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ASSESSMENT OF PHYSICAL, FUNCTIONAL, HYGIENIC STATUS AND BACTERIOLOGICAL QUALITY OF MEAT IN SELECTED MUNICIPAL ABATTOIRS AND BUTCHER SHOPS IN CENTRAL ETHIOPIAN REGION

MSc THESIS

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A Thesis Submitted to the College of Veterinary Medicine and Agriculture of Addis Ababa University in partial fulfillment of the requirements for the degree of Master of Science in Veterinary Public Health

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DECLARATION

This is to declare that this thesis entitled: *"Assessment of physical, functional, hygienic status and bacteriological quality of meat in selected municipal abattoirs and butcher shops in Central Ethiopian Region"* submitted in partial fulfillment of the requirements for the award of Master of Science in Veterinary Public Health (MVPH) to the Graduate Program of the College of Veterinary Medicine and Agriculture, Addis Ababa University by Ramato Habtamu (ID No. GSR/0328/16) is authentic work carried out by him under our guidance. The matter embodied in this thesis work has not been submitted earlier for award of any degree or diploma to the best of our knowledge and belief.

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First, I declare that this thesis is my genuine work and that all sources of materials used for this thesis have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirements for the award of Master of Science degree at Addis Ababa University, College of Veterinary Medicine and Agriculture is deposited at the University/College library to be made available to borrowers under rules of the Library. I solemnly declare that thesis this thesis not submitted to any other institution anywhere for the award of any academic degree, diploma or certificate. Brief quotations from this thesis are allowable without special permission provided that accurate acknowledgement of source is made. Requests for permission for extended quotation from or reproduction of this manuscript in whole or part may be granted by the Principal advisor or the head of department or the Dean of the College when in his or her judgment the proposed use of the material is in the interests of scholarship. In all other instances, however permission must be obtained from the author.

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AHSVE	Animal Health Strategy and Vision for Ethiopia
ANOVA	Analysis of Variance
CAC	Codex of Alimentary Commission
CCP	Critical Control Point
CFU	Colony Forming Unit
CSA	Central Statistical Agency
DTMABS	Durame Town Municipal Abattoir and Butcher Shops
EFSA	European Food Safety Authority
FAO	Food and Agricultural Organization
FBDs	Food-borne diseases
GDP	Gross Domestic Products
GFSI	Global Food Safety Initiative
HACCP	Hazard Analysis and Critical Control Point
HTMABS	Hosanna Town Municipal Abattoir and Butcher Shops
ISO	International Standard Organization
NASA	National Aeronautics and Space Administration
QGIS	Quantum Geographical Information System
SRVLC	Sodo Regional Veterinary Laboratory Center
TCC	Total Coliform Count
TSC	Total Staphylococcus Count
TVC	Total Viable Count
WHO	World Health Organization
WTMABS	Worabe Town Municipal Abattoir and Butcher Shops

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ABSTRACT

Abattoir is the only specialized official place in which food animals were slaughtered, inspected, processed and prepared for direct human consumption and butcher shops are places were meat provided for consumers. Cross-sectional study design was carried out from November 2024 to April 2025 with the objectives of the assessment of physical, functional, hygienic status and bacteriological quality of meat in selected municipal abattoirs and butcher shops of Hadiya, Silte and Kambata zones in the Central Ethiopian Region. The data were collected by using semi-structured questionnaires and check lists on facilities and sanitary practices in the abattoir followed by laboratory bacteriological assessment of the meat in-contacts slaughtered at the abattoirs and butcher shops. Hosanna, Durame and Worabe town municipal abattoirs were purposively selected then Multistage sampling techniques were employed to obtain swab samples from carcass and in-contact surfaces of abattoirs and butcher shops while simple random sampling was used to incorporate 132 participants for interview. A total of 71 swab samples from meat and in-contact surfaces of abattoirs and butcher shops were collected for microbial assessment from five sample types then serial dilution method was applied to determine bacterial load. The present study showed that from total participants 71 (53.78%) were not trained on meat safety and 84 (63.6%) were not followed their medical checkup and 47 (35.6%) infrequently wash their protective clothes. In this study 72 (54.5%) and 64 (48.5%) of the participants have no awareness for about zoonosis and food borne-illness respectively. The highest mean total viable count (TVC) and total coliform count (TCC) with 7.3±0.4 log 10 cfu/cm^2 and 7.1±0.05 log10 cfu/cm^2 from Hosanna town municipal abattoir workers hand and total staphylococcus count (TSC) 6.4±0.5 log10 cfu/cm^2 from worker's hands of Worabe town municipal abattoir. The overall study results from microbial count and survey indicates the poor hygienic condition and processing of all the three town municipal abattoirs. Therefore, regulations, good slaughtering and handling of meat along the meat production chain should be applied to produce wholesome and safe meat for consumers.

Key words: *Abattoirs, Bacterial load, Central Ethiopia Region, Meat bacteria Quality,*

1. INTRODUCTION

Ethiopia is home of largest livestock population in Africa with 70.3 million cattle, 42.9 million sheep, 52.5 million goats, 8.1 million camels and more than 59.4 million poultry according to Central Statistical Agency (CSA, 2021) livestock sample survey. About 60-70% of Ethiopians rely on the livestock subsector for their livelihoods. The livestock sector contributes about 45% of the agricultural gross domestic products (GDP), 18.7% of the total national gross domestic products and 16–19% of the total foreign exchange earnings of the country (Behnke and Metaferia, 2011). Meat, milk, eggs, honey and other non-food items including draught power for crop cultivation, transportation of goods and people, foreign exchange revenues, input to agro-processing companies, crop manure and fuel are all provided by livestock (FAO, 2018).

An abattoir is an essential part of a modern urban community, providing safe and hygienic conditions for the slaughter and processing of animals, which enables the production of meat products for consumption (Coelho *et al*., 2022). Beyond ensuring safety and hygiene in meat production, abattoirs are crucial for regulating and inspecting meat quality. This function protects consumers from potential health risks and guarantees that only high-quality meat reaches the market World Health Organization (WHO, 2022). A standard abattoir should include several key components: lairage, slaughter hall, slaughter slab, gut and tripe section, detained meat section, offal section, condemned meat section, water supply and cold room. Additional facilities may include a hide and skin section, veterinary inspection section, sanitary section, veterinary office, laboratories, and waste disposal facilities (Gali *et al*., 2020).

Meat contamination has been linked to a number of factors, including unsanitary meat handling practices, storage, distribution, transportation, and processing (Getenesh *et al*., 2020). The state of sanitation and hygiene during the manufacturing and processing of meat and meat products has a significant impact on their microbiological quality. The environment in butcher shops and slaughterhouses can be a significant source of meat microbiological contamination if sufficient hygiene management is not maintained (Manga *et al*., 2014). About 40% of the worldwide burden of food-borne illness has been attributed to animal source foods (Lia *et al*., 2019). This

burden exacerbates an already precarious health system and is greater in low-and-middle-income countries. Microbial safety is among the most crucial concerns when it comes to meat since meat and meat products offer a great environment for the growth of microorganisms, especially harmful bacteria. When these microbes are present, the quality of the product can lead to food-borne illnesses in people (Sohaib *et al*., 2016). *Salmonella species, Campylobacter jejuni,* and *Escherichia coli* are the most significant pathogenic and spoilage bacteria that can contaminate meat (Pal *et al*., 2018).

Bacterial contamination during the handling of raw meat at abattoirs and butcheries is a significant issue in many developing countries. This is largely due to the lack of technological applications for hygienic meat processing, insufficiently trained personnel, and economic challenges. According to Birmaduma and Menda, (2017), there are very few abattoir facilities in Ethiopia that meet the standards required for hygienic meat production. Additionally, there is a noticeable gap in food safety knowledge among workers in abattoirs and butcher shops. Assessing the physical and functional conditions of these facilities could help identify sources of microbial contamination in meat and inform intervention strategies to ensure the production of hygienic meat for consumers, thereby reducing spoilage and losses.

Determining and quantifying microbes in meat is crucial for raising awareness about microbial safety and developing measures to mitigate meat contamination and meat-borne diseases. Implementing these standard practices in slaughterhouses could enhance the production of safe meat for consumers and protect public health. Additionally, the current condition of abattoirs and butcher shops in the study area reveals a lack of information about their operational and physical status, as well as the microbial quality of meat across various studies. Monitoring and other conditions at slaughter have been identified as one method of determining the disease status of the herd; however, the Central Ethiopian Region does not fully utilize this source of information, particularly when it comes to determining the degree of human exposure to specific zoonotic diseases and evaluating the hygienic conditions of butcher shops and abattoirs

However, the majorities of abattoirs in Ethiopia is not well built with sufficient facilities and skilled meat inspectors, and have unsanitary conditions that encourage the spread of harmful germs and inadequate sanitary procedures (Komba *et al*., 2012). The previous research on bacterial load on carcass, Bersisa *et al*. (2019) found 4.5 from Bishoftu; and Aschalew (2020) found 5.9 in Adama town (expressed by log 10 cfu/ cm^2). Additional reports were made from contact surfaces such as 6.6 on floors, 3. 4 on hands, 5.1 on walls, 6.4 on knives, 4.6 on hooks from Mumbai, India by Sudhakar *et al*. (2009) and 6.1 on the knife in Bishoftu by Bersisa *et al*. (2019), and 5.67 and 5.3 from hands and knives (expressed by log 10 cfu/ cm^2) respectively from Mekelle (Endale and Hailay, 2013). Regional butcher shops and abattoirs in this study however lack information on current slaughtering procedures and facilities, as well as on bacterial loads associated with carcasses and in contacts. Therefore, it is crucial to place enough emphasis on finding solutions in order to improve health, the quality and supply of beef for both home consumption and international markets. Therefore, the objectives of this study were formulated as general and specific objectives as follows:

General objective

- To assess the physical, functional, hygienic status of abattoirs and meat bacterial quality of the meat produced from selected municipal abattoirs and butcher shops of Hosanna, Worabe and Durame town in Central Ethiopia Region.

Specific objectives

- ❖ To determine meat handling and processing practice, knowledge of slaughter personnel's and butchers from the Hosanna, Durame and Worabe town.
- ❖ To investigate the microbial quality of meat produced in the municipal abattoirs and butcher shop from the Hosanna, Durame and Worabe town.
- ❖ To assess the status of physical infrastructures, operational facilities, hygiene and sanitation of Hossana, Worabe and Durame town municipal abattoirs and butcher shops in Central Ethiopia Region.

2. LITERETURE REVIEW

2.1. Abattoirs

Abattoir is the only specialized official place in which food animals should be slaughtered, inspected, processed and prepared for direct human consumption (Akapabio *et al*., 2015). Many abattoirs had differed in size and sophistication depending on location and local government ordinance, but they should contain the following facilities: lairage, isolation block, slaughter hall, cooling hall, hide and skin store, offices, condemned meat room, worker dressing room, laboratory, laundry, and toilet (Obidegwu *et al*., 2019). Food processing and handling is a complex operation process with possible problems leading to food poisoning and infection. Animal products such as meats, fish, and their products are generally regarded as high-risk commodities in respect of pathogen contents, natural toxins, and other possible contaminants and adulterants (Haileselassie *et al*., 2013). Animal origin food such as meat from infected animals or carcasses can be contaminated with a pathogenic microorganism (Nouichi, 2009; Abebe *et al*., 2020). An abattoir goal is to provide hygienically prepared meat by handling the animals humanely and employing sanitary methods for dressing and slaughter (Kundu *et al*., 2015).

2.2. Operational Facilities of Abattoirs

There are over three hundred local abattoirs are found in Ethiopia that supply meat for local consumption with different abilities and infrastructures, however all of them with low basic hygienic standards. Although food-borne pathogens have been reported from beef meat in different abattoirs and butcher shops as studied by Abayneh *et al*. (2014) have little information available for about beef hygienic handling practices along the beef production and distribution continuum in Ethiopia. Several abattoirs are differing in operational facilities and management way that can affect the quality of meat and meat products differently (Eshetie *et al*., 2018).

In Ethiopia most municipal abattoirs are clearly evident of poor design, dilapidated slaughtering and processing facilities, insufficient amount of water supplies and not enough facilities for collection and waste disposal (Ovuru *et al.*, 2024). Any production quality control washing and

disinfecting processes are major procedures of keeping the hygiene of meat and it products (Njoya *et al*., 2019). The problem of meat microbial contamination particularly magnifies in developing countries as meat and meat products are most of the time produced under poor hygienic and safety condition and insufficient operational facilities World Health Organization (WHO, 2004).

2.2.1. Site Selection for Abattoirs

Most abattoirs lack proper temporal dimension, because of the rapid expansion of urban land uses. In addition to this slaughterhouses are seldom exposed to higher danger of pollution which is typical occurrence particularly in abattoir facilities near waste disposal sites that have needed relocation sooner than expected. However, selecting the right location for an abattoir is very important in order to reduce the impact and risk that it can poses to the environment to pollution and transmission of diseases (Marre *et al*., 2020). The increasing environmental degradation caused by slaughterhouses is largely attributed to different key factors, such as the rapidly increasing population and urbanization, the rise in affluence, and shifts in consumer behavior and preferences (Yasin *et al*., 2023). Human health is at risk due to the degradation of drinking water supplies, agriculture, air quality, and marine life caused by abattoir waste (Negera, 2017).

Environmental regulations and the relocation of meat processing facilities away from major cities have greatly reduced effluent issues. On the other hand, the meat-processing and abattoir businesses, like those in other developing nations, especially those located inside the city limits of Ethiopia's cities and towns, are seriously endangering the environment of the local populations (Hassen, 2020). The abattoir site selection must be far away from surface water (streams, rivers, lakes, or the sea) in order to reduce the contamination (Abubakar *et al*., 2023). In order to stop contamination from spreading, abattoirs could be built below city level. As a result, high-altitude regions were deemed inappropriate for site selection, while low-altitude regions were deemed extremely appropriate. The study also emphasized how crucial it is to choose locations that are remote from residential areas in order to reduce any potential adverse effects on the

neighborhood. Additionally, throughout the site selection process, elements like accessibility to transit networks and utility availability were taken into account (Fard and Zahraei, 2012).

2.2.2. Types and Size of Abattoirs

Export abattoirs: The site's size needs to be carefully considered, taking into account space for different buildings and traffic flow. In terms of acreage, abattoirs can be divided into three groups: small (1-2 acres, 30000 animals), medium (2-4 acres, 50,000 animals), and large (4-6 acres, 100,000 animals). A specialized facility authorized and certified by the regulatory body for animal inspection, sanitary slaughter, processing and efficient preservation and storage of meat products for human consumption is known as an export abattoir. Before being released for public consumption, meat animals and meat products must be received, held, slaughtered and inspected at a specialized facility that has been licensed to do so (Alonge, 2005).Ethiopia has seen the establishment of a number of contemporary slaughterhouses recently, including Helimex, Elfora, Metehara, Modjo, and Luna. Ethiopia there is 12 export abattoirs and 8 new establishing with production of 30% their installed capacity. The demand for carcasses and organs is rising, as seen by the rise of abattoirs; however, the supply is declining as a result of illness and production issues (Eze and Ivuoma, 2012). With the demand for live animals for both formal and informal (cross-border) trade as well as domestic consumption, export abattoirs are vying for the supply of live cattle, sheep, and goats (Asfaw and Mohammad, 2007).

In general, 80–90% of the country's live animal exports come from informal marketing. Hazard Analysis and Critical Control Point, good hygienic practices and International Organization for Standardization for standards are not well applied in all export abattoirs. As a result of poor hygiene and sanitation a number of trade bans was imposed in the past on some of the export abattoirs, causing heavy financial losses to the abattoirs and the country. Breakdowns in the cold chain are one of the common problems, which at times result in the total rejection of the meat consignment (Legendre, 2010). There are difficulties in maintaining the temperature within the cold chain along the export chain, from export abattoirs up to end markets. This has resulted in poor sanitary standards and deterioration of the quality of the product. Ethiopian laws related to

animal health and meat safety are outdated and do not conform to international standards. In light of changing disease risks and occurrences, as well as scientific advances and improving international standards, current government laws fail to address the changing situation and emerging challenges (AHSVE, 2013).

*Municipal abattoirs***:** Most slaughterhouses in Ethiopia lack prompt health examinations and training for the area. Municipal abattoirs, which have fewer amenities than typical, provide services to the majority of Ethiopian butchers. The facilities and management systems used in different abattoirs have varying effects on the behavior of the animals during slaughter and the final product's quality. These facilities are where the majority of public slaughters take place. For a price, licensed butchers and dealers use these facilities, which essentially offer a location for the slaughter of animals in compliance with marketing, inspection, and public health standards. These companies, which usually only operate in major cities and densely populated areas, offer necessary services while being closely monitored by state and local authorities (Mummed and Webb 2015).

Order-based animal slaughter forces processing facilities to work at maximum capacity and raises overhead expenses, making abattoirs less competitive on pricing. The main obstacles to the development of red meat and cattle feedlot systems are poor market infrastructure and roads; a lack of technical knowledge among value chain actors, particularly processing technicians; a lack of market information; and a lack of connections between producers, processors, and export abattoirs (Shapiro *et al*., 2015). Based on Ethiopian Ministry of Agriculture data, there are a total of 293 municipal abattoirs in Ethiopia with most slaughtered animals originating from near rural areas (Desalagn, 2020).

2.2.3. Functional and Operational Standards of Abattoirs

In most developing countries including Ethiopia, slaughter tends to across numerous smaller abattoirs which oppose with the developed countries that have a more integrated and centralized approach to slaughter (Heinz, 2008). With the exception of the first category, the levels of hygiene, worker safety, animal welfare, and environmental pollution applied in these facilities

can be highly variable. This is due to facility design, but also to regulation, and operator knowledge and skill levels, which can also be highly variable and frequently are insufficient for addressing key risks associated with slaughter (Thomas *et al*., 2017). Rat-proof, slightly sloping, easily cleaned and disinfect able waterproof flooring, a suitable drainage system, washable paint or coating, sufficient ventilation, steam extraction, enough natural or artificial lighting that doesn't cast shadows or distort colors, a sufficient supply of hot, drinkable water, and a wastewater disposal system. There is enough equipment in the workrooms to clean and sanitize tools and hands. There should be a dedicated area for manure, next to the lairage and livestock lorry wash, as well as a location with sufficient cleaning supplies and a disinfection vehicle (Adem, 2022).

There should be a reasonable relationship between the size of slaughter facilities and the number of animals to be slaughtered. Cleaning and sanitation are an integral part of slaughtering and handling of meat and should already be taken into consideration at the planning and construction stage of slaughter facilities (Birhanu and Menda, 2017). Value chain actors refer to those individuals or entities that engage in a transaction and products from inception to end-use through explicit negotiation and partner selection (Diamond *et al*., 2014). However, because they only consider what would profit themselves and not the quality of the products they handle for the future generation of actors, there is biased communication among Ethiopian livestock value chain actors (Harko, 2015; Gadisa *et al*., 2018). Only 19,104.7 tons (41.4%) of Ethiopia's 46,120 tons of beef were exported in 2016–17. Despite having the tenth-largest livestock population in the world, Ethiopia produces very little meat, accounting for only 0.2% of global meat output, the majority of which is restricted to sheep and goat meat. According to this, Ethiopia is the world's 55^{th} largest producer of meat (Brasesco *et al*., 2019).

2.2.4. Water and Energy Supplies for Abattoirs

Various operations occurring in an abattoir involve the use of large amount of water. Most of the time such water requirements are satisfied from the corresponding municipal town's water supply system. However, where such water supply system is inadequate or absent, deep wells should be

borehole. About 70–85% of the potable water used in abattoirs to treat corpses and other related materials for human consumption is released into the environment as effluents (Jabari *et al*. 2016). The water utilized in municipal abattoirs and butcher shops can contaminate meat during washing, cleaning procedures and meat processing in the abattoir must fulfill the drinking water quality (Wale *et al*., 2010). For this reason, an adequate supply of potable water should be available to meet operational and cleanup needs and it should be analyzed frequently to confirm its quality (Barros *et al*., 2020).

Abattoirs should have sufficient facilities for disposal, treatment, and an ample supply of water. Since the planning spectrum includes location, site characteristics, space requirements, environmental control, management, and accessibility, these issues can be resolved with careful planning (Andreoletti *et al*., 2010). A sufficient and convenient supply of hot and cold portable water should always be available thanks to established equipment, according to the World Health Organization. When decontaminating meat, hot water can be sprayed at higher pressures, flooded with cascading sheets of hot water, and used during pre-evisceration, final washing, slaughtering, dressing, and chilling when deboning carcasses on meat cuts and trimmings for ground beef production. Light intensity should be 540 lux for meat examination, and depending on the circumstances, it may be 220 lux or 110 lux in other work areas (Lawan *et al*., 2013).

2.2. Hygienic Practices in Municipal Abattoirs and Butcher Shops

A visual inspection of the facility and the animals themselves should be part of any effort to maintain hygienic conditions in the abattoir. Animals with illnesses should not be permitted to be killed. The environment, including microbes in the soil, surfaces, and ground water, is adversely affected when good manufacturing and hygiene practices are not followed. This can result in contamination from hides, hooves, and the contents of the alimentary tract during evisceration (Singh *et al*., 2011). Poor meat handling and hygienic practices, insufficient food safety laws, poor regulatory systems lack of enough financial sources, improper storage process, inadequate personal and equipment hygiene during preparation, long time refrigeration, inadequate cooling and reheating create a favorable condition for the spread of food-borne etiologic agents. Socio-

demographic factors, worker's food safety, and hygiene information, knowledge on food safety and hygiene, food safety principles and practices, food source, and others are a few of the food contamination predictors (WHO, 2008).

Cattle slaughterhouses are one of the critical units in the meat supply chain from which food-borne pathogens can distribute along the meat processing and distribution continuum including retail shops subsequently reaching the final consumers. Therefore, proper hygienic practices at municipal abattoirs and butcher shops during distribution, during sales are key points in ensuring the quality and safety of meat to safeguard public health (Rani *et al*., 2017).

2.2.1. Equipment Hygiene

Studies indicate that meat contamination in butcher shops can occur due to different factors. Those factors include unclean utensils, microbial growth, poor water quality, ungraded packaging materials, a lack of waste disposal facilities and the personal hygiene of meat handlers (Gebru *et al*., 2023). Meat contamination in abattoirs and retail meat outlets result from the use of contaminated water, unhygienic practices like poor handling, use of contaminated tables to display meat intended for sale, and the use of contaminated knives and other equipment in cutting operations (Fasanmi *et al*., 2010). Equipment for raising the carcasses during slaughter is necessary for the sanitary handling of meat and carcasses. Working tables should be avoided wherever possible in favors of hoists. It is advised to implement procedures that guarantee a regular or ongoing cleaning of hoists. Because of the intricate design of machines, cleaning and disinfection are frequently made difficult or impossible. Hygienic production and cleaning and disinfection options must be taken into account when selecting and purchasing machines. Retail store weighing scales, wooden boards, and knives can all harbor bacteria, including *Shigella* and *Staphylococcus aureus* (Ali *et al*., 2010).

2.2.2. Personal and Processing Hygiene

Meat hygiene and meat safety are not restricted to slaughterhouse facilities, but it is also related with knowledge, attitudes and practices of meat handlers (Wambui *et al*., 2017). Known that

meat is highly perishable food type, meat handlers' unhygienic condition can contribute to the spread of pathogens through their hands, clothes, wounds and hair. Abattoirs in Ethiopia, which are thought to be a prerequisite for producing hygienic meat, are devoid of infrastructure and contemporary technology(Siluma *et al*., 2023).Pathogens can contaminate meat and make consumers sick if hygienic procedures including hand washing, using protective cloths, cleaning supplies, and utensils are neglected (Djeni *et al*., 2014).

Different studies conducted in Ethiopia indicates that high prevalence of pathogenic microbes which include *Escherichia coli O157, Salmonella,* and *Staphylococcus aurous* are observed in meat and its products (Mengistu *et al*., 2017; Adugna *et al*., 2018; Zerabruk *et al.,* 2019). The slaughter house and butcheries are potential sources of bacterial contamination that have significant effects on the meat shelf life, public health risk, and economic loss. Several causes can be taken for this, like poor facilities, inadequate knowledge for hygienic practices, and less attention from the administration (Gutema *et al.*, 2021). Everyone in the food chain has a responsibility to ensure that meat is healthful. Abattoir workers, butchers, meat producers, suppliers, handlers, and the general public all require extensive education and training in food-borne disease prevention in order to rectify the mistakes made from farm to table (Ebuete *et al*., 2020). It is crucial to wear an apron or gown when handling meat in order to shield the meat and the person handling it from food-borne viruses (Sulleyman *et al*., 2018).

2.2.3. Sanitary Facilities

The following facilities should be present in or close by: lairage, isolation block, slaughter hall, cooling hall, hide and skin store, guttery and tripery, offices, condemned meat room, laboratory and lavatory, dressing accommodations with lockers and laundry. However, the size and sophistication of abattoirs vary depending on location and local government ordinance. Different abattoirs in Ethiopia have varying amenities and management, especially between private and municipal abattoirs (Mummed and Webb, 2015). Water sources hoses, sterilizers for hand tools and cleaning equipment must be provided in sufficient numbers. The facilities that serve as

sanitary purpose must include sufficient number of toilets and arrangements for hand-washing or bathing.

These facilities should be kept clean and well established. To avoid back-flow from toilets in case of flooding the toilet outlets must be separated from common wastewater outlets. Rooms for resting and eating may be required assuring that food for the personnel and the carcasses cannot be mixed (G/Egziabher, 2010). The production and delivery of healthy meat for human use depend on adequate and appropriate abattoir procedures, including ant-mortem inspection, slaughtering, bleeding, evisceration, post-mortem examination, and waste disposal. According to Alhaji and Baiwa (2015) and Richard *et al*. (2015), this can only be accomplished with the provision of sufficient, standard, and functioning operating facilities, as well as appropriate sanitary conditions and acceptable hygiene procedures in the abattoir.

2.3. Hazards Associated with Meat

2.3.1. Physical Hazards

Physical risks include things that shouldn't be in food or that weren't intended to be food but end up in it. Glass or metal fragments, toothpicks, cigarette butts, stones, hair, jewelry, and staples are a few examples. Meat or its products can get contaminated physically at any stage of the production process, leading to harm but infrequently fatalities (Stopforth *et al*., 2011). Numerous factors, such as tainted raw materials, badly built or maintained buildings and machinery, incorrect processing techniques, and inadequate staff training and practices, can introduce physical dangers into meat products (Das *et al*., 2019).

2.3.2. Chemical Hazards

Chemical contaminants in food may be naturally occurring or may be added during the processing of food. Harmful chemicals at high levels have been associated with acute cases of food borne illnesses and can be responsible for chronic illness at lower levels. Different types of chemical substances can be present in foods for many reasons. Chemical agents are present in

foods either intentionally or unintentionally. Intentional chemical agents can include additives, pesticides, veterinary drugs, and adulterants. Unintentional chemical agents can include sanitizing or other chemicals, environmental chemicals, and naturally existing toxins (FAO, 2023). A chemical contaminant is a potentially harmful chemical substance of anthropogenic or natural origin, which may be present in food following deliberate treatment or accidental contamination during the production, transformation or preservation of foodstuffs (Saegerman *et al*., 2006).

Contamination of these foods with pathogenic microbes and chemical residues can result during production at the farm level, transportation, storage, distribution and preparation for consumption (Karshima, 2013). The chemical identified to date could come from drugs and growth promoters aimed at treating diseases and improving production parameters, and environmental contaminants linked to atmospheric pollution, from the soil and/or water (Maria and Mary, 2012). Foods from animals can potentially be contaminated with one or more of the thousands of manufactured chemicals, which are used in society. Relatively few of these occur with any regularity in foods from animals, and the most contentious residues (in terms of probability of occurrence and impact on human health, trade or consumer confidence) are antibacterial drugs, hormonal growth promoters or production adjuncts, polyhalogenated hydrocarbon pesticides, industrial chemicals and heavy metals (Chirag *et al*., 2013).

2.3.3. Biological Hazards

Microbiological organisms like bacteria, viruses, fungi, and parasites are known as biological risks, and they are the primary source of acute food borne illness in people. Humans and raw materials that enter restaurants are frequently linked to these critters. Most are deactivated or killed by cooking, as well as properly managing handling and storage procedures, the number can be reduced (FAO, 2023). Raw meat, salt, spices, and other natural casings, such as harmful bacteria, viruses, prions, and parasites, are typically the sources of biological risks. One important source of contamination for raw meat and meat products is the first micro biota on the carcass surface (Adeyanju and Ishola, 2014). The long process of slaughter, transportation, and

storage exposes the carcass surfaces to different degrees of contamination, even though the muscles of healthy animals are free of microbes (Antwi-Agyei and Maleku, 2014).

The unhygienic conditions of slaughterhouses and its surrounding environments are important factors in the pathogenic contamination of meat. The abattoir environment, the transport and the storage conditions not only contaminate the meat, but also enhance the growth of various types of spoilage and pathogenic microorganisms (Bhandaria *et al*., 2013). The growth of microorganisms depends on the hygienic practices, the automation level, the decontamination technologies used and the cleaning practices. Other potential sources of microbial raw and processed meat contamination include the processing environment, storage environment, equipment's, utensils and workers contributing through cross-contamination (Ahmad *et al*., 2013; De Filippis *et al*., 2013).

2.3.4. Hazard Analysis Critical Control Points in the Meat Processing Plant

Hazard Analysis and Critical Control Point (HACCP) was developed in the early 1960s in the United States by Scientists and Engineers from Pillsbury Company to ensure food safety for the first manned National Aeronautics and Space Administration space missions (NASA) to produce zero-defect food products for NASA astronauts (Kishore, 2020). It was one of the first truly global food safety systems. This leads to common communication and expectation amongst customers, suppliers and regulatory enforcement authorities around the world and has become the basis for more recent global standards developments such as the Global Food Safety Initiative (GFSI) (Fung *et al*., 2018). In meat processing time high degree of certified effectiveness need to be created for the safeguard of product during processing, processors hygiene and in addition to processors device manipulation is important. Meat processing in well known a procedure step to save you and reduce dangers to secure or safe level via making use of Hazard Analysis and Critical Control Point. A major role of governments and industry/trade associations in the developing countries is to provide adequate, accessible technical support including Hazard Analysis and Critical Control Point prerequisites for small and medium abattoirs as consultancy is rarely available (WHO, 2006).

The first phase identifies the several types of risks associated with raw meat, such as chemical, physical, and microbiological risks. The primary microbial risk associated with raw meat is controlled at both the farm and slaughterhouse levels. Crucial control points also include the addition of curing salt and the starting lifestyle. In order to prevent further infections, those ingredients must be of extremely high quality. They must also function well in order to create an environment that is conducive to the growth of beneficial bacteria used in fermented products. Due to the rapid drop in pH that stops the suppression of the growth of the greatest number of pathogenic microorganisms; the fermentation degree is any other critical control point (CCP). A wide range of organisms may be reduced and their growth inhibited by the heating and drying levels (Rhea, 2009).

2.4. Bacterial Quality of Meat at Municipal Abattoirs and Butcher Shops

The primary sources of contamination in fresh meat are thought to include soiled animal hide and hair, knives, hands and arms; worker clothing and unintentional punctures of the gastrointestinal tract during the skinning and evisceration process (Saleh *et al*., 2021). Carcasses can be contaminated during the slaughter process through the contact with the animal's skin, blood, hair, limbs, bile and stomach, gut contents, and facilities, equipment, water supplies, air pollution and worker's hands and clothes (Zailani *et al*., 2016). The routine veterinary inspection in the slaughterhouses is not included a microbiological examination. Therefore, microbial contamination of meat may affect its quality with a potential of food poisoning or spoilage due to microbial feeding on meat nutrients such as sugars and free amino acids, which liberate undesired volatile metabolites (Bogere and Baluka, 2014).

Meat-contaminating with microbes not only make the meat more likely to perish, but they are also often linked to the transmission of food borne illnesses. All tissues that may be consumed are contaminated during processing and killing by a range of external and internal sources (Zhu *et al*., 2022). *Salmonella* species, *Escherichia coli*, and a wide range of enteric pathogens suggesting poor evisceration and fecal contamination are among the pathogenic microorganisms linked to the contamination of meat and its products. Although *Staphylococcus aurous* is a natural flora on human skin, butchery workers might contaminate beef by handling meat (Lianou

et al., 2023). Contaminated meat, together with its byproducts, can transmit diseases to customers and shorten the product's shelf life (Barcenilla *et al*., 2022).

A key challenge for smallholder slaughter in low to middle income countries is assessing the microbiological safety of meat. Most basic meat inspection processes rely on identifying gross changes that might suggest unfitness for human consumption. However, many of the key hazards in meat, particularly in the modern era, involve contamination with food borne microbes. These include those significant such as *Campylobacter, non-typhoidal Salmonella*, *Escherichia coli* and *Listeria monocytogenes* (Karison, 2023). Methods that aim to pro-actively reduce risk are also applicable. Although formal hazard analysis and critical control point based programs are not necessarily suitable for home and village slaughter situations, the principles that underlie hazard analysis critical control point can be applied. World Health Organization offers guidance to the application of hazard analysis critical control point in small or less developed food businesses (FAO and WHO, 2013).

2.5. Common Sources for Meat Contamination

The common sources of meat contamination are slaughtered animals, the meat handling persons and working area, and to some extent contamination from air via aerosols and the utilizing water for carcass washing. High bacteria counts can be caused by inadequate handling and poor sanitation (Tasew *et al*., 2010). Contamination of meat in slaughterhouses and butcher shops resulted from the use of contaminated water, poor hygienic practices like improper handling, use of contaminated equipment's to display meat intended for sale, and use of contaminated knives and other equipment in cutting operations (Fasanmi *et al*., 2010). Knives, wooden boards and weighing scales from the butcher shops are common sources of pathogenic contamination, particularly *Staphylococcus aureus* and *Shigella species* (Ali *et al*., 2010). Meat is one of the vehicles for significant proportion of food borne-disease. Although the spectrum of meat-borne diseases of public health importance has changed with changing production and processing systems, continuation of the problem has been well illustrated in recent years by human surveillance studies of specific meat-borne pathogens such as *Escherichia coli O157:H7, Salmonella species, Campylobacter species* and *Yersinia enterocolitica (*Zailani *et al*., 2019).

2.6. Prevention and Control of Meat Contaminating Pathogens

Control over meat safety must be maintained throughout the food chain, starting with the farm of origin and continuing through inspections before and after slaughter, handling, and storage of meat and products until they are consumed. The production of safe meat is the joint duty of all stakeholders in the meat business as well as the regulatory body with the legal ability to enforce safety and sanitary requirements. According to Vilas *et al*. (2008), the surveillance at the abattoir allows all animals entering the human food chain to be examined for odd symptoms, lesions, or particular diseases. The surveillance of numerous diseases that are important to both human and animal health has been greatly aided by the abattoirs.

The livestock supply markets in Central Ethiopia Region consists local markets and secondary markets. Traders transport animals through non-dedicated trucks and long trekking without feeding and watering. Meat value chain analysis results show that the main activities in the red meat supply chain consist of input supply, production, transportation, meat processing, meat marketing, and consumption. Key stakeholders in the supply chain include primary producers, live animal traders, transporters, domestic abattoirs, butchers and meat vendors, and consumers. Most of the time illegal animal slaughtering of animals during festival time in Central of Region Ethiopia by backyard slaughtering system that causes for contamination of meat and difficult to apply the Hazard analysis control point system (Gebremedhin *et al*., 2021).

3. MATERIALS AND METHODS

3.1. Description of Study Area

The study was conducted on selected municipal abattoirs and butcher shops located in Hossana, Worabe, and Durame towns in Central Ethiopia Region (Figure 1) which are located in Hadiya, Silte and Kambata zones of the region. The study areas have an altitude ranging from 836 to 3436 meters above sea level and location described below in (Table 1). All municipal abattoirs provide a slaughtering service for their respective town according to the customer's order or market conditions. Mostly butcher shop owners buy food animals from the open market and bring them to municipal abattoirs for slaughter service. The sources of animals to the abattoirs for each town are from primary producers, local markets and traders from near woreda's for each town municipal abattoirs of Central Ethiopia Region. Key stakeholders in the meat supply chain include primary producers, live animal traders, transporters, butchers, meat vendors and consumers. The slaughtering numbers of animals in the selected town municipal abattoirs depends on demands based on the seasonal occasions (holidays, ceremonies and other cultural practices) and depending on the capacity of abattoir differ from time to time in the study area.

The municipal abattoirs of Hossana, Durame and Worabe towns were built in 1968, 1975 and 2001 respectively. The abattoirs are located at the center in the case of Hossana and Durame but the Worabe town abattoirs located far from the town and have relatively their own compound (fence, water supply, electric supply, road facilities). The slaughtering animals stay in the lairage of Hosana and Worabe Municipal abattoirs for 8 hours until slaughtering at night 9:00-12:00 local time. The lairage present in Hosanna and Worabe town municipal abattoirs that cleaned daily routine and Durame town municipal abattoir lack lairage for animal stay until slaughtering. The number of animals slaughtered per day, owner name, and sex of animals, age and date of slaughter recorded in the three municipal abattoirs of this study. During ante-mortem examination the sick animals separated and stay until fully recovery most of the time males slaughtered in case females examined for pregnancy and if not pregnant allowed for slaughtering. The slaughtering of animals started after stunning by stabbing at atlanto-occipital

region by using sharp knife or axes after that proceed to bleeding, removing head and feet in horizontal position on the floor. De-hiding, evisceration, post mortem examination and labeling of carcass were performed in vertical position after manually hanging the carcass by hooks and drag it over rail system in Hosana, Durame and Worabe municipalities. Then meat inspection for each abattoir was takes place accordingly. All the slaughtering operations such as bleeding, splitting, evisceration, removal of red and green offal and inspection was done And finally the carcasses were transported to butcher shop by vehicle at Hosanna and Worabe town but in Durame carcasses transported by horse cart ("gari)" or three wheels vehicle (bajaji). There were 85 registered hotels and butcher shops in Hosanna town, 42 hotels and butcher shops in Durame town and 35 registered hotels and butcher shops in Worabe town according to their recorded data of each town municipal abattoirs. In the three town municipal abattoirs local breeds slaughtered in large number and exotic breeds in rare cases.

The number of employees in Hosanna town municipal abattoir was sixty; Durame town municip al abattoir was fourty and thirty five in Worabe town municipal abattoirs. In Durame and Worabe town municipal abattoirs the service charges for each animal for slaughter processing was 500 Ethiopian birr per head. The municipal abattoirs and butcher shop workers in each town include meat inspectors such as veterinarians and animal health workers, meat cutters, meat sellers, meat transporters and cleaners or sanitary personnel and butcher shop owners those are permanent and contract employer served as information sources for survey part of this study.

Table 1: Study area description shortly.

Site of abattoirs and butcher shops	**Name of zones**	**Distance from Addis Ababa (km)**	**Global loc.**	**Altitude**	**Tem. (°C)**	**Rain fall (ml)**
Hosanna town	Hadiya	237 from south western direction	7°33′N 37°51′E	2177	16.5	2380
Durame town	Kambata	274 from south eastern direction	7°14′N 37°53′E	2101	19.3	1144
Worabe town	Silte	172 from south western direction	8°1′N 38°20′E	2113	20	1012

Source: CSA, (2022)

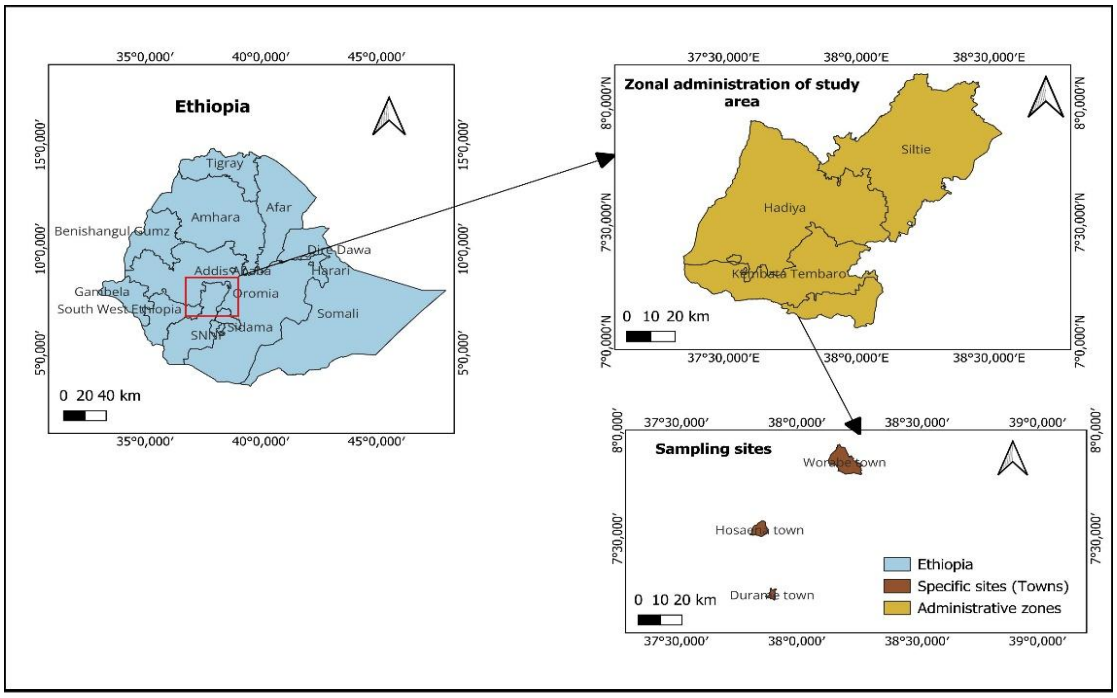

Figure 1: Map of the study area generated by QGIS

3.2. Study Design

A cross- sectional study design was employed from November 2024 to April 2025 in selected municipal abattoirs and butcher shops of three towns (Hossana, Worabe and Durame towns) of Central Ethiopia Region.

3.3. Study Population and Study Facilities

The study population for this study included abattoir workers and owner of butcher's shops, all selected municipal abattoirs and butchers shops; carcass surfaces from local and cross breed cattle and in-contacts that sourced from different local markets around to Hosanna, Durame and Worabe town. Cattle sourced for Hosanna town municipal abattoirs mostly from Lemo, Anlemo, Misha, Soro of Hadiya zone and Gurage zones, for Worabe town municipal abattoirs cattle from Wulberag, Silte, Dalocha, Lanfro and Hadiya zone and for Durame town municipal abattoirs cattle come from Damboya, Doyogena, Angacha of Kambata zone and Wolaita zones. The majority of the cattle that slaughtered were local breed adults take largest proportion for survey

parts all voluntary participants of abattoir workers and owners of butcher shops. For Physical, functional and hygienic status study on municipal abattoirs and butcher shops of the three towns (Hossana, Worabe and Durame towns) were used to assess the parameters.

3.4. Sampling Methods

The Central Ethiopian region was purposively selected then followed by Multistage sampling method for zones selection and the number of total municipal abattoirs and butcher shops in the study area was obtained from each zone town municipal revenue offices. Three municipal abattoirs from the Hadiya, Silte and Worabe zones were also selected purposively to save working duration and to keep the quality of sample by decreasing the distance to traveling sample to laboratory. Cattle carcasses swab samples were collected from slaughtered animals by using random sampling methods on each study visitation days. In addition to these meat swab samples, additional swab samples were collected from abattoir workers hands, knifes and hooks, cutting table (board) and cutting knifes from selected butcher shop during sampling periods of this study. In the selection of butcher shops from each town, the kebeles were selected by stratified sampling methods. Then butcher shops for sample collection were also selected by lottery sampling method.

3.5. Sample Size Determination

The sample size was estimated using a single proportion formula, $n= \underline{z^2pq}\ n/d^2$, where: n is the required sample size, z is the reliability coefficient at 95% confidence interval (1.96), p is the population proportion, q is equal to 1-p, and d is the acceptable error (0.05). In the current study area, there was no previous work on assessment of the physical, functional, hygienic status and meat bacterial quality of selected municipal abattoirs and butcher shops and population proportion *i.e*. p assumed to be 50% (0.05). Therefore, sample size (n) become, $N= (1.96)^2$ (0.5) (0.5)/ $(0.05)^2$= 3.84 (0.25)/0.0025 = 384. But, the current total population (*i.e*.135) from three abattoirs is less than 10,000 which necessitate the use of correction formula (Cochran, 1977) as follow: nf= ni/1+ni/N, where, nf= final sample size; ni =standard sample size, and N= total sample was taken. Hence: nf= 384/ 1+384/135 = 132. From 135 total abattoir workers, 132 of

them were recruited for the study purpose. For laboratory microbial load determination, a total of seventy one swab samples from five different sample types were used as described in (Annex 3).

3.6. Data Collection and Transportation of Samples

All of the municipal abattoirs and selected butcher shops for each town in the study area were visited one day before the starting of data collection.

3.6.1. Questionnaire Survey and Observational Questions

The purpose of the study was explained to the respondents and data collected after obtaining the consent from them. The semi-structured close-ended questionnaire and observational checklist questions were prepared and interviewed to assess hygienic practices, operational facilities, water and electric supplies, workers training, daily working practices, time of inspection and all information of the physical and functional status of the municipal abattoirs as well as the knowledge of workers in abattoir based on their willingness. In addition to interview, personal observation was conducted during slaughtering activities in this study time. The observed and identified sections, parts and their hygienic condition were pictured using a digital camera to show their status. The questioner was constructed in English language and it was transformed to Koobo collect tool then during the time of the interview it was translated to the preferred language of the respondents; Hadiyigna, Kembatagna, Siltigna and Amharic orally. The questionnaires and checklist were derived from related studies in and out of Ethiopia with some modifications (Lawan *et al*., 2013; Gutema *et al*., 2021).

The questionnaire survey was collected through close-ended questionnaire type and direct observation of study area. The questionnaire was conducted by using simple random sampling techniques from abattoir workers and owner of butcher shops. The total number of participants was one hundred thirty two which includes thirty from Worabe town municipal abattoir forty nine from Durame town municipal abattoir and fifty three from Hossana town municipal abattoir based on number and production capacity of abattoirs. The questionnaire was included socio-demographic characteristics of abattoir workers, presence or absence of facilities, sanitation

practice, receiving training, medical checkup, awareness about source of contamination, knowledge of food borne-diseases, and zoonosis were considered. The observation was used to answer questions concerning facilities, equipment, the current status of hygiene and sanitation practices in an abattoir, and bio-security protective ways of abattoirs. The observational check list was incorporated in this study to assess all hygienic status, cleanliness of meat processing and handling meat up to customers.

3.6.2. Swab Sample Collection and Preparation for Microbial Analysis

The swab samples were collected aseptically from carcasses and in-contacts according to the method described by (ISO, 2005). The swab samples were taken from carcass surfaces (ribs, flank and hind leg), hooks and knives (both sides), workers hand (both hands) from abattoirs and meat cutting table and cutting knife from butcher shops by consideration of critical control points. The samples were collected in three non-consecutive sampling days from each town municipal abattoirs and butcher shops aseptically. To increase the enumeration of total bacterial load, totally seventy one swab samples from five sample types in selected municipal abattoirs and butcher shops from each of three towns of the study area. Types of sample include carcass surfaces, hooks and knives, workers hand from abattoirs and meat cutting table and cutting knife from butcher shops.

A total of forty five swab samples were collected from three of selected municipal abattoirs of each town and twenty six swab samples from each town butcher shops. Sterile cotton tipped swabs soaked into buffered peptone water was used for swabbing. The sterile cotton swab was applied to collect swab samples first rolled into the horizontal direction and then vertically on the limited area 20 cm^2according to (Abdalla *et al*., 2009). After that the cotton swabs were retained into screw-capped tubes and the swab shafts were broken by pressing it against the inner wall of the test tube and disposed leaving the cotton swab in the screw-capped test tube containing ten milliliter of sterile peptone water as transporting media.

All samples were properly labeled with necessary information, including sampling date, address of sample, sample code and type. Immediately, the samples were kept in icebox and transported

to Sodo Regional Veterinary Laboratory for microbiological analysis. The samples were stored at 4^{o}C(refrigeration temperature) in laboratory and processed within 24 hrs. Ten-fold serial dilutions up to 10^{7}were prepared for bacteriological analysis. The serial dilution homogenates were conducted based on the availability of peptone and saline water at the laboratory. Appropriate plates containing distinct microbial colonies were selected and counted using a colony counter. The growth bacterial colony was counted in a particular dilution was multiplied by the dilution factor obtained using the standard formula. The results of the total bacterial counts were expressed as the number of cfu/cm^2 of the swab sample and then the results were calculated into log value. CFU per cm^2/ml of sample = c/ d × v, Where: c= is the number of colonies on the standard plate, d=the dilution rate of the counted plate, v= the inoculated volume of this dilution (EFSA, 2011).

3.7. Bacteriological determination

Laboratory work was carried out at Sodo Regional Veterinary Laboratory Center (SRVLC) in bacteriological laboratory for conducting bacterial load assessments from swab samples of selected municipal abattoirs and butcher shops.

3.8. Laboratory Media Preparation

3.8.1. Nutrient Agar

The nutrient agar base (Laboratorios Conda S.A, PRONADISA$^{(R)}$) contained 5.0 (g/l) of gelatin peptone, 3.0g/l of beef extract and 15.0 g/l of bacteriological agar. The media was prepared by dissolving 23 grams of medium in one liter of distilled water. The mixture was agitated and boiled for two minutes until completely dissolved, then sterilized in the autoclave at 121^{o}C for 15 minutes. Cooled at 45^{o}C and poured into sterile petri dishes ready for inoculation.

3.8.2. MacConkey Agar

The MacConkey agar (Laboratorios Conda S.A, PRONADISA$^{(R)}$) was prepared by dissolving 52 grams of the medium in one liter of distilled water. The mixture was agitated and boiled for two

minutes until completely dissolved and sterilized in the autoclave at 121^{o}C for 15 minutes. Cooled at 45^{o}C and poured into sterile petri dishes ready for inoculation.

3.8.3. Mannitol Salt Agar

The Mannitol salt agar media was prepared according to the manufacturer's instructions, typically by dissolving the powder in distilled water, autoclaving, and then pouring into sterile petri dishes. The mixture agitated and boiled for two minutes until completely dissolved and ster ilized in the autoclave at 121^{o}C for 15 minutes. Cooled at 45^{o}C and poured into sterile Petri dish plates ready for inoculation. Serial dilutions of the sample are performed, and aliquots are spread onto mannitol salt agar plates using a sterile spreader.

3.8.4. Normal Saline Preparation

In order to make a phosphate buffered saline, 8.5grams of sodium chloride was thoroughly mixed with one liter distilled water. Several test tubes were filled with normal saline solution and sterilized in autoclave at 121^{o}C for 15 minutes.

3.9. Sample Preparation and Inoculation

In the laboratory each test tube and universal bottle with surface swabs and water samples were opened aseptically by flaming of the mouth part of test tubes and universal bottles. The samples were taken using sterile pipette and further diluted serially (10 folds dilution) into 10 test tubes. The diluents were mixed well and then one milliliter of diluted sample were poured into various sterile Petri dish plates and covered with 20 milliliters of sterile nutrient agar or MacConkey agar or Mannitol salt agar. Each plate was swirled gently taking care not to spill its contents and allowed to set. All samples inoculated with nutrient agar were incubated at 37ºC for 24 hours in order to get total viable count, Mannitol salt agar for total Staphylococcus species count while samples inoculated in MacConkey agar were incubated at 37ºC and 44ºC for 24 hours for total coliform count respectively.

3.9.1. Enumeration of Total Aerobic Bacteria

Bacterial load assessments of collected swab samples with intention of colony count were conducted in the bacteriological laboratory. Total aerobic plate count was conducted according to horizontal methods of serial dilution techniques (ISO, 2013). For the purpose of total bacterial count determination, 1ml of each ten-fold was transferred and poured on a single plate count agar by using clean micropipette tip for each dilution. Each swab sample was added to 9ml of sterile peptone and saline water under aseptic condition and well mixes with vortex mixer. After this procedure serial dilution up to 10^7 was made from 1ml of the sample and 9ml of buffered peptone water. From the proper dilutions, 1ml of the suspension was poured into labeled sterilized Petri dish plates by using pour plate methods and approximately 20ml of sterile melted plate count agar that kept at (47^0C in water bath) were poured. After proper mixing, the inoculated and control plates were allowed to solidify at room temperatures before being incubated in inverted position at 37^0C for 24 hrs.

The number of distinct colonies on each plate was enumerated using a colony counter, colonies ranging from 30–300 on each plate were accepted (Scott, 2011). The total viable plate count and Staphylococcus species count was calculated on plates containing 30-300 colonies and recorded. On the other hand, colonies below 30 were too few to count and colonies greater than 300 were too numerous to count and expressed as log cfu/cm^2. For MacConkey 15-150 colonies below 15 were too few to count and colonies greater than 150 were too numerous to count (BSI, 2015). The results were classified as below average and above average compared with the standards described by World Health Organization and the maximum limit of bacterial load that is acceptable (WHO, 2007).

3.10. Data Management and Analysis

The collected data and microbiological findings from swab samples, questionnaire was entered into Microsoft Excel spreadsheet and data was analyzed by using R.4.3.2 version software. Descriptive statistics such as frequency and percentage were computed to describe the nature and characteristics of questionnaire survey. One-way ANOVA was used to compare the means of the bacterial load assessment. Microbiological count data were first transformed to log (base 10). A

95% confidence interval at p value 0.05 and less than 0.05 will be considered as statistically significant.

3.11. Ethical consideration

The study was conducted after ethically approved by the Addis Ababa University, College of Veterinary Medicine and Agriculture ethical review committee (*Certificate Ref. No: VM/ER/02/5 6/17/2025*) and all study work was conducted according to research ethics attached as (Annex 5).Permission letters from the directorates of each municipality were sent to each abattoir included in the study. Verbal orientation, briefings, and discussions were conducted with zonal abattoir workers and verbal consents were obtained before starting the actual data collection in each abattoir. The aim and purpose of the study were communicated with them.

4. RESULTS

4.1. Socio-Demographic Characteristics of Participants

In present study, a total of 132 voluntary workers from the three town municipal abattoirs and owners of butcher shops were interviewed. From them 120 (91%) were male and 12 (9%) were female. This study findings show that the participant age were largest proportion 31 to 40 years with 40.15% and followed by age group 40 years. The religious status of the interviewed workers more than half were Protestants with frequency 82 (62.1%) and Muslim 32 (24.2%). For educational background of this study participants 45 (34.09%) attended only high school while 41 (31.06%) attended elementary school and 13 (9.8%) had no formal education or illiterate. Regarding occupational status 91 (68.9%) of the participants were the abattoir workers that include the permanent and contract workers who have direct participation on meat handling and processing. From them 38 (28.8%) were the owner of the butcher shops who bought the slaughtering animals from open market brought it to abattoirs and involve in assisting of slaughtering process and other activities in the abattoir (Table 2).

Table 2: Socio-demographic characteristics of respondents

Variables	Categories	Frequency	Percentage (%)
Gender	Male	120	91
	Female	12	9
Age	18 to 30	25	18.9
	From 31 to 40	55	40.15
	Over 40	52	39.3
Religious status	Orthodox	18	13.6
	Protestant	82	62.1
	Muslim	32	24.2
Level of education	Illiterate	13	9.8
	Elementary school	41	31.06
	High School	45	34.09
	Diploma	20	15.1
	Bachelor of Science (degree)	10	7.6
	Doctor of veterinary medicine	3	2.3

4.2. Assessments of Meat Handling Practices of Participants

From 132 voluntary participants of this study, 56 (42.4%) clean their working area and 62 (46.9%) their equipment infrequently both before and after use. To avoid contamination of meat the workers protective cloth hygiene is important. However the workers personal protective clothes washed infrequently 47 (35.6%) and never cleaned 23 (17.4%) in this study. From total participants of this study 84 (63.6%) did not follow their medical checkup and no certification for their health status. To reduce meat contamination by workers the removal of jewelry (rings, bracelets and watch) is necessary however, 40 (30.3%) remove their rings sometimes and 22 (16.7%) handle meat with bare hands and rings on their fingers. Almost above half of the participant have no access for training on meat safety and hygienic practices of their work in abattoirs 71 (53.78%). Over all knowledge level of the participants about personal hygienic practices in meat handling and processing, cross-contamination of meat and transmission of food borne disease was summarized as follows (Table, 3).

Table 3: Assessments of meat handling practices of participants

Variables	Categories	Frequency	Percentage (%)
Occupational status	Employee of the abattoir	91	68.9
	Employee and owner of butcher shop	41	31.1
Job responsibility in abattoir	Cleaner	35	26.5
	Slaughterer	39	29.5
	Meat distributor	37	28.03
	Supervisor	10	7.6
	Meat inspector	11	8.3
Access for meat safety training	Yes	61	46.2
	No	71	53.8
If yes training frequency	Monthly	0	0
	Not supplied	71	53.8
	Twice annually	28	21.2
	Every year	33	25
Medical check up	Every six months	36	27.3
	Every month	0	0
	Each year	12	9.09
	Absolutely not	84	63.6

	Infrequently	56	42.4
	Occasionally	28	21.2
	Always	40	30.3
Do you thoroughly clean your equipment both before and after use?	Never	13	9.8
	Infrequently	62	46.9
	Occasionally	35	26.5
	Always	22	16.7
Do you properly clean your protective gear?	Never	23	17.4
	Infrequently	47	35.6
	Always	33	25
	Occasionally	29	21.9
When you return to work after taking a break, do you wash your hands?	Never	6	4.5
	Seldom	89	67.4
	Occasionally	11	8.3
	Constantly	26	19.7
When your hands get dirty, do you wash them?	Never	4	3.03
	Seldom	60	45.5
	Occasionally	30	22.7
	Constantly	38	28.8
When you use the toilet, do you wash your hands?	Never	65	49.2
	Infrequently	5	3.8
	Occasionally	41	31.06
	Constantly	21	15.9
When working, do you wear gloves?	Never	53	40.2
	Infrequently	44	33.3
	Occasionally	10	7.6
	Always	25	18.9
When working, do you wear jewelry?	Never	66	50
	Infrequently	40	30.3
	Occasionally	22	16.7
	Always	4	3.03
Do you wear a hat to work?	Never	55	41.7
	Infrequently	21	15.9
	Occasionally	19	14.4
	Always	37	28.03

4.3. Meat safety practices of the respondents

In this study, 72 (54.5%) and 64 (48.5%) of the participants have no awareness on zoonosis and food borne illness respectively. From the total respondents, 103 (78.03%) did not follow proper hygienic cleaning procedures during work time and after finishing their work. Regarding the proper personal protective wear, 6 (4.6%) did not wear personal protective clothes during their work time. All municipal abattoirs in this study lack enough meat processing rooms and remove solid waste regularly. Among respondents from abattoirs 85 (64.4%) of them did not practice wearing head cover (Table 4).

Table 4: Meat safety practices questions for respondents

Meat safety practices questions	**Total number of participants**	**Response of participants**	
		Yes	**%**
Do you wear a head covering	132	47	35.6
Do you wear personal protective equipment when working in an abattoir	132	126	95.4
Do you follow cleaning procedures when processing	132	29	21.9
During processing, do you remove solid waste	132	132	100
Do your processing rooms have enough room	132	0	0
Are you aware of zoonosis	132	60	45.5
Are you aware of food-borne illnesses	132	68	51.5

4.4. Observational Check List for Municipal Abattoirs and Butcher Shops

The current study observed structural defects on building, inadequate facilities, poor sanitary and cleaning conditions and improper solid and liquid waste disposal.This observational checklist assessment indicates that abattoirs depilated and were not free of the dust and waste of the non-asphalt road that passes near the abattoirs of Hosanna town and Durame. Lairage for both Hossana and Worabe town had fences that took the animals to a place of slaughter but Durame town municipal abattoir lacks lairage. Isolation pen for sick animals are not available in Durame and Worabe town municipal abattoirs but present in Hossana town municipal abattoir. The

drainage system in three town municipal abattoirs was an open and grated trench that trapped blood and other solid materials.

Separate and hygienic rooms for handling skins and hides, for cleaning and treating of intestine offal, inedible and condemned carcasses meat and cooling facilities were not available in the all three abattoirs that included in this study. In this study observation there was scarcity of clean water for hand washing and dipping knifes in three town municipal. Each abattoir has a veterinarian in charge of regulating the slaughtering process and meat inspection. The cattle were stunned by a piercing in the foramen magnum with a sharp-edged knife, instantaneously followed by bleeding and removal of the head and feet while the carcass lay horizontally on the floor. After manually hanging the carcass with hooks and sliding it over the rail system, the following slaughter processes (de-hiding, evisceration, and post-mortem inspection) were undertaken in a vertical position in Durame and Hossana town municipal abattoirs but in case of Worabe town municipal abattoir no hanging of carcasses. In all three town municipal abattoirs most process were carried out in horizontal position on the floor. However, in Worabe and Hossana town the floor was cracked, water and other liquid wastes logged in several areas. The carcasses in all abattoirs were washed with water after evisceration, but not with pressurized water. Finally, it was reserved at room temperature and transported to butcher shops.

The habit of using the protective clothes by workers was observed to lack regularity and tidiness. After accomplishment of their working activities all participants washed their hands and waste management. Participants did not disclose some potential contaminating practices in the work place such as smoking, eating or drinking beverages. Preventive measures were not installed for insects and rodents in the abattoirs which provide great opportunity to contaminate the exposed tissues of the carcasses with pathogenic microorganisms. Furthermore, observation showed that there was no proper disposing system as result pile up paunch contents and other solid wastes, scraps of tissues, horns and solid wastes were found near the abattoir and serves for the resides of rodents, cats, dogs, hyenas and scavenger birds.

Based on the different assessment criteria such as: abattoirs site, building and general arrangeme nt of premises, design and construction of floors and ceilings, sanitation standards and operating procedures, maintenance of hand washing, sanitizing and toilet facilities, slaughtering facilities and production areas, hygienic practices of abattoir workers, the component status and hygienic practices of butcher shops and butcheries of each selected town municipal abattoirs and butcher shops assessed. The overall observation was summarized as follows (Table 5).

Table 5: Observational check list for municipal abattoirs and butcher shops

List of facilities	**HTMA BS**	**DTM ABS**	**WTMA BS**
Far from residential area	No	No	Yes
Free from flooding, provided with perimeter fence and vegetation is controlled	No	Yes	No
Grounds compact with gravel and good housing	Yes	Yes	No
Lairage and drain path way	Present	Absent	Present
Separate entrance of personnel and exit of product	Present	Absent	Absent
Separated slaughter area and isolation pens for sick animals	Present	Absent	Absent
Resistant walls and ceiling to wear and corrosion	Absent	Present	Absent
Proper floor-wall joint, properly constructed and in good repair	Absent	Present	Absent
Safety and supply of water	Present	Present	Absent
The condition and cleanliness of meat contact surfaces	Absent	Present	Absent
Cleaning and sanitizing records	Present	Absent	Present
Hand washing facilities	Present	Absent	Absent
Toilet, facilities	Present	Present	Absent
Cleaning facilities for live transport carrier and meat delivery system	Absent	Absent	Present
Live transport carrier and meat delivery vans	Absent	Absent	Present
Deboning, cutting and packing area	Present	Absent	Absent
Hygiene of meat handlers	Absent	Present	Present
Meat handlers wash hands before commencing work/prior to handling meat	Present	Absent	Present
Hair is tied back and hair net/cap is used	Absent	Present	Absent
Protective clothes are long-sleeved and completely cover personal clothes	Present	Present	Absent
Staff with watch/jewelry wears while meat is handled	Absent	Present	Absent
Hygiene of meat handlers	Absent	Present	Present
Same personal protective cloth is used for different	Yes	Yes	No

activities in the shop/butchery			
Structure of shop/butchery including walls, floors, ceilings and fixtures are in good condition and will not yield cross contamination	Yes	No	No
Counter and hooks of butchery/shop are clean	No	Yes	No
Cutting tables contain non-harmful materials (rust, mold), disposable paper towels are available	Yes	Yes	No
There is a safe water supply to the butchery/shop	No	Yes	Yes
Clean equipment such as weighing scales, mincers and slicers are separately used for raw meat and ready to eat meat	No	Yes	No
Waste is confined, managed and properly disposed	Yes	No	No
Cleaning cloths and detergents are stored in sight	No	Yes	Yes
Pest control devices are available	No	No	Yes

4.5. Total Bacterial Load Assessment

4.5.1. Bacterial Load in Abattoir and Butcher Shops

The mean values of total viable count, total coliform count and total staphylococcus count were d etermined for carcass surface, hooks and knife, workers hands, cutting table (meat cutting board) and cutting knife swab samples from each of three town municipal abattoirs and butcher shops. The highest mean total vial count was 7.3±0.4 cfu/cm^2 from Hosanna town municipal abattoir workers hands was recorded. The highest mean total coliform count 7.1±0.05 cfu/cm^2 were also recorded from Hosanna town municipal abattoir worker hand and total staphylococcus count 6.4±0.5 cfu/cm^2 from worker's hands of Worabe town municipal abattoir. Generally the mean bacterial loads were found commonly from all sample types of all sampling areas but more bacterial load were found in Hosana and Durame towns municipal abattoirs and butcher shops followed by Worabe one showed as (Table 6).

Table 6: Bacterial load profile based on area and swab sampling site

Abattoir and butcher s hop location	**Sample type and number of sample**	**Mean ± SD**		
		TVC	**TCC**	**TSC**
Hosanna	Carcass surface (5)	6.8± 0.5	6.6± 0.5	6.2± 0.08
	Hooks and knifes (5)	6.9± 0.6	4.9± 2.4	6.1± 0.2

	Workers hands (5)	7.3± 0.4	7.1± 0.05	6.2± 0.1
	Cutting table (4)	7.2± 0.5	6.5± 0.6	6.3± 0.06
	Cutting knife (6)	6.8± 0.5	5.3± 0.5	6.1± 0.05
Worabe	Carcass surface (5)	7.01± 0.5	5.9± 0.3	6.2± 0.08
	Hooks and knifes (5)	6.8± 0.6	5.9± 0.2	6.1± 0.2
	Workers hands (5)	6.7±0.6	5.9± 0.3	6.4± 0.5
	Cutting table (4)	6.9± 0.5	6.3± 0.6	6.2± 0.4
	Cutting knife (4)	6.8± 0.7	6.0± 1	5.3± 0.6
Durame	Carcass surface (5)	6.3± 0.2	5.9± 0.7	6.0± 0.2
	Hooks and knifes (5)	6.7± 1.01	6.03± 0.9	6.07± 2.7
	Workers hands (5)	6.4± 0.7	4.8± 2.8	4.8± 0.2
	Cutting table (4)	6.6± 0.5	5.9± 0.8	6.07± 0.1
	Cutting knife (4)	6.4± 0.6	6.1± 0.9	5.8± 0.2

TVC= Total viable count, TCC= Total coliform count and TSC=Total staphylococcus count.

4.5.2. Mean of Total Bacterial Loads for each Abattoirs and Butcher Shops

The mean, maximum and minimum values of total viable count were highest from Hossana town municipal abattoir and butcher shop with 7.018±0.28 cfu/cm^2, from Worabe town municipal abattoir and butcher shop and 5.397 cfu/cm^2 from Durame town municipal abattoir and butcher shop and lowest mean from Durame town municipal abattoir and butcher shop with 6.47±0.43 cfu/cm^2 respectively (Table 7).

Table 7: Mean total viable count for each abattoir and butcher shop with total sample

Sampling area	**No. of sample**	**Mean ±SD (TVC cfu /cm^2)**	**Standard error**	**Minimum**	**Maximum**
Hosanna	25	7.018±0.28	0.5	6.079	7.469
Worabe	23	6.843±0.31	0.6	6.017	7.471
Durame	23	6.471±0.43	0.7	5.397	7.462

The mean, maximum and minimum values of total coliform was highest from Hossana town municipal abattoir and butcher shop with 6.3±1.8 cfu/cm^2, 7.2 cfu/cm^2 from Hossana town municipal abattoir and butcher shop and 4.8 cfu/cm^2 from Worabe town municipal abattoir and butcher shops and lowest mean from Durame town municipal abattoir and butcher shop with 5.4 ±2.22 cfu/cm^2 respectively (Table 8).

Table 8 : Mean total coliform count to each abattoir and butcher shop with total sample

Sampling area	No. of Sample	Mean ± SD (cfu/cm^2)	Standard error	Minimum	Maximum
Hosanna	25	6.3±1.8	1.3	5.9	7.2
Worabe	23	6.02±0.32	0.51	4.8	7.1
Durame	23	5.4±2.22	0.003	5.4	5.4

The mean, maximum and minimum values of total staphylococcus was highest from Hossana town municipal abattoir and butcher shop with 6.2 ±0.016 cfu/cm^2, 7.2 from Worabe town municipal abattoir and butcher shops and 4.8 cfu/cm^2 from Worabe town municipal abattoir and butcher shops and lowest mean from Durame town municipal abattoir and butcher shop with 5.7 ± 1.64 cfu/cm^2 respectively (Table 9).

Table 9: Mean staphylococcus count to each abattoir and butcher shop with total sample.

Sampling area	No. of sample	Mean ± SD (TSC cfu/cm^2)	Standard error	Minimum	Maximum
Hosanna	25	6.2±0.016	0.1	5.9	6.4
Worabe	23	6.09±0.14	0.3	4.8	7.2
Durame	23	5.7±1.64	1.3	5.8	6.3

4.5.3. Mean Analysis by Using One-Way ANOVA

There was no significant difference between the sample collection areas in terms of the mean bacterial load result increment (p value>0.05).There was a significant difference between Hosanna, Worabe and Durame for total viable count (p value <0.05). But there was no significant difference between Hosanna and Durame for total viable count and

also for total coliform count and total staphylococcus count between all town municipal abattoirs and butcher shops (Table 10).

Table 10: Comparison of the mean total viable, total coliform and total staphylococcus counts

Variable	Category	M/D	S/E	P-value
TVC	Hossana	0.457	0.311	0.0164 *
	Worabe	0.282	0.311	0.207
	Durame	-0.175	0.311	0.527
TCC	Hossana	0.557	1.470	0.256
	Worabe	0.322	1.470	0.641
	Durame	-0.234	1.470	0.782
TSC	Hossana	0.122	0.180	0.580
	Worabe	-0.026	0.180	0.976
	Durame	-0.148	0.180	0.451

*The mean difference is significant at 0.05; M/D = Mean difference, S/E= Stand error

5. DISCUSSION

Adequate infrastructures and proper hygienic production of meat are major elements in the production of wholesomeness meat in abattoirs as the same time prevents and control the spread of food borne disease (Biu *et al*., 2006). The proper hygienic conditions of abattoirs and environment in which they operate are key contributors for protection on meat contamination from bacteria (Brown *et al*., 2000). Generally, the floor of abattoir should be hard concrete and impervious, free from cracks to decrease dirt and contamination in the abattoirs allow easy of cleaning and drainage. In the present study, abattoirs located in Central Ethiopia Region were not impervious, smooth, and difficult to clean easily, breakage and deformity due to long service usage. The findings revealed that there were no separated clean and enough spaces of lairages and no separated areas prepared for stunning. Equipment used for slaughtering were not to the standard, the abattoir uses hammer and axes for stunning purposes, which make animal to suffer in pain compromising the animal welfare and quality of meat produced. Previous study by Mohammed and Webb, 2015 indicated that, similar to current study, the absence of stunning boxes in most public and private abattoirs in Ethiopia.

In the present study, there was observation of workers movement from dirty area to clean area. Due to these slaughtering practices, cross contaminations are more likely to happen. Additionally, the toilets were not proportional to the abattoir workers and there was no hand washing facility in the toilet which can be one potential source of carcass contamination. The personal protective clothes of workers were not clean and their poor hygienic status and workers did not wash their hands in each slaughtering stages. This showed that there was no good personal hygienic practice in the all three town municipal abattoirs of this study finding. The absence of hot water in the abattoir for hand wash for workers in this study agrees with similar study in Bishoftu were most workers wash their hands by cold water (Gutema *et al*., 2021).

In present study the inappropriate location of abattoirs, non functional or poor operational facilities, unhygienic meat production and handling were observed. While the absence of hot water baths for knife dipping and hand wash, insufficient hand washing before and

after work, lack of trained abattoir workers, no medical checkup of workers, absence of cooling facilities, handling and processing meat with jewelry and infrequent washing of utensils were found to be unsatisfactory practices of all town municipal abattoirs in current study investigation. Regarding to this current study in line with Nigeria by Nafarnda and his teammates water supply was very poor in most cases stream and cited wells used, contaminated by surface run-offs and poorly discharged effluents (Nafarnda *et al*., 2012). Based on findings of the abattoir assessments in this study the majority of the facilities were not in good standard. The abattoir location should be far from residential area to reduce public health effect and environmental pollution. Hence, meat production itself produce large amounts of solid and liquid waste, bad odors, all of those can adversely affect health of public (Mujere, 2016).

In the present study period all the town municipal abattoirs were not separated from residential buildings and they need additional planting area for improvement of hygienic meat production to customers. To reduce meat discoloration and quality decline after long transportation of animals to relieve stress in the animals. In addition, to relieve stress, abattoir should have a lairage with an isolation pen for sick animals. But isolation pen for sick animals was not available in Durame and Worabe town municipal abattoirs. This study agrees with Adeyemo *et al*. (2009), in Nigeria that lairage has been largely implicated as point for contamination among animals being rested after long journey to the slaughtering houses and with poor resting of livestock before slaughtering.

After having rest in lairage animals were transferred to slaughtering hall and sunned before slaughtering. Following stunning all study town municipal abattoirs accomplished bleeding on the floor in horizontal position. Horizontal bleeding, while it increases faster bleeding rates is less hygienic than vertical bleeding. However, flaying of skin and evisceration were done on the dirty floor of all town municipal abattoirs. This could expose the carcasses to blood and dirty from the skin. This would also contaminate the carcasses and reduce the meat quality.

Cooling facilities are absent in three town municipal abattoirs. The absence of attachment to cooling facility, may be due to animals were slaughtered; carcasses are quartered, and

dispatched to butcher shops on the same day. As result of this meat were preserved in abattoirs at room temperature and delivered to butcher shops through vehicles (meat van) in Hosanna and Worabe municipal abattoirs but in case of Durame they used horse cart (gari) and three wheels vehicle (bajaji) without refrigeration. This study observation opposes the study of Ovuru *et al*. (2024) there must be sufficient space and capacity for chilling of meat produced and constant temperature must be maintained at all the times of meat production chain.

Subsequently, the meat was displayed without out cover and cooler in all butcher shops, subjecting it to dust particles and flies. This has a significant impact on meat product quality and shelf life. In order to ensure the quality and safety of meat and meat products, cold chain management in meat storage and supply is necessary (Sani and Siow, 2014). Production of safe and wholesome meat is the overall sum of facilities in abattoir and meat processing outlets, butcher shops, and meat handlers' practices in the meat production chain. Meat handling practices play an important part in improving the quality and safety of meat (Rani *et al*., 2017).

Most of the participants in this study had no good hygienic practices and formal education, poor awareness for about zoonosis and food borne illness. Because of this it is difficult to ensure the food safety of animal products and reduce food borne diseases (Martins *et al*., 2012). These things might happen due to less awareness, knowledge, and attitudes of abattoir workers and the higher sectors were not administered by professionals or academics. That means abattoirs in the study area were directed by municipality administration rather than all concerning stakeholders and health authorities with the collaboration of other sectors. This study was in agreement with the study conducted by Gadisa *et al*. (2019) from Eastern Oromia. In present study most of workers or sixty four percent of the workers did not have access to medical checkup and health certificate this might results in potential source of public health hazards such as diarrhea, sore throat, fever, cold or open skin lesions. However, health checkups for slaughterhouse workers at the time of employment and every six months were reported in Bishoftu, Ethiopia (Aynewa *et al*. 2021).

In most scientific research findings state that meat handlers are the common sources of contamination due to this reason wearing proper personal protective clothing protects the meat from contamination. A substantial percentages of the slaughterhouse workers wore their personal protective clothes and head cover among those participants infrequently (35.6%) of them could wear and keep hygienic condition of their clothes which was higher to report of Bersisa *et al*. (2019) (29%) not wear their protective garments but lower to Aynewa *et al*. (2021) from Bishoftu. Therefore, correct practices of using aprons, white coats, boots, and hair masking was appropriate at each slaughterhouse and it was critical to shield both the personnel and the meat from exposure to pathogens. To produce wholesome and fit meat for human consumption, the slaughter house building should be well build free from cracked floors and water proof, well maintained and thoroughly wiped clean and disinfect immediately after slaughter. Therefore, establishment of abattoirs with important centers and good infrastructure enhances the hygienic manufacturing of meat especially in government- based municipal abattoirs in Ethiopia.

In the current study, all the three town municipal abattoirs were cleaned daily by only cold water. In addition to this no demarcation and regular meat inspection in the slaughter houses with lower number or eight percent meat inspectors from total participants was observed during my study period. In fact, it was reported that many slaughterhouses and slaughter slabs in developing countries are poorly designed and have insufficient slaughter as well as meat inspection amenities. In addition to this, qualified meat inspectors are always in short supply (Komba *et al*., 2012). Moreover, performing skinning and evisceration on the ground without separating the dirty and clean areas increases the risk of cross contamination during meat processing, putting meat consumers at risk of food borne illness. The abattoir work is obviously need physical strength and energy to restrain animals for slaughtering process, deboning and evisceration for long time. Due to this reason the entire three town municipal abattoir workers the majority were male (91%) followed by only (9%) female.

Training and education of abattoir workers about meat safety and good hygienic production and practices are key point in keeping the quality of meat to consumers. The

previous reports of Adams *et al*. (2024) on training and education of meat handlers regarding to basic concepts and personal hygienic condition plays great role in ensuring safe meat product for consumers. But current study shows most of the workers did not have access for training and minor (34.09%) participants had accomplished high school level education this opposes the previous aforementioned study of Adams and his members. But present study agrees with previous findings that have found meat handlers to be more trained in meat hygiene (Haileselassie *et al*., 2013; Gutema *et al*., 2021).

From the interviewed participants only (18.9%) in slaughter houses in case for inspection of meat wore hand gloves only during handling of meat. But the previous study investigated the use of gloves might protect the meat from contamination by abattoir workers (Alhaji and Baiwa, 2015). In countries where the frequent change of gloves is economically not feasible like in Ethiopia, instead of this frequent hand washing with soap and hot water is an effective measure to prevent cross contamination of meat.At the slaughter houses of this study the habit of wearing boots, personal protective clothes and hand washing practices were good but not in well manner. These practices are important to protect both the personnel and the meat from exposure to pathogens (Nel, *et al*., 2004).Microbial contamination of meat depends on condition of slaughtering animals prior to slaughtering. The common sources for microbial contamination of meat might be from the slaughtering animals (skins, hides and gastro-intestinal tract), workers hands, equipment, air and water. Hence the level of microbial contaminations of a carcass at this stage depends up on the degree of sanitation practiced during the slaughtering-dressing procedures.

From the food and agricultural organization reports total viable plate counts, total coliform count and total staphylococcus count exceeding 5 log 10 cfu/cm^2, 2 log10 cfu/cm^2 and 2 log10 cfu/cm^2 on fresh meat are not acceptable on meat hygiene (Mohammed *et al*., 2014). But in this study the results contrast to this statement and the finding was greater than the conducted research of Mohammed and his colleagues (2014). In addition to this different study the acceptable limits of meat samples of total viable counts, total coliform count and total staphylococcus count counts are blow 5 log10 cfu/cm^2, 2 log10 cfu/cm^2 and) 2 log10 cfu/cm^2 respectively. But more than the

acceptable level of bacterial count is under the group of unacceptable ranges (FAO, 2007).

In opposite to this the current study area result indicated above to acceptable load counts from swab samples of different sample type. This study result agreed with the findings conducted from Debre Berhan by Atlabechew and Mamo (2021). In this study finding, the mean total viable count, total coliform count and total staphylococcus count from swab samples were 7.3 log10 cfu/cm^2, 7.01 log10 cfu/cm^2 and 6.4 log10 cfu/$cm^2$from workers hands and carcass surfaces respectively. The result revealed that the carcass surfaces and worker hands swab samples were contaminated by pathogenic and spoilage bacteria due to unhygienic practices in the abattoir operation including unsterilized equipment (knives) used.

On the other way, this result of contact surfaces swab samples was 7.3, 7.01, 6.7 log10 cfu/$cm^2$from workers hands, carcass surface, hooks and knifes of Hossana, Worabe and Durame town municipal abattoirs and butcher shops respectively for total viable count. For total coliform count results 6.6, 7.1 and 6.7 log10 cfu/cm^2 from Hosanna town municipal abattoir carcass surface, workers hand and butcher shop meat cutting knifes, respectively. The result for total staphylococcus count 6.4, 6.07 and 6.1log10 cfu/cm^2 from Worabe town municipal abattoir workers hand, Durame town municipal abattoir carcass surface and Hosanna town municipal abattoir hooks and knives respectively. To prevent the occurrence of food borne illness and spoilages of meat the important thing is keeping the meat safety and good hygienic condition.

Total viable count was used to indicate the general bacterial load on meat is useful tool to monitoring food safety. This study finding shows the highest mean log values in abattoir were 7.3l cfu/cm^2 from workers hand, 7.01 cfu/cm^2 from carcasses surfaces and 7.2 cfu/$cm^2$from Hossana and Worabe town municipal abattoirs and butcher shops. From result of this study higher total viable count from all sample types in comparison to 5.04 log 10 cfu/cm^2 from Tanzania conducted by Ntanga *et al*. (2014), 4.4 log 10 cfu/cm^2 from Algeria by Amine *et al*. (2014), 4.5 log10 cfu/$cm^2$from Eastern Cape, South Africa on carcass and 5.80 log10 cfu/$cm^2$from India by Bhandare and his colleagues (2009).

In the countryside, the finding of total viable count was higher in the study reported by Gebeyahu *et al*. (2013) (5.2 log 10 cfu/cm^2) from Adama town and 4.79 log10 log 10 cfu/$cm^2$from Gullele Sub-City by Zerabruk (2017). The observed differences in microbial load in various studies were due to lack of good hygienic processing practices and hygienic standard operating procedures along meat production chain which was observed through the questionnaire survey. The high total viable count obtained from abattoir workers hand in this study is an indication of ineffective and inadequate washing of their hands by clean water and soap. They are also indicators of fecal pollution from slaughtering animal's skin during skinning, during evisceration and washing, contamination from intestinal contents as well as from rinsing and washing of carcasses by water.

The highest mean values for total coliform count 7.1 log10 cfu/$cm^2$and were observed on from workers hand this could be the poor hygienic hand washing that cause meat contamination. This result contrast the study done by Tarwate *et al*. (1993) reported 5.9 log10 cfu/cm^2 from meat cutting knifes. They are also indicators of fecal pollution from slaughtering animal's skin during skinning, evisceration and washing, contamination from intestinal contents as well as from rinsing and washing of carcasses by water. In present study the results obtained from all sample types are higher which exceeds from recommended set standards of coliform bacteria counts less than 2 log 10 cfu/cm^2 by food and agricultural organization (FAO, 2007) that is not acceptable and meat hygiene along the production chain must be improved. The total Staphylococci count can be taken as index of sanitary conditions under which meat and its products are manufactured and handled. Staphylococci can be carried on hands, nasal passage or throats. Most food borne illness out breaks is originated as a result of contamination from meat handlers and production of heat stable toxins in meat (Potter, 2001).

From result of this study, also the mean total staphylococci count found from 6.4, 6.3and 6.2 log10 cfu/cm^2workers hand, cutting table, and hooks and knifes, respectively. These results could best be explained by poor hygienic practices and how the meat was handled in the abattoir and also agrees with previous study results of 6.18 log10 cfu/cm^2 from

carcass surfaces Adetunde *et al*., 2011). However, this contradicts results which reported that the mean values of microbial load of abattoir meat were low (5.04 log cfu/cm^2) (Haileselassie, *et al*., 2013). Similar higher staphylococcus species load was reported from Addis Ababa and Adama towns of Ethiopia (Gebeyehu *et al*., 2013; Teshome *et al*. 2020). Staphylococcus species count reported in the present study was higher than the standard set by Codex Alimentary Commission (CAC, 2005).

The current study mean total staphylococci count noticed from workers hand, cutting table, hooks and knifes were 6.4, 6.3 and 6.2 log 10 cfu/cm^2, respectively indicates unacceptable hygienic standards particularly poor personal hygiene. The mean total staphylococci count noticed from the knife, cutting table, and weighing balance were 4.81, 4.16, and 3.98 log10 cfu/cm^2, respectively recorded from meat contact in the United Kingdom was lower than the current study the differences in mean count between the two countries may indicate variation in personal hygiene practices. *Staphylococcus species* can be part of normal flora on the skin of humans and animals which can be transmitted from person to product through unhygienic practices (Postgate, 2000).

There was no significant difference between the sample collection areas in terms of the mean bacterial load result increment ($p>0.05$). There was a significant difference between Hosanna and Durame town municipal abattoirs and butcher shops for total vial count ($p<0.05$). But there was no significant difference between Hosanna and Durame for total vial count and also for total coliform count and total staphylococcus count between all town municipal abattoirs and butcher shops. The reason for this might be resulted from variation of hygienic, sanitary practices and contamination level of each abattoirs and butcher shops described in (Table 11). High mean microbial contamination of meat resulted from unhygienic slaughtering practices, lack of hot water, cooling facilities, lack of proper utilization of personal protective clothes, lack different operational units, and lack of sterilization of utensils.

In order to produce safe meat there is need of good sanitary operation, good animal husbandry, good handling and processing of meat, good habit of hand washing, sanitary standardized operating procedures and hazard analysis critical control point system along

meat production chain (Larson *et al*., 2003). Generally, in present study area abattoirs and butcher shops bacterial load results indicate above the acceptable level. According to the European Safety Authority, the limit for total viable should be less than 5 log 10 cfu/ cm^2, for total coliform count (enterobacteriaceae) less than 2 log 10 cfu/cm^2,and staphylococci less than 2 log cfu/cm^2 for beef carcasses (EFSA, 2011). However, the drawback for this study was the selected pathogens for assessing microbial contamination in meat supply and production chain gives valuable information about general microbial load and hygienic conditions. But it does not exhaust all potential public health important pathogens that cause significant public health risk. These limitations were related to financial, laboratory reagents and chemicals scarcity for isolation, characterization and identification of common public health important bacteria from the colony forming units.

6. CONCLUSSION AND RECOMMENDATION

This study indicated that the existing municipal abattoirs in the study area lack basic abattoir facilities; the abattoir with poor hygienic practices, poor personal hygiene and sanitation, inadequate knowledge and awareness in zoonosis and food borne illness of workers. The lower educational status of workers and lack of training on food safety, poor sanitary condition of abattoirs which was predominant factors for meat contamination and compromise the quality of meat and meat products. In addition to this there were no sterilization facilities, hot water provision for workers hand wash and knives dipping, and no veterinary laboratory facility. The obtained results from this study shows considerably high bacterial load compared to the acceptable level that leads public health risk. The poor hygienic and physical status of abattoir and butcher shops and the dressing of carcasses on the floor, low level of abattoirs sanitation and hygiene were responsible for high bacterial load count. The results higher microbial log mean values total viable count, total coliform count and total staphylococcus count from tested samples are the indication of poor meat quality and making it as sources for food borne illness and meat spoilages. Estimation for contamination was from the abattoirs to butcher shops. However, contaminants might occur also during transportation of meat from abattoirs to butcheries and within butcher shops where they sold to consumers. Thus meats produced in the study area were contaminated before reaching consumers hand. Therefore, hygienic production and supply of meat are important to reduce adverse public health risk, zoonosis and meat spoilages and cross contamination.

Based on these findings, the following recommendations were put forwarded:

- In order to avoid adverse health effect of public the Municipal authority should relocate the abattoirs to new area.
- Training of abattoir workers is recommended on meat safety including keeping personal hygiene, slaughtering practices, zoonosis and sanitary measures to be followed.
- Guidelines, policies and regulation regarding meat safety at all stages of production at abattoir and butcher shop part of meat supply chain should be prepared and enforced to produce safe, suit and wholesome meat to consumers.

- The use of wooden meat cutting boards in butcher shops should be discouraged because it harbors microorganisms and accumulate organic wastes.
- Further studies on the assessment of microbial contamination in meat supply and production chain including all public health significant pathogens combined with isolation and characterization of the isolates should be done.

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8. ANNEXES

Annex 1: Questionnaire for abattoir workers

ADDIS ABABA UNIVERSITY

COLLEGE OF VETERINARY MEDICINE AND AGRICULTURE

Title: Assessment of physical, functional, hygienic status and bacteriological quality of meat in selected municipal abattoirs and butcher shops in the Central Ethiopian Region.

Formal survey questionnaires on meat hygienic practices, physical and functional status of municipal abattoirs and butcher shops in Central Ethiopian Region

Date: _____

Name of zone: _____

Part 1.1: Demographic characteristics of respondents

1. Name of respondents ----------
2. Respondents' gender: Female ☐ Male ☐
3. Participants' age in year's group: 18 to 30 ☐ From 31 to 40 ☐ Over 40 ☐
4. Religious status of respondents: Orthodox ☐Protestant ☐Muslim ☐
5. Respondents' level of education: Doctor of veterinary medicine ☐ Illiterate ☐ Bachelor of Science (degree) ☐ Diploma☐ Elementary school ☐ High School ☐
6. The respondents' occupation: Employee of the abattoir ☐ Employee of a butcher shop ☐ Owner of a butcher shop ☐
7. Job responsibility in abattoir: Cleaner ☐ Slaughterer ☐ Meat distributor ☐ Supervisor ☐ Meat inspector☐

Part1.1: Meat hygienic practice related questions administered to participants

1. Do you wear a head covering? Yes ☐ No☐

2. Do you wear personal protective equipment when working in an abattoir? Yes ☐ No ☐

3. If so, how many personal protective garments do you own?

Single ☐ Two ☐ More than two ☐

4. What kind of footwear do you wear when working in an abattoir?

Sandals open ☐ Rubber boots☐

5. Do you have access to training for your job in the abattoir? Yes ☐ No ☐

6. If so, the training frequency is Monthly ☐Not supplied ☐ Twice annually ☐ Every year ☐

7. Before and after work, do you thoroughly clean the workspace? Never ☐Infrequently☐ Occasionally ☐Always ☐

8. Do you thoroughly clean your equipment both before and after use? Never ☐Infrequently☐ Occasionally ☐Always ☐

9. Do you properly clean your protective gear? Never ☐Infrequently☐ Occasionally ☐Always ☐

10. When you return to work after taking a break, do you wash your hands? Never ☐ Seldom ☐ Even Occasionally ☐ Constantly ☐

11. When your hands get dirty, do you wash them? Never ☐ Seldom ☐ Occasionally ☐ Constantly ☐

12. When you use the toilet, do you wash your hands? Never ☐ Seldom ☐ Occasionally ☐ Constantly ☐

13. When working, do you wear gloves? Never ☐Infrequently☐ Occasionally ☐Always

14. When working, do you wear jewelry? Never ☐Infrequently☐ Occasionally ☐Always

15. Do you wear a hat to work? Never ☐Infrequently☐ Occasionally ☐Always ☐

16. Do you follow cleaning procedures when processing? Yes ☐ No ☐

17. During processing, do you remove solid waste? Yes ☐ No ☐

18. Do your processing rooms have enough room? Yes ☐ No ☐

19. How frequently do you get checked out by a doctor? Every six months ☐ Every month Each year☐ Absolutely not ☐

20. Are you aware of zoonosis? Yes ☐ No ☐

21. Are you aware of food-borne illnesses? Yes ☐ No ☐

Annex 2: Observational assessment check list of the abattoirs and butcher shops.

Part 1.3: Hygienic practices of abattoirs, practices of workers and their infrastructures

Number	Assessment criteria	Municipal abattoirs		
		Hosaina Yes/No	Durame Yes/No	Worabe Yes/No
1	Abattoir location or site			
1.1	Far from residential area			
1.2	Far from industry			
1.3	Far from crop farms			
1.4	Free from flooding, provided with perimeter fence and vegetation is controlled			
1.5	Free from dust, objectionable odor and ash			
1.6	Free access to the road connecting to the plant			
1.7	Grounds compact with gravel and good housing			
2	Building and general arrangement of premises			
2.1	Lairage and have drain path way			
2.3	Separate entrance for clean and dirty area			
2.4	Separate entrance of personnel and exit of product			
2.5	Production areas allow enough working space and one way processing flow			
2.6	Each production areas are physically separated as required			
2.7	Provide production space for specific activity different from other activity			
2.8	Fence that takes the animal to the place of slaughter			
2.9	Separated from the slaughter area and isolation pens for sick animals			
2.10	Rooms in slaughterhouses for cleaning and			

	treatment of intestines and offal, storage, disposal, treatment of inedible and condemned animals, carcasses and meat			
3	Design and construction of floors and ceilings			
3.1	Impervious to water, made of non-slip material and can be easily cleaned			
3.2	Resistant to wear and corrosion			
3.3	Proper floor-wall joint, properly constructed and in good repair			
3.4	Sufficient height to permit carcasses to hang into prevent touching the floor			
3.5	Free of ledges over the work surfaces, kept clean and prevent accumulation of flakes			
4	Sanitation standards and operating procedures			
4.1	Safety and supply of water			
4.2	Condition and cleanliness of meat contact surfaces			
4.3	Cleaning and sanitizing records			
4.4	Stunning box present or not			
4.5	Non meat contact surfaces and prevention of cross-contamination			
4.6	Personnel's protective equipment's, practices and habits			
4.7	Well drainage system and good lighting			
4.8	Footbath, veterinary laboratory and office			
4.9	Laboratory results			
5	Maintenance of hand washing, sanitizing and toilet facilities			
5.1	Hand washing facilities			
5.2	Toilet facilities			
5.3	Sanitizing facilities and cleaning chemicals (insecticides and rodenticides)			
5.4	Labeling , storage and use of toxic chemicals			
6	Slaughtering facilities and other production areas			
6.1	Uploading and holding pen			
6.2	Cleaning facilities for live transport carrier and meat delivery system			
6.3	Live transport carrier and meat delivery vans			
6.4	Meat inspection station			
6.5	Deboning, cutting and packing area			
6.6	Refrigeration and freezing facilities			
6.7	Programming, documentation and recording			
7	Hygienic practices of abattoir workers			
7.1	Hygiene of meat handlers			
7.2	Meat handlers wash hands before commencing			

	work/prior to handling meat			
7.3	Use of gloves when meat is handled			
7.4	Hair is tied back and hair net/cap is used			
7.5	Use of waterproof boots for footwear			
7.6	Protective clothes are long-sleeved and completely cover personal clothes			
7.7	Staff wears watch/jewelry while meat is handled			

Part 3.2: Hygienic practices of butcher shops and butcheries

No.	**Assessment criteria**	**Butcher shops**		
		Hosaina Yes/No	**Durame Yes/No**	**Worabe Yes/No**
1	Same personal protective cloth is used for different activities in the shop/butchery			
2	Persons handling meat also handle money			
3	Staff preparing and handling raw meat is separate from staff preparing and handling ready to eat meat			
4	Cleanliness of working clothes and recent dirt on working clothes			
5	Structure of shop/butchery including walls, floors, ceilings and fixtures are in good condition and will not yield cross contamination			
6	Counter and hooks of butchery/shop are clean			
7	Cutting tables contain non-harmful materials (rust, mold), disposable paper towels are available			
8	There is a safe water supply to the butchery/shop			
9	Clean equipment such as weighing scales, mincers and slicers are separately used for raw meat and ready to eat meat			
10	Waste is confined, managed and properly disposed			
11	Cleaning cloths and detergents are stored in sight			
12	Pest control devices are available			
13	Display of meat			

14	Meat of different species are physically separated and are in same window display			
15	Meat appears red in color and has no unpleasant odor			
16	Meat appears dark brown/discolored and has a strong odor			

Annex3: Sampling points, sample size and surface sampling area in abattoirs and butcher shops.

Sample type(swab)	**Abattoir**			**Butcher shop**			**Total**	**Area**
	Hosana	Worabe	Durame	Hosana	Worabe	Durame		
Carcass surface	5	5	5				15	$20cm^2$
Workers hand	5	5	5				15	Both hands
Hooks and knifes	5	5	5				15	Both sides of knifes
Cutting table				4	4	4	12	$20cm^2$
Cutting knifes				6	4	4	14	$20cm^2$
Total	15	15	15	10	8	8	71	

Part 3.3: Materials for serial dilution and for plating purposes

Materials for preparation of serial dilutions: (A) stock solution (swab sample), (B) 10-mL screw cap vials with label, (C) Racks , (D) pipettor tips, (E) pipettor, (F) Sterile swabs (G) prepared agar plats for general bacterial load and MacCOkeny agar for coli form count (H) disposable nitrile gloves, (I) disposable mask , sterile Petri-dishes and sterile cotton stick swab.

Part 3.4: Procedures for sample collection and enumeration

1. Transport the sample with an ice box and store into refrigerator till processing
2. Serial dilution will be made up to 10^7

3. Preparation of plate count agar, MacCokeny agar and manitol salt agar media and culture bacteria by using sterile cotton stick swab on solidified culture media.

4. After solidifying incubate for 24 hours and then count by using colony counter

Part 3.5: Procedures of bacterial load count

7 test tubes was taken and labeled one up to 7

9 ml of saline/peptone water Poured to these test tubes

1 ml aliquot of the stock solution (swab sample) is added to tube 1 which contains 9 ml of distil water the product of this mixture is $solution_1$

1 ml of solution from test tube 1 transferred to test tube 2 and mixed well

1 ml of solution from test tube 2 transferred to test tube 3 and mixed well

Repeat by aliquoting 1 ml of the newly created $solution_1$ and adding it to tube 1- 7 tubes.

Similar preparation of sterile Petri dish equaled to the test tube, labeling each petri dish, added 1ml of the preparing 1:9ml diluting sample into the petri dish up to seven and pours on the plate count agar on it.

After spread on solidified media finally incubated at 37^0 c for 24 hours and counting by using colony counter ranging from 30-300 cfu/cm^2 for plate agar and manitol salt agar and 15-150 cfu/cm^2 for MacConkey.

Annex 4: Photos captured during observation, sample collection and laboratory works.

(A) (B)

Figure 1: Hosanna town municipal abattoir lairage (A), open liquid waste drainage trench of Hosanna town municipal abattoir (B).

(C) (D)

Figure 2: Worabe town municipal abattoir lariage (C), wild animals and birds in Worabe town municipal abattoir compound (D)

(E) (F)

Figure 3: Water tanker and slaughter hall of Hosanna town municipal abattoir (E), Water tanker and slaughter hall of Worabe town municipal abattoir tanker (F).

(G) (H)

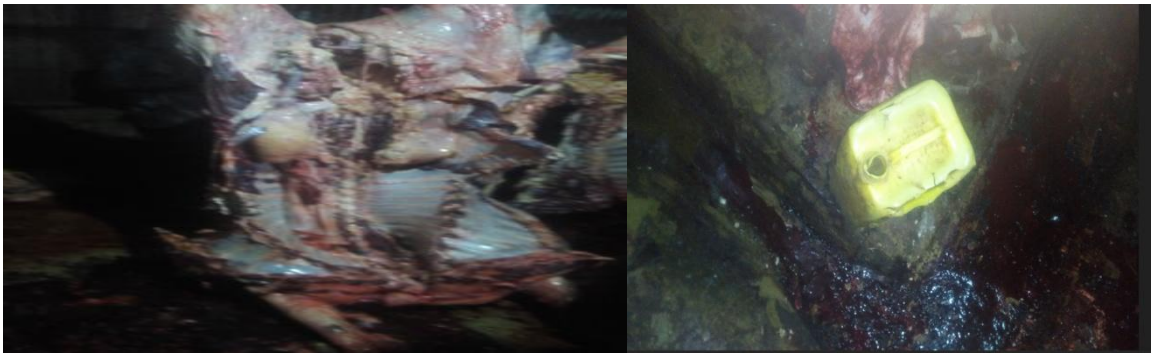
Figure 4: Slaughtering of animals on bare poor hygienic floor in Worabe town municipal abattoir (G), inspection of red offal's in poor hygienic floor of Worabe town municipal abattoir (H).

(I) (J)

Figure 5: Dirty hooks and ceiling/wall of Hosanna town municipal abattoir (I), dirty rail system of Hosanna town municipal abattoir and (J).

(K) (L)

Figure 6: Cracked dirty floor of Hosanna town municipal abattoir(K), slaugthering of animals without water in Durame town municipal abattoir(L).



(M) (N)

Figure 7: Inadequate light for post-mortem examination of meat in Hossana town municipal abattoir (M), improper supply of water with plastic jerkin and scarcity for slaughtering processes for Hossana town municipal abattoir (N).

(O) (P)

Figure 8: Meat cutting in Hosanna town butcher shop without head covering (O), meat handling and cutting with fly trap that pose for cross- contamination in Worabe town butcher shop (P).

(Q) (R)

Figure 9: Dirty wood meat cutting table, and knifes in butcher shops of Hosanna town (Q), dark, pale and dry meat that stays without refrigeration of left over in butcher shops of Hosanna town (R).

(S) (T)

Figure 10: Flaying and evisceration of meat handling without wearing personal protective equipments on a bare untidy floor in Worabe municipal abattoir that expose for cross-contamination (S, T).

(U) (V)

Figure 11: The slaughter hall of Worabe town municipal abattoir (U), non-functional fencing with uncontrolled plant of Worabe town municipal abattoir in this study period (V).

(W) (X)

Figure 12: Dirty meat cutting axis and meat transportation by horse cart (gari) from Durame town municipal abattoir (W, X).

(Y) (Z)

Figure 13: Improper solid and liquid waste management of Hosanna town municipal abattoir (Y), improper solid and liquid waste disposal from Durame town municipal abattoir (Z).

(1) (2)

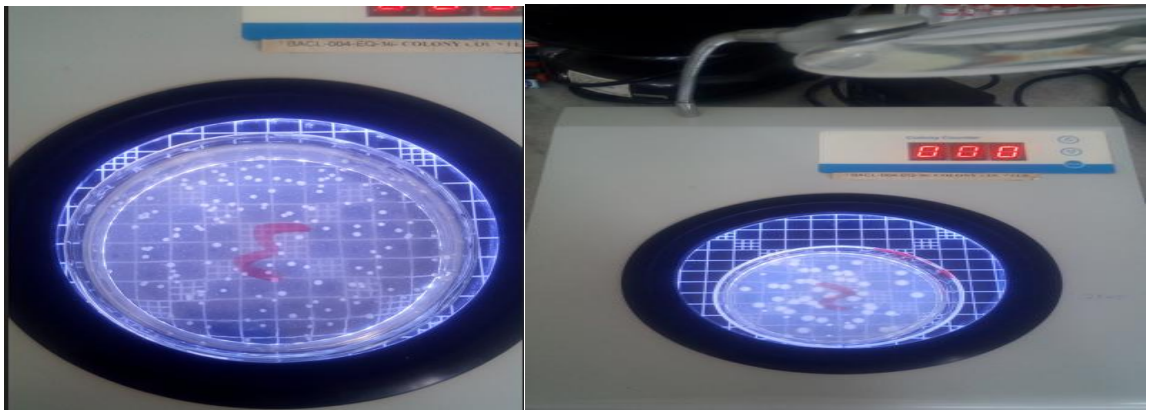
Figure 14: Media preparation (1). Utilized swab stick, micropipettes and its tips (2).

(3) (4) (5)

Figure 15: Swab sampling from carcass surfaces (3). Swab sampling from workers hand (4). Swab sampling from knifes of abattoir (5).

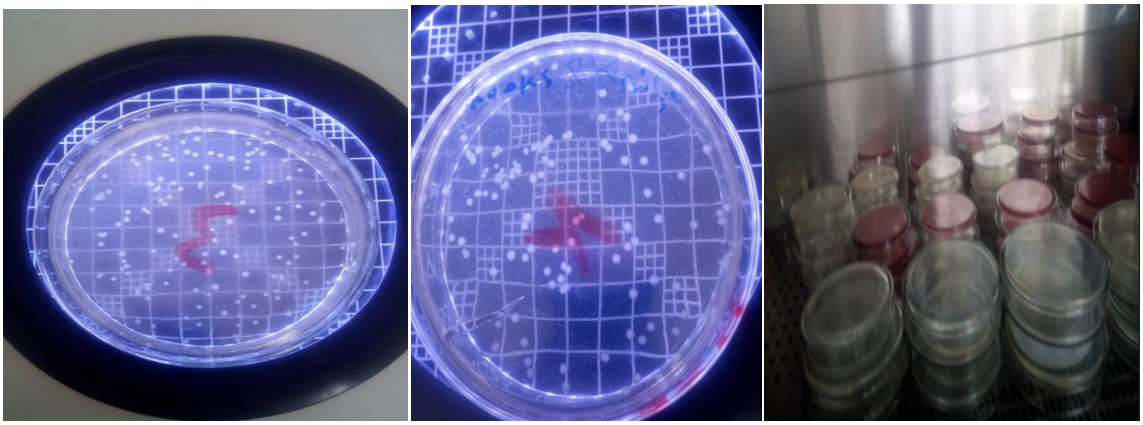
(6) (7) (8)

Figure 16: Swab sampling from meat cutting board of butcher shops (6 and 7). Swab sampling from meat cutting knife of butcher shops (8).



(9) (10)

Figure 17: Typical grown colony forming unit of total viable count in nutrient agar media from workers hand swab sample labeled three (9).Typical grown colony forming unit of total viable count in nutrient agar media from knife swab sample labeled 2 (10).



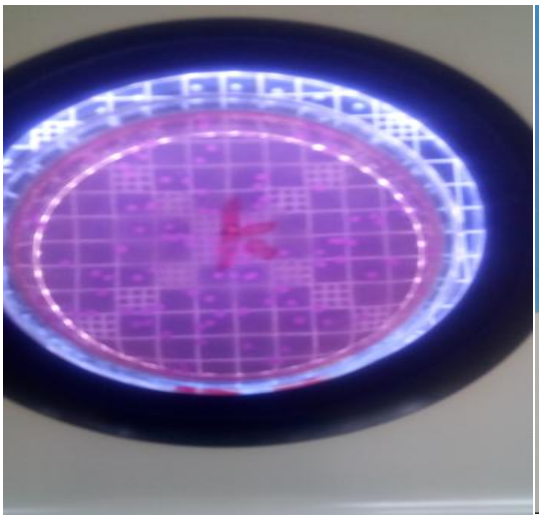
(11) (12)

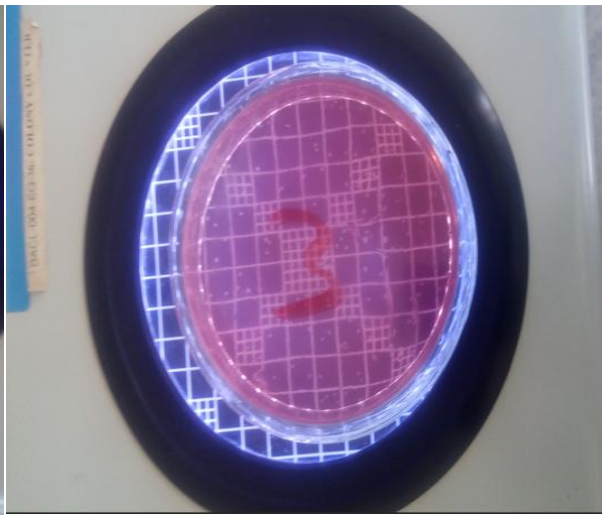
Figure 18: Typical grown colony forming unit of total viable count in nutrient agar media from workers hand swab sample labeled k (11). Prepared culture MacConkey, Nutrient and Mantol salt agar media under biological safety cabinet (12).

(13) (14)

(15) (16)

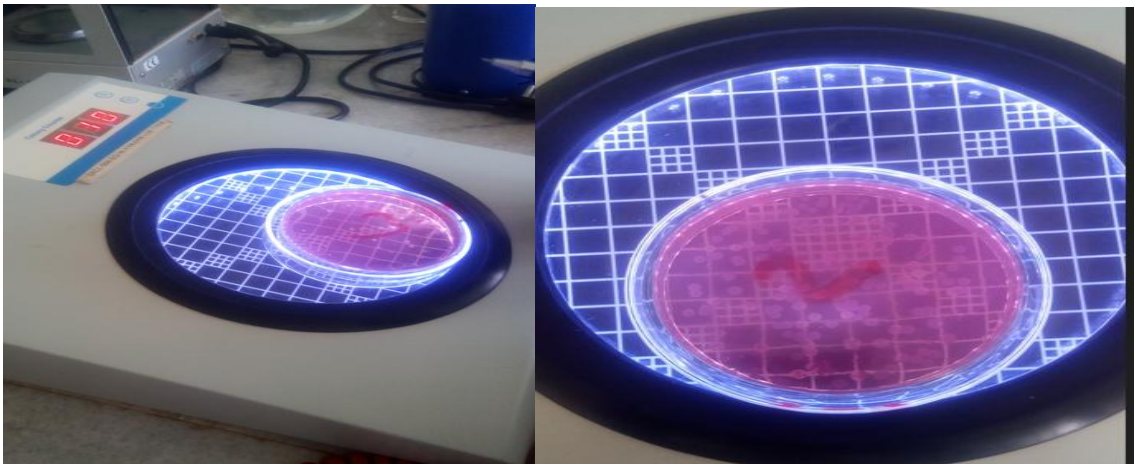
Figure 19: Dilution made from original stock to labeled tubes (13). Colony forming unit count by colony counter (14, 15). Spreading of bacteria on prepared media under biological safety cabinet (16).





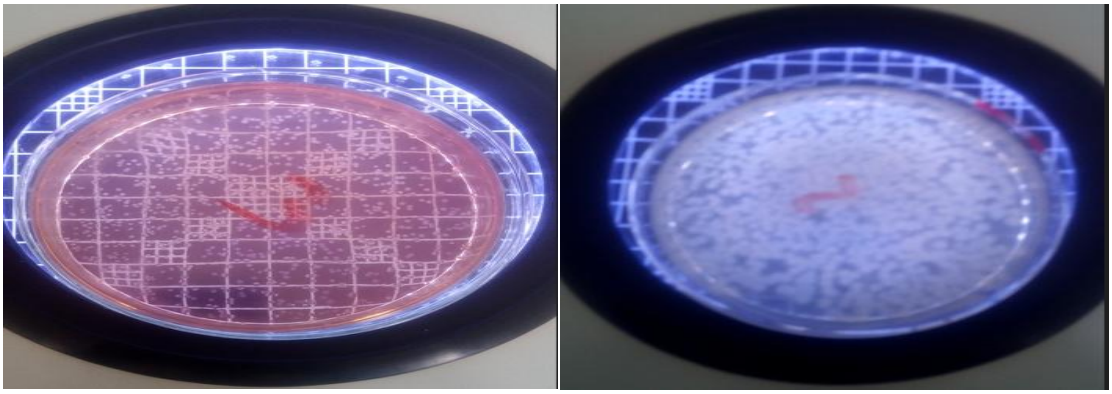
(17) (18)

Figure 20: Typical grown colony forming unit of total coliform count in MacConkey agar media from workers hand swab and carcass surface sample labeled as k and 3 respectively (17,18).



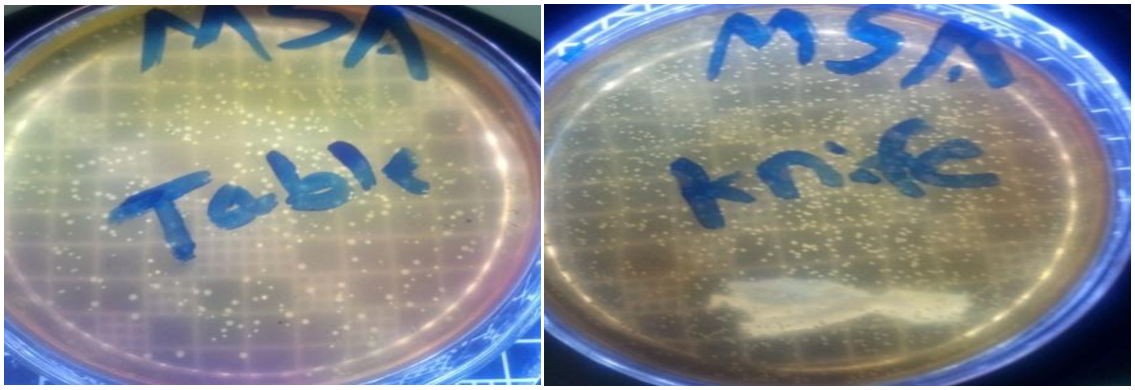
(19) (20)

Figure 21: Too low to count grown on MaConker agar media (19) and Too many to count grown on MaConker agar media (20, 21).



(21) (22)

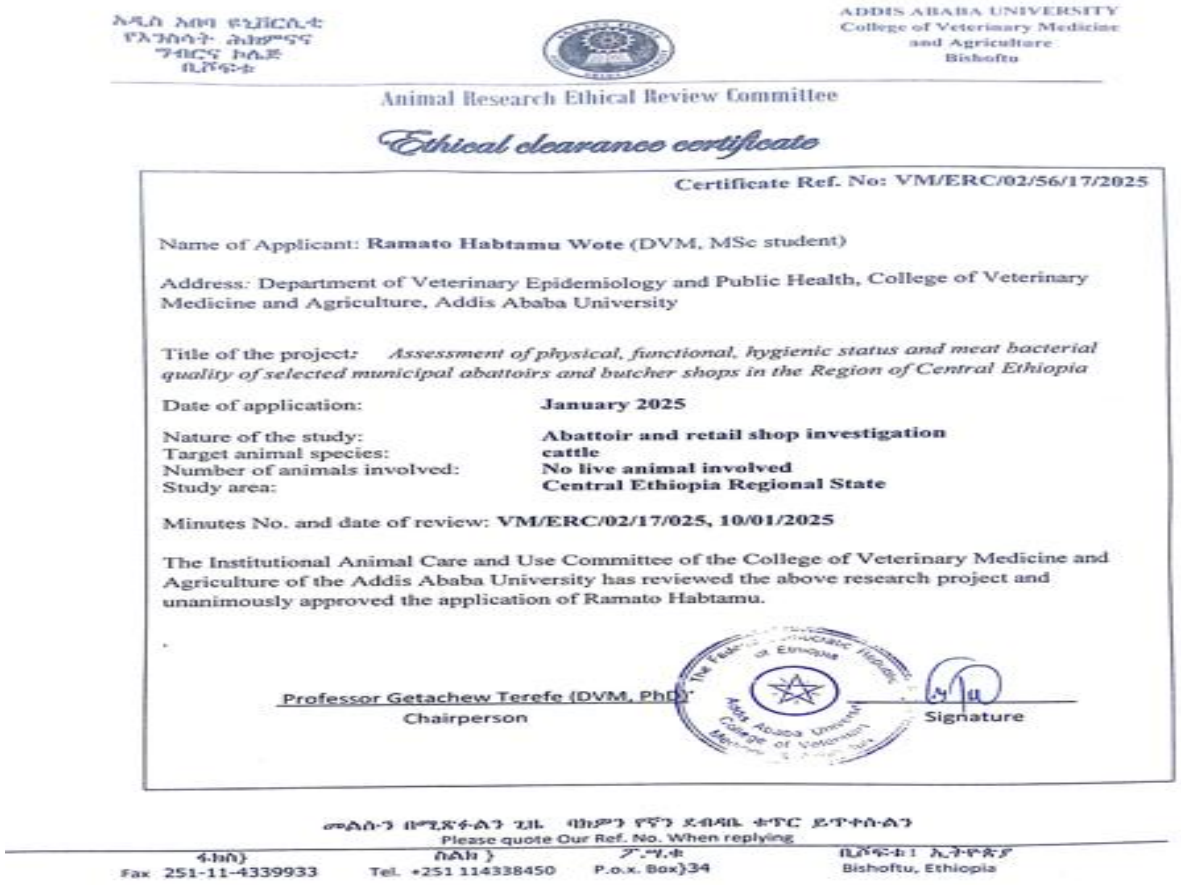
Figure 22: Too many to count colony forming units that grown on Nutrient agar media (22).



(23) (24)

Figure 23: Typical grown colony forming unit of total staphylococcus species count grown in manitol salt agar media sample from meat cutting table (23).Typical grown colony forming unit of total staphylococcus species count grown in manitol salt agar media sample from knife (24).

Annex 5: Animal research ethical clearance



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ADDIS ABABA UNIVERSITY
College of Veterinary Medicine
and Agriculture
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Animal Research Ethical Review Committee

Ethical clearance certificate

Certificate Ref. No: VM/ERC/02/56/17/2025

Name of Applicant: **Ramato Habtamu Wote** (DVM, MSc student)

Address: Department of Veterinary Epidemiology and Public Health, College of Veterinary Medicine and Agriculture, Addis Ababa University

Title of the project: *Assessment of physical, functional, hygienic status and meat bacterial quality of selected municipal abattoirs and butcher shops in the Region of Central Ethiopia*

Date of application: **January 2025**

Nature of the study: **Abattoir and retail shop investigation**
Target animal species: **cattle**
Number of animals involved: **No live animal involved**
Study area: **Central Ethiopia Regional State**

Minutes No. and date of review: **VM/ERC/02/17/025, 10/01/2025**

The Institutional Animal Care and Use Committee of the College of Veterinary Medicine and Agriculture of the Addis Ababa University has reviewed the above research project and unanimously approved the application of Ramato Habtamu.

Professor Getachew Terefe (DVM, PhD)
Chairperson

Signature

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Please quote Our Ref. No. When replying

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