 square kilometers, as reported in the Nigerian census of 2006. The Nigerian Television Authority, Federal Radio Corporation, the Ministry of Environment, and the Cereal Research Institute in Amakama are notable organizations in the region (John, 2016). The LGA is made up of the four well-known clans, Olokoro, Ubakala, Umuopara, and Old Umuahia, which are further divided into forty autonomous communities: Amakama, Umuobia, Umuntu, Amangwu, Amizi, Umuajata, Umudere, Avonkwu, Itu, Agbama, Itaja, Umuoparaozara, Okwu, Abam, Amibo, Amuzu, Avodim, Eziama, Ipupe, Laguru, Mgbarakuma, Nisirimo, Nsukwe, Umuogo, Umuosu, Apumiri, Umuezeala, Umuecheokwu, Okwu, Umuovo, Amuzuta, Ezeleke, Ogbodiukwu, Amizi, Umuajata, Umuovo, and Umunwawa (Ukandu et al., 2011). Release and Drainage: Low-lying to moderately high plain topography with surface elevations ranging from 59.5 to 164.5 meters above sea level characterizes the Umuahia South Local Government Area (Ukandu *et al*., 2011). The Imo River and its tributaries, which flow south and empty into the Atlantic Ocean, drain the region. The majority of the drainage pattern is dendritic, with tributaries typically flowing southward.

Materials and Methods

Socio-economic/cultural setting

The main economic activity of Umuahia South LGA is agriculture, which includes both commercial and subsistence farming. Cassava, maize, melon, yam, and cocoyam are among the principal crops (John, 2016). The principal cash crops are palm oil and kola nut plants. Typically, the slash and burn process of clearing bush marks the start of land preparation in April. For approximately five years, agricultural lands are left fallow in order to replenish soil nutrients. The people who live there also engage in major trading, especially in palm oil that dates back to the British colonial era (Ukandu *et al*., 2011). Every August, the New Yam Festival is a much-loved cultural celebration commemorating the harvest and eating of fresh yams. Following an offering to the Ala goddess, the top priest declares the celebration date (Ukandu *et al*., 2011). Furthermore, "Okonko," "Oboni," and "Ekpe" are well-known cultural groups that operate in most areas as covert societies. For adult males who attend initiation and swear an oath of secrecy, they act as the final arbiter and disciplinarian, guaranteeing adherence to community rules (John, 2016). One commonality among the independent communities in Umuahia South LGA is the marriage customs. The payment of bride riches, which represents a woman's position in the community, is deemed necessary for a traditional marriage (Ukandu *et al*., 2011). In Igbo culture, births and deaths are significant occasions, and burial customs are determined by the circumstances of the departed. Traditionally, people who committed suicide or died giving birth were buried in the evil woodland, but the influence of Christianity has changed these customs. Suicide is still viewed as taboo, necessitating customary purification rituals to please regional gods (John, 2016). The study area map is shown in Fig. 1 below, and the sample collecting area map is shown in Fig. 2.

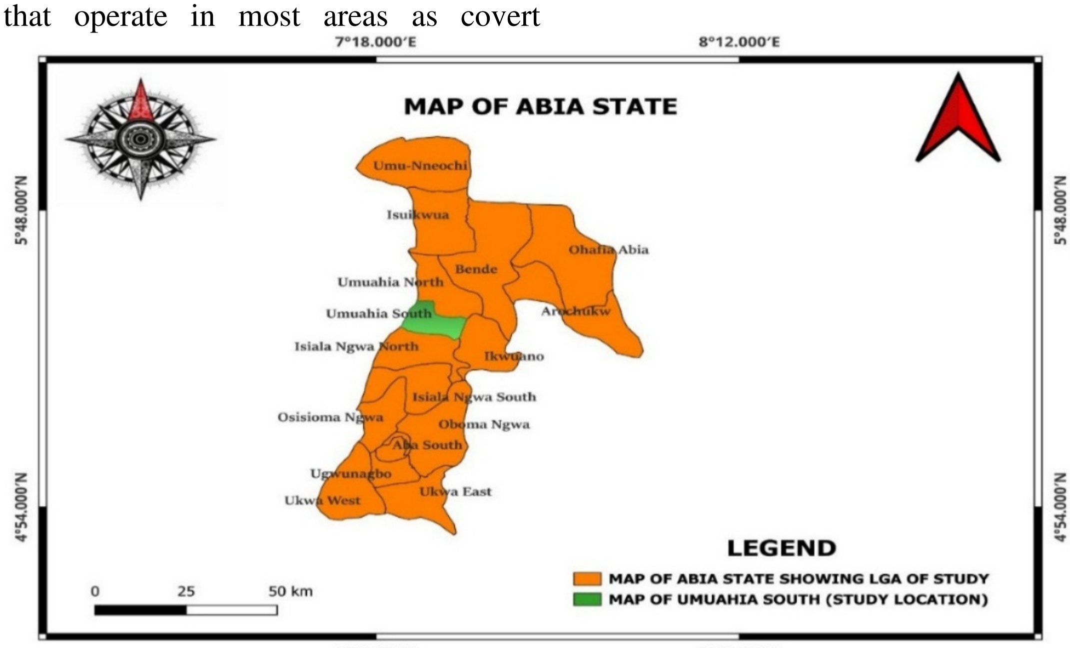

Fig. 1: Map of the study area

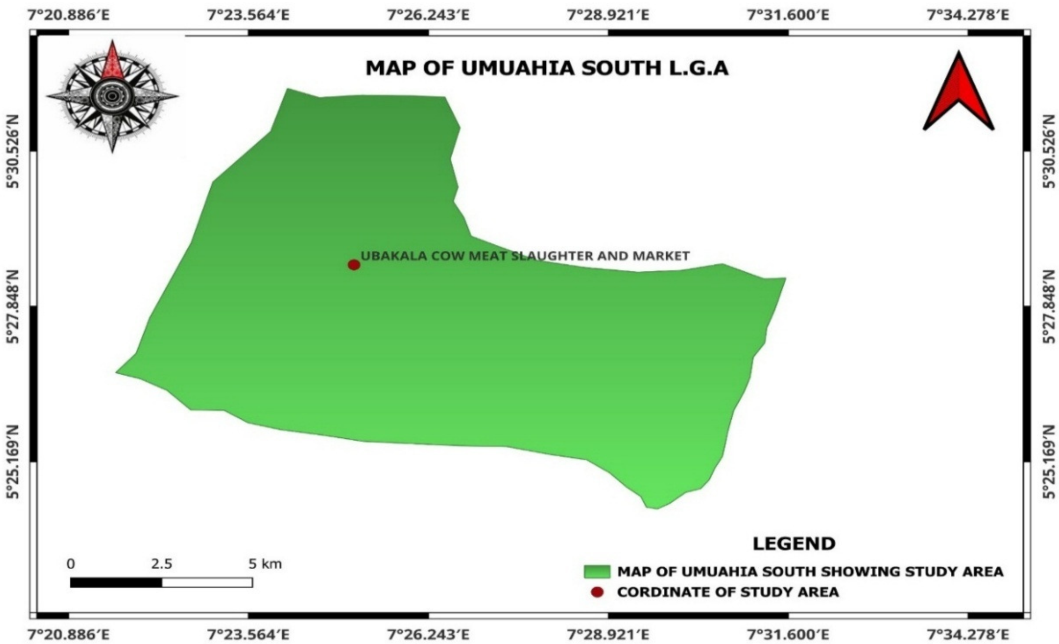

Fig. 2: Map of the sample collection area

Sample Size and Sampling Technique

The persons employed by the slaughterhouses were the study's target population. In all research regions, questionnaires were administered using basic random sampling techniques. A systematic questionnaire was used to gather data on the abattoir's hygiene and meat safety procedures through direct human observation. For this investigation, a total of twenty employees from the Ubakala Umuahia South abattoir were chosen. An association led by a chairman oversees the abattoir, and local government inspectors check the animals each morning before they are killed. In order to evaluate the knowledge of abattoir personnel regarding hygienic and sanitary measures during meat slaughter and processing, twenty copies of a well-structured questionnaire were produced and distributed. The following subjects were included in the questionnaire: (i) The participants' socio demographic details; (ii) meat handlers' hygiene habits; (iii) the hygienic state of their work clothes; (iv) the supermarket/butchery's infrastructure and hygiene upkeep; and (v) the meat's presentation in the butchery. To guarantee validity and reliability, pre-tests were conducted on the questionnaires. In accordance with Hill's (1998) advice, a pilot survey including 10 to 20 participants was carried out prior to the main survey. According to Van Teijlingen *et al*. (2001), this pilot survey offered insightful information about study procedures, resource management, and scientific validity. Therefore, Hill (1998) recommended that survey research pilot projects involve 10 to 20 participants. In this regard, the formula provided by Berenson *et al*. (2006) is used to a sample of 10 to 20 participants in this study;

$$n = \frac{Z2 \ X \ S2}{D2} \qquad (1)$$

n = is the minimum sample size
z = is value of the distribution function (for normal distribution z = 1.96 while for alpha = 0.05)

s = is the population standard deviation

When the sample standard deviation is divided by the square root of the sample size, the permissible standard error of the mean, or d, is obtained. The single proportion formula was used to estimate the sample size. Using the Cochran (1977) method, this sample size (n households out of total households) yields a 95% confidence level with a 5% margin of error. The following formulae were employed to calculate the sample size:

$$n = \frac{\frac{t_{2\ Pq}}{d_2}}{1_N^1 \left[\frac{t_{2\ Pq}}{d_2} - 1\right]} \quad (2)$$

Where t is the degree of confidence (set at 0.95, making t = 1.96), d is the margin of error (set at 0.05), n is the minimum number of samples, N is the population size, p is the proportion of particular characteristics (group), q is 1 – p, and 1 is a constant number. At every sampling site, coordinates were captured using a Garmin GPS device (model). Bacteriological analysis, which counts colonies and identifies harmful bacteria using sterile swabs taken from meat contact surfaces, was included to the study.

Study Design for Microbiological Analysis

Using basic random sampling techniques, one of numerous abattoirs in Ubakala, Umuahia Southern Zone, was chosen for the cross-sectional descriptive study design. Over the course of four weeks, the descriptive cross-sectional survey investigation was carried out. The majority of the population under study was made up of butchers and meat sellers who worked in abattoirs.

Microbiological Analysis

Using Plate Count Agar, Violet Red Bile Agar, MacConkey Agar, Mannitol Salt Agar, and Salmonella-Shigella Agar, respectively, the microbiological quality and safety of meat and meat products were evaluated to identify microbial counts. Samples of floor meat, table meat, and knife surfaces that came into touch with meat were also taken from the slaughterhouses. For additional bacteriological investigation, all samples were collected aseptically and brought to the lab in ice boxes filled with peptone water.

Microbiological Analysis Sampling Size and Techniques

The experiment's animals were chosen at random from among the over seven animals that are typically slain each day in Ubakala, Umuahia South. Over the course of three months, visits were made once a month on alternate weeks. Three meat samples from slaughtered calves were taken during each visit to the chosen abattoirs, for a total of nine meat samples. These aseptically collected samples, which were the meat's flesh portion, were kept in an ice-packed flask. Furthermore, three swab samples were aseptically taken with knives from table meat contact surfaces. These swab samples were shipped in ice boxes with peptone water to the lab so that additional bacteriological examination could be performed. Every abattoir with flooring where animals were killed has concrete slabs that have been cleaned once daily, both in the morning and evening.

Meat Samples Collection/ Media Preparation

Samples of sliced meat weighing around 20 g were taken from the flesh area at the slaughterhouses. For microbiological examination, all samples were put in capped, sterile tubes, packed in a cool box with ice packs, and brought to the lab. Pour plate culture was used on the materials (Bersisa *et al*., 2019). Every medium that was utilized was produced in compliance with the manufacturer's guidelines and sterilized (nutrient broth medium) for 15 minutes at 121°C. For the purpose of counting bacteria on nutritional agar plates and enumerating coliforms on MacConkey agar, 0.1 ml of the 10^{-6} dilution was duplicated from 10-fold homogenate dilutions (ICMSF, 1996). After that, plates were incubated for 24 hours at 37°C. Following the incubation time, countable colonies on plates were viewed and counted with a colony counter that is digital. CFU/g was used to express the numbers. Furthermore, for microbiological counts, 0.1 ml aliquots from suitable serial dilutions were plated on different kinds of media (Gurmu and Gebretinsae, 2013).

Surface Swabs from Meat Contact Surfaces

With sterile, moistened cotton wool swabs, the surface swabs from meat contact areas were collected aseptically. Respecting the selected template surface area to be swabbed, they were rubbed tightly across the predefined surface area utilizing parallel stroke lines and gradual rotation. Wet sterile cotton wool swabs were used in the abattoirs to swab the floors (20 cm^2), tables (60 cm^2), and scrapped meat surfaces (CRMCF, 2005). Following that, the swabs were labeled and placed into corresponding capped sterile tubes that held 5 ml of normal saline (0.9%). For the purpose of cleaning bacteria off the swab surfaces, they were moved around inside the tubes. After being sealed in a cooling box, the sterile tubes with caps were brought to the lab for microbiological examination. The methods outlined by the ICMSF (1996) were used to determine the microbial count and the isolation of bacteria. The protocols outlined by Cappuccino and Sherman (2016) were followed for the biochemical identification and validation of the isolates. The protocols for bacterial isolation were carried out in accordance with Okonko *et al*. (2010) and Fawole and Oso (2001).

Determination of Microbial Count

For the purpose of counting microorganisms, one milliliter of the homogenate was serially diluted under aseptic conditions. The homogenates were produced in accordance with Fawole and Oso (2001) using ten-fold dilutions. For the microbiological count (TCC) and fecal coliform counts (FCC), the serially diluted homogenates of the meat samples were inoculated onto aerobic plate agar (Himedia, India) using the pour plate method. Following that, the plates were incubated aerobically for 24 hours at 37°C. For every count type, the average number of colonies counted was represented as log10 colony forming units per gram (cfu g^{-1}) of material. The Food and Agriculture Organization (FAO) created microbiological standards for fresh meat, which were used to determine the samples' quality. The phrases "good condition," "critical condition," and "unacceptable" were employed (Heinz and Hautzinger, 2007).

Isolation of Bacteria from Meat Samples and Contact Surfaces

The protocol outlined by the International Commission on Microbiological Specifications for Foods (1996) was followed while isolating microorganisms. For pre-enrichment, a piece of each beef sample was inoculated into 10 milliliters of buffered peptone water. Following inoculation, the samples were incubated for 24 hours at 37°C. Using a 1 ml pipette, 0.1 ml of the pre-enriched broth was added to 1 ml of

Rappaport Vassiliadis (RV) medium to provide selective enrichment after a 24-hour incubation period. RV broths that had been inoculated were incubated for 24 hours at 42°C. A loopful of the enrichment broth was plated onto MacConkey agar and Brilliant Green agar after 24 to 48 hours. After a 24-hour incubation period, the inoculation plates were examined for colonial features in accordance with ICMSF (1996) guidelines. Every piece of beef was injected into a nutrient-d broth that was sterile. The bottles were correctly labeled, sealed, and incubated for twenty-four hours at 37°C. Each loopful of culture from the broth was streaked onto MacConkey agar after it had been incubated for 24 hours. After correctly labeling the infected plates, they were incubated for 24 hours at 37°C. For purification, pink colonies were chosen and cultivated on new MacConkey agar. After applying Gram stain, the colonies were examined for medium-sized, slender, pink, Gram-negative rods. After being further subcultured on Eosin Methylene Blue (EMB) agar and incubated for 24 hours at 37°C, suspicious colonies were checked for the presence of a greenish metallic sheen. On nutrient agar slants, suspect colonies were stored in preparation for more research (isolate identification and confirmation).

Data Analysis

Using a Microsoft Excel 2010 spreadsheet, the questionnaire collected both qualitative and quantitative data from the cross-sectional study. The study employed SPSS version 20.0 for Windows to calculate descriptive statistics for the variables that were gathered. Descriptive statistics, such as frequencies and cross-tabulations, were applied to the microbiological analysis.

Results and Discussion

Socio-demographic Characteristics Attributes of Abattoir Operator

Table 1 summarizes the socio-economic characteristics of abattoir operators, which include age, gender, marital status, educational attainment, and average monthly salary. According to data on the gender of abattoir operators, men were more likely than women (15.0%) to be employed in the slaughterhouse industry (85.0%). According to the marital status of abattoir operators, married operators made up the largest percentage (80.0%), followed by single operators (10.0%) and widows and widowers (5.0% each). According to the educational background of abattoir operators, roughly 25.0% had only completed primary school and 75.0% had attended secondary school. A more thorough examination of average monthly income showed that 60.0% of abattoir operators were in the ₦100,000–₦200,000 income range, while 40.0% were in the ₦201,000–₦300,000 and above income range. According to the respondents' socio demographic data, the majority of operators (85.0%) were men, and 50.0% of them belonged to the younger age group (Table 1). This is understandable given that employment at butcher shops is generally thought to be dominated by men. The results pertaining to the youthful age and poor educational attainment of meat handlers in this nation's abattoirs align with previous research endeavors (Junaidu *et al*., 2015; Enem, 2017). Only 25% of respondents finished elementary school, and 75% finished high school. Meanwhile, 50% of operators stated that their average monthly income fell between ₦100,000 and ₦200,000, and 25% fell between ₦201,000 and ₦300,000. Studies have shown a connection between low levels of education and lower levels of environmental consciousness, public health concern, and environmental regulation compliance between education level and environmental awareness (Daramola, 2012; Daramola, 2015).

Table 1. Socio-economic attributes of abattoir operator

Variables	Frequency	Percentage
Gender		
Male	17	85.0
Female	3	15.0
Age (years)		
20 – 30	1	5.0
31-41	10	50.0
41 and above	9	45.0
Marital Status		
Single	2	10.0
Married	16	80.0
Divorced	-	-
Widow	1	5.0
Widower	1	5.0
Educational Level		
Primary School	5	25.0
Secondary School	15	75.0
Tertiary	-	-
No Formal Education	-	-
Average Monthly Income		
₦100,000 - ₦200,000	10	50.0
₦201,000 – ₦300,000	8	40.0
₦300,000 and above	2	10.0

Attributes of Abattoir

In addition to the socioeconomic characteristics of abattoir operators, the purpose, location, and duration of the abattoir's operation, as well as the number of cows slaughtered every day, were also determined and are shown in Table 2. Just 5.0% of cows were slain every day, compared to 95.0% of cows that were murdered every day for more than seven cows. The placement of abattoirs was influenced by a number of factors, including being close to a river or stream (80.0%), a market, and the availability of open space land (10%). About 95.0% of abattoir operators reported having been in operation for more than 20 years, compared to just 5.0% of slaughterhouse operators who reported being in operation for 11 to 20 years. Features of the slaughterhouses showed that 95.0% of the cows were killed every day (Table 2). Eighty percent of the abattoirs' locational factors showed that they were close to a river or stream, and most of them had been in operation for more than 20 years. These results suggest that deficiencies in these crucial characteristics and hygienic factors cast doubt on the safety of meat from these slaughterhouses since poor or nonexistent sanitation creates a haven for microorganisms that cause illness (Dandago, 2009).

Table 2: Attributes of abattoir

Variables	Frequency	Percentage
Number of Cows Slaughtered Daily		
1 -3	-	-
4 – 7	1	5.0
Above seven cows daily	19	95.0
Factors Responsible for Location of Abattoir		
Nearness to River/Stream	16	80.0
Very High Water Table	-	-
Nearness to Market	2	10.0
Availability of Land	2	10.0
Availability of Cheap Labour	-	-
Period of Establishment (Years)		
1-10	-	-
11- 20	1	5.0
Above 20	19	95.0

Environmental Hygiene/ Sanitation Practices in Abattoir

Examining the environmental hygiene and sanitation techniques used by butchers in the study area is a significant result of the abattoir features (Table 3). Table 6 provides a full investigation of the procedures used in the abattoir to dispose of waste. The majority of solid waste disposal methods - 60.0% - come from burning waste, followed by 25.0% from dumping into surrounding shrubs and 15.0% from dumping on undeveloped land. When compared to daily disposal, which records a proportion of 35.0%, weekly disposal of solid waste records a greater rate of 65.0%. In terms of how often aprons are washed, 15.0% wash them every day and 85.0% wash them once a week. 100% of animals that are rejected by veterinary doctors who conduct inspections are disposed of without being killed. According to the abattoir's sanitary status, 65.0% of operators regularly dispose of their waste by burning, and 60.0% of operator’s burn their trash (Table 3). Once a week, aprons are cleaned, and animals that are rejected are disposed of without being killed. A major part of preventing meat-borne illnesses is played by butchers because of the high danger of meat contamination at the butchery level. It is essential to follow and uphold proper hygiene when handling meat in order to guarantee safe and fresh meat for human consumption (Khanal and Poudel, 2017). Reducing microbiological contamination in the abattoir requires routine cleaning and disinfection.

Table 3: Hygiene status of the abattoir

Variables	Frequency	Percentage
Solid Waste Disposal Methods		
Burning	12	60.0
Dump on Vacant Land	3	15.0
Dump in Nearby Bush	5	25.0
Dump along Drainage	-	-
Frequency of Solid Waste Disposal		
Daily	7	35.0
Twice in a Week	13	65.0
Monthly	-	-
Frequency of washing aprons/overalls		
Daily	3	15.0
Once a week	17	85.0
Twice weekly	-	-
Thrice weekly	-	-
Only when adjudged dirty		
Rejected animal by inspected veterinary doctors for slaughter		
Slaughtered	-	-
Treated	-	-
Dispose without slaughtering	20	100.0

Assessment of meat safety practices and hygiene

The evaluation of meat safety procedures and cleanliness is displayed in Table 4. As a result, 80.0% of the abattoir operators said they were unaware of meat hygiene procedures, and the majority (100.0%) said they had never been trained in meat hygiene. But 65.0% of the operators said they wash their hands before starting work and before handling meat. When handling meat, about 40% of respondents said they wore gloves, 25% said they wore caps or hair nets, and 30% said they wore aprons. When handling meat, 20.0% of operators wore jewelry, and 30.0% used waterproof boots and protective coveralls. Furthermore, 85.0% of respondents said they handled both money and meat at the same time, and 80.0% reported using the same apron for various tasks in the butchery (Table 4). According to the study's evaluation of meat safety procedures and hygiene, 80.0% of the operators knew what was meant by "meat hygiene" (Table 4). More than half, however, only had a fair understanding of what is needed for meat cleanliness, which is in line with results from other research that indicate butchers have a low to fair understanding of hygiene (Ansari-Lari *et al*., 2010; WHO, 2019). According to Pius (2013), the survey also discovered that the majority of employees in butcher shops and abattoirs had low levels of education. This could make it more difficult for them to follow stringent hygienic requirements and use new methods of slaughtering, which would lead to microbial contamination.

Additionally, none of the study's abattoir operators (100.0%) had any formal training or certification in meat hygiene procedures. It has also been observed that meat handlers in Ethiopia and Nigeria lack proper training, which affects their knowledge and skills (Alhaji and Baiwa, 2015). The hygienic conditions of the workers in the abattoir may contribute to contamination throughout the meat processing process, even though 65.0% of them reported washing their hands before handling meat. According to Adetunde *et al*. (2011), microbiological contamination was facilitated by filthy hands, clothes, and equipment used in carcass dressing procedures. Additionally, the study discovered that 20.0% of abattoir workers wore jewelry (watches, bracelets, and rings) during working hours, 30.0% did not wear aprons, 75.0% did not cover their hair, and 60.0% did not wear gloves. This result is consistent with that of Haileselassie *et al*. (2013), who found that jewelry wearing was uncontrolled and that 61.6% of workers in slaughterhouses did not cover their hair. Meat contamination can be lessened by donning protective gear. Therefore, it is essential to always wear protective overalls or hair coverings when handling meat in order to prevent contamination of the meat and meat processing facilities from personal apparel. It is recommended that overalls be light in color to facilitate the identification and cleaning of contamination. Additionally, it is not advisable to wear jewelry, watches, or other detachable objects as they may collect dirt and organisms and pose a risk of foreign body contamination should they fall into the meat (Table 4).

The findings from this study reveal that 80.0% of the abattoir operators wear the same clothes every day without washing them as often as they want (Table 4). According to Sulleyman *et al*. (2018), meat contamination and subsequent food poisoning can result from poor hygiene and sanitation practices. Given that the meat slaughtering process involves significant dirty labor, work garments should ideally be cleaned daily (Nyamakwere *et al*., 2017). Studies have consistently highlighted that personal clothing can introduce microorganisms into meat or meat-handling facilities. Thoroughly cleaned protective clothing helps reduce contamination buildup and lowers the risk of contamination. Regular cleaning is crucial in preventing the accumulation of contaminants (Mbonabucha and Fweja, 2019). Additionally, 85.0% of butcher shop workers handle money while serving food (Table 4). In contrast, studies by Zerabruk *et al*. (2019), Gurmu and Gebretinse (2013) in Ethiopia, and Chepkemoi et al. (2015) in Kenya report that over 90% of butchers handle money while selling meat, which increases the risk of contamination.

Therefore, by refraining from such activities, butcher shops play a critical role in reducing foodborne infections. Lower denomination notes are handled more frequently when exchanging paper money for goods and services globally, and their huge surface area serves as a breeding ground for diseases (Gadsby, 1998). Unwashed hands can be major sources of contamination when handling money and carcasses (Nevry *et al*., 2011). Cross-contamination can also occur when food is handled with bare hands, claim Muinde and Kuria (2005). This study supports the idea that meat handlers should take all necessary precautions to minimize or completely eliminate the danger of microbial contamination. Abattoir-related problems with hygiene also include incorrect methods for marketing and processing meat. Remarkably, 10.0% of respondents claim that inadequate hygienic practices and a lack of infrastructure are to blame for butcher shops' subpar state (Table 4). While 65.0% of operators said that the floors of butcher shops appear clean, they could nevertheless be home to germs, and 95.0% said that there are no hazardous materials on the cutting tables. Ninety percent of the operators in this survey have access to disposable paper towels. Additionally, studies indicate that using soft, absorbent paper towels is the better option when trying to encourage people to practice good hand hygiene (Abd-Elaleem *et al*., 2014). Additionally, a safe water supply is available to 95.0% of butcher shops, which is essential for avoiding the contamination of meat during washing and processing. In order to perform cleaning operations and prepare meat in abattoirs, adequate water quality regulations must be fulfilled (Adebowale *et al*., 2010). As a result, maintaining an adequate supply of potable water is crucial to fulfilling cleaning and operational needs, and its quality should be routinely checked (CFIA, 2010).

Table 4: Assessing meat safety practices and hygiene

Variables	Frequency	Percentage
Ever heard of meat hygiene		
Yes	16	80.0
No	4	20.0
Received meat hygiene training		
Yes	-	-
No	20	100.0
Availability of health certificate		
Yes	-	-
No	20	100.0
Hand washing before commencing work/prior to handling meat		
Yes	13	65.0
No	7	35.0
Use of gloves when handling meat		
Yes	8	40.0
No	12	60.0
Hair is tied back, and hair net/cap is used		
Yes	5	25.0
No	15	75.0
Use of Apron/gown/coat		
Yes	14	70.0
No	6	30.0
Use of waterproof boots for footwear		
Yes	6	30.0
No	14	70.0
Protective clothes are long-sleeved cover clothes		
Yes	6	30.0
No	14	70.0
Staff wears jewelry while handling meat		
Yes	4	20.0
No	16	80.0
Same apron used for different activities in the butchery		
Yes	16	80.0
No	4	20.0
Person handling meat also handle money		
Yes	17	85.0
No	3	15.0

The staff members who prepare and handle raw meat are kept apart from those who prepare and handle meat that is ready to eat, according to the majority of abattoir operators (100.0%) (Table 4). Furthermore, just 10.0% of respondents mentioned that the butchery's infrastructure and hygienic conditions were maintained. Additionally, just 5.0% of respondents said the butchery's structure is in good shape and does not promote cross-contamination. It was discovered that while 95.0% of respondents said cutting tables had non-toxic elements like mildew and rust on them, 65.0% said the butchery floor looked clean. 95.0% of abattoir owners reported having a safe water supply to the butchery, while the majority (90.0%) claimed that disposable paper towels are accessible. Ninety-one percent of respondents agreed that chopping boards, knives, tongs, and other utensils are used separately for raw meat and ready-to-eat meats. In contrast, only five percent of respondents said that weighing scales, mincers, and slicers are used separately for raw meat and ready-to-eat meats (Table 4).

Table 4: Assessing of meat safety practices and hygiene cont'd

Variables	Frequency	Percentage
Staff preparing and handling raw meat is separate from staff preparing and handling ready to eat meats		
Yes	20	100.0
No	-	-
Availability of Infrastructure and maintenance of hygiene in butchery		
Yes	2	10.0
No	18	90.0
Structure of butchery is in good condition and will not yield cross contamination		
Yes	1	5.0
No	19	95.0
Butchery floor appears clean		
Yes	13	65.0
No	7	35.0
Cutting tables contain non-harmful materials (rust, mold)		
Yes	19	95.0
No	1	5.0
Disposable paper towels are available		
Yes	18	90.0
No	2	10.0
Availability of safe water supply to the butchery		
Yes	19	95.0
No	1	5.0
Weighing scales, mincers and slicers are separately used for raw meat and ready to eat meats		
Yes	1	5.0
No	19	95.0
Chopping boards, knives, tongs, and other utensils are separated for raw meat and ready to eat meats		
Yes	18	90.0
No	2	10.0

According to Table 4, 80.0% of the waste from the abattoir is contained, controlled, and disposed of appropriately. Furthermore, 95.0 % of respondents state that detergents and cleaning cloths are kept visible. But just 5.0% can be attributed to the availability of pest control equipment. Operators in slaughterhouses have observed that the meat frequently has a strong stench and is discolored or dark brown. The results show that there is a sanitary control system in place, which makes up roughly 95.0% of the system, and that veterinary doctors inspect cattle at a rate of 100.0%. Additionally, regular worker medical checkups and treatments are performed (65.0%). Additionally, it was shown that 95.0% of people handle meat even when they have diarrhea, a cough, or skin illnesses (Table 4). Only 5.0% of respondents said they knew that weighing scales, mincers, and slicers are used separately for raw and ready-to-eat meats (Table 4). In contrast, 95.0% of respondents said they knew that chopping boards, knives, tongs, and other utensils are used separately for raw and ready-to-eat meats.

It was discovered that there was less usage of personal protective equipment (PPE), proper coughing technique, and sickness and injury management at work. This result is in line with research from Andhra Pradesh (Venkata *et al*., 2019). In addition, 80% of respondents stated that garbage is contained, handled, and disposed of appropriately, and 95% said that cleaning supplies and detergents are kept visible. To stop the spread of viruses that cause foodborne illnesses, butcher shops and abattoirs must properly dispose of their waste (Kwaghe *et al*., 2016). The killing process—which includes stabbing, bleeding, skinning, evisceration, hanging, and cutting/deboning—was not clearly divided, according to the report. Additionally, the abattoir lacked a preventive system for controlling pests and rodents, which is consistent with findings in earlier publications (Haileselassie *et al*., 2013). Before killing an animal, veterinary professionals inspect it, according to the majority of operators (100.0%) (Table 4). Although a large percentage of workers (65.0%) receive medical checks and treatments, 95.0 percent of operators acknowledged handling meat despite having symptoms including diarrhea, coughing, or skin infections.

Research has recommended that in order to stop the spread of illnesses, abattoir operators should undergo clinical and bacteriological tests (WHO, 1959). The research area's slaughterhouse operations negatively impact the environment, according to observations and questionnaire responses. This is because the smells of the facilities draw disease-carrying insects like cockroaches, flies, and rodents, which can expose people to diseases like malaria, typhoid, and cholera. Recreation involving water can also spread pathogens to humans, including *E. coli, Bacillus, Salmonella* infections, *Brucellosis*, and helminthic disorders (Daramola, 2012). The possible pollution of aquatic life is another risk posed by these procedures. Physical observations, in addition to questionnaire replies, highlight the necessity of better slaughterhouse design and efficient waste management in the city.

Table 4. Assessing of meat safety practices and hygiene cont'd

Variables	Frequency	Percentage
Waste is confined, managed, and properly disposed		
Yes	16	80.0
No	4	20.0
Cleaning cloths and detergents are stored in sight		
Yes	19	95.0
No	1	5.0
Pest control devices are available		
Yes	1	5.0
No	19	95.0
Meat appears dark brown/dis-coloured with strong odour		
Yes	20	100.0
No	-	-
Presence of sanitary regulation system		
Yes	19	95.0
No	1	5.0
Livestock must be inspected by veterinary doctors		
Yes	20	100.0
No	-	-
Medical examination and treatment of workers		
Yes	13	65.0
No	7	35.0
Handling of meat when having Cough, Diarrhea, Skin infection		
Yes	19	95.0
No	1	5.0

Mean Population of Microbial Count and Microbial Isolate Identification in Table Meat

As shown in Tables 5, meat samples from tables were collected and examined. The average pH level was 6.8, and the overall mean microbial count (log10 cfu/cm^3) ranged from 6.8×10^{-3} to 7.4×10^{-3}. The results showed that the following microbial isolates had been identified: *Lactobacillus species, Escherichia coli* species*, Bacillus species, Streptococcus species, Pseudomonas species, Enterobacta species, and Stigella species,* in that order. There were seven distinct microbial isolates found in table beef, with a mean population of microbial organisms ranging from 6.8×10^{-3} to 7.4×10^{-3} (Table 5). According to this, there is a greater chance of consuming unwholesome meat, which can have an adverse effect on one's health and quality of life. These factors include inadequate conditions in abattoirs or meat processing factories, as well as ineffective meat inspection services (Abdullahi *et al*., 2016; Fasanmi *et al*., 2018). According to Endale and Hailay (2013), meat contamination may result from the presence of bacterial pathogens on surfaces that come into contact with meat.

Table 5: Mean population of microbial count and microbial isolate identification in table meat

S/n	Sample Label	pH	M/C [× 10^{-3} CFU/mL]	Microbial Isolate Identification						
				A	B	C	D	E	F	G
1	Table meat 1	6.8	$6.8{\times}10^{-3}$	+	-	-	+	-	-	+
2	Table meat 2	6.1	$7.4{\times}10^{-3}$	-	+	-	-	-	+	-
3	Table meat 3	6.4	$6.8{\times}10^{-3}$	-	-	+	-	+	-	+

Key: += Present; -= Absent
A=Lactobacillus spp*, B=Escherichia coli* spp*, C=Bacillus* spp*, D=Streptococcus* spp*,*
E=Pseudomonas spp*, F= Entherobacta* spp*, G= Strigella* spp
CFU/ML= Colony Forming Unit per ml

Mean Population of Microbial Count and Microbial Isolate Identification in Floor Meat

As indicated in Table 6, floor meat samples were collected and subjected to microbial count analysis. At a pH of 6.7, it was discovered that the mean microbial count (log10 cfu/cm^4) varied between $11.0{\times}10^{-4}$ and $12.2{\times}10^{-4}$. The presence of microbial isolates was discovered through additional research. These isolates included *Salmonella* spp*., Micrococcus* spp*., Pseudomonas* spp*., Bacillus* spp*., Yersinia enterocolitica, Escherichia coli* spp*., Streptococcus faecalis* spp*., Vibrio* spp*., and Staphylococcus aureus* spp. Ten microbial isolates were found, and the mean number of microorganisms in floor meat varied from $11.0{\times}10^{-4}$ to $12.2{\times}10^{-3}$ (Table 6). These results reveal that the floor meat's high microbiological burden is a sign of insufficient cleaning procedures. The study area's equipment was not properly sterilized, and floors were frequently cleaned with non-potable water. Moreover, one knife was used often in spite of coming into contact with soiled or contaminated surfaces. Haileselassie *et al*. (2013) and Bersisa *et al*. (2019) both reported similar results. Furthermore, as per Bersisa *et al*. (2019), the slaughtering process (stunneling, bleeding, skinning, evisceration, hanging, and cutting/deboning) was not clearly divided, and municipal slaughterhouses lacked any preventive measures against insects and rodents. These findings are consistent with those of Haileselassie *et al*. (2013).

Table 6: Mean population of microbial count and microbial isolate identification in floor meat

S/n	Sample Label	pH	M/C [× 10^{-4} CFU/mL]	Microbial Isolate Identification									
				A	B	C	D	E	F	G	H	I	J
1	Floor meat 1	6.3	$12.2{\times}10^{-4}$	+	-	-	+	-	-	+	-	-	+
2	Floor meat 2	6.7	$11.4{\times}10^{-4}$	-	+	-	-	+	-	-	+	-	-
3	Floor meat 3	6.0	$11.0{\times}10^{-4}$	-	-	+	-	-	+	-	-	+	-

Key: += Present; -= Absent,
A= Escherichia coli, *B= Streptococcus feacalis*, *C=Bacillus* spp, *D= Yersinia enterocolilies, E= Staphylocoucss aureus*, *F= Vibro* spp, *G= Klebsiela* spp, *H= Salmonella* spp, *I= Micrococus* spp, *J= Pseudomonas* spp
CFU/ML= Colony Forming Unit per ml

Mean Population of Microbial Count and Microbial Isolate Identification in Scrapped Meat

The scraped meat samples had microbial counts (log10 cfu/ml) of 6.0×10^{-5} in sample 1, 3.4×10^{-5} in sample 2, and 5.9×10^{-5} in sample 3. The pH values of the samples ranged from 6.3 to 7.2, as shown in Table 7. The following microbiological isolates were found: *Salmonella* spp*, Micrococcus* spp*, Pseudomonas* spp*, Enterobacta* spp.*, Bacillus* spp*, Escherichia coli, Klebsiella* spp*, Streptococcus* spp*, Micrococcus* spp*, Salmonella* spp.*,* and *Staphylococcus* spp. (Table 7). Eleven distinct microbial isolates were found in the scraped flesh, with a mean population of microorganisms ranging from 3.4×10-5 to 6.0×10-5 (Table 7). According to Haileselassie *et al*. (2013), there may have been variations in the microbial load in the scraped meat due to improper handling techniques and a lack of adherence to hygienic standard operating procedures across the meat production chain. Nevry *et al*. (2011) observed the possibility of cross-contamination between nearby raw meats due to dirty hands of handlers, blades, and cutting table surfaces when evaluating the bacteriological quality of beer sold in different markets in Abidjan. *Salmonella species, Shigella species, Campylobacter jejuni, Campylobacter coli, Yersinia enterocolitica, verotoxigenic Escherichia coli (E. coli), and Listeria monocytogenes* are among the pathogenic microorganisms linked to meat contamination and its byproducts (Little *et al*., 2008; Meyer *et al*., 2010; Warren *et al*., 2007). Because *Staphylococcus aureus* is a typical flora on human skin, butchery workers' unsanitary handling of cattle contaminates it (Kebede *et al*., 2016).

Shigella spp., which are found in the human gastrointestinal tract, are indicative of poor hand hygiene among handlers, while *Salmonella spp., Campylobacter jejuni, Campylobacter coli, Yersinia enterocolitica, and verotoxigenic Escherichia coli (E. coli)* contamination of beef indicates poor evisceration practices (Nouichi and Hamdi, 2009). According to Bhandare et al. (2007) and Nechas *et al*. (2008), contaminated meat and its products might shorten product shelf life and act as carriers of infections for customers. According to several researchers (Kadariya *et al*., 2014; Mead *et al*., 2006; Newell *et al*., 2010), eating contaminated beef and its products can cause outbreaks of various diseases, including staphylococcal intoxication, gastroenteritis, shigellosis (dysentery), and salmonellosis (DuPont, 2007). Effective management methods in butcheries and the beef value chain depend on monitoring the quantity and presence of microbes in meat (Poumeyrol *et al*., 2010). However, even though animals that have been slaughtered may initially have fewer bacteria, microbial contamination can occur due to contamination of the flesh surface throughout the processes of slaughter, evisceration, transportation, and vending (Kagambega *et al*., 2011).

Table 7: Mean population of microbial count and microbial isolate identification in scrapped meat

S/n	Sample Label	pH	M/C [× 10^{-5} CFU/mL]	Microbial Isolate Identification										
				A	B	C	D	E	F	G	H	I	J	K
1	Scrapped meat 1	7.2	6.0×10^{-5}	+	-	-	+	-	-	+		-	+	-
2	Scrapped meat 2	6.3	3.4×10^{-5}	-	+	-	-	+	-	-	+	-	-	+
3	Scrapped meat 3	7.2	5.9×10^{-5}	-	-	+	-	-	+	-	-	+	-	+

Key: += Present; -= Absent,
A= Escherichia coli, *B= Streptococcus feacalis*, *C=Bacillus* spp, *D= Yersinia enterocolilies, E= Staphylococuss aureus*, *F= Vibro* spp, *G= Klebsiela* spp, *H= Salmonella* spp, *I= Micrococus* spp, *J= Pseudomonas* spp
CFU/ML= Colony Forming Unit per ml

Conclusion and Recommendation

This study analyzed the health hazards associated with consuming meat infected with germs in Ubakala, Umuahia South, Abia State, as well as the socio demographic traits, features, and hygienic state of meat safety practices at an abattoir. Based on socio demographic parameters, the majority of operators (85.0%) were male, and 50.0% were younger in age. Features of the slaughterhouse disclosed that 95.0% of the time, more than seven cows were killed each day, and 80.0% of the respondents said the facility is situated next to a river or stream. According to the abattoir's hygienic status, 60.0% of trash was burned, 65.0% was disposed of often, and 85.0% washed their aprons once a week. According to an assessment of meat safety procedures and cleanliness, 80.0% of respondents knew what meat hygiene was, However, 100% hadn't received any instruction on proper handling of meat. In addition, 25.0% of respondents tied back their hair, 30.0% put on protective cover garments, 20.0% wore jewelry, and 65.0% cleaned their hands after handling meat. In addition, 90.0% of individuals who handled meat also handled money, and 85.0% of them reported that the abattoir lacked infrastructure. Veterinarians examined animals 100% of the time, however only 5.0% of respondents said they had pest control devices. In 65.0% of cases, workers received medical examinations and treatment, and 95.0% of them handled meat when ill with skin infections, diarrhea, or coughing. With raised mean microbiological values and the isolation of pathogenic bacteria from meat contact surfaces and meat portions, which indicated poor quality,

Meat contact surfaces and meat parts had higher mean microbial values, indicating poor meat quality and possible causes of foodborne illnesses and meat decomposition. Despite this, the microbiological quality of the meat in the research area was found to be high. Particularly, *Escherichia coli* spp., *Bacillus* spp., *Streptococcus* spp. and *Pseudomonas* spp. were prevalent microorganisms identified in table meat, floor meat, and scraped meat. The findings indicate that the abattoir may have been contaminated before the product was consumed. Inadequate methods of handling meat can lead to major public health issues and a high risk of cross-contamination. Therefore, it is essential to produce and distribute meat in a hygienic manner in order to minimize or completely remove dangers to the public's health, prevent illnesses, and prevent financial losses from early meat spoiling brought on by cross-contamination. In order to minimize waste and generate employment opportunities, more research should be done to identify and describe the bacterial loads present in the meats from various abattoirs. Additionally, efforts should be made to find ways to repurpose non-consumable animal parts.

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