CURRENT STATUS OF FOOD HYGIENE PRACTICE AND FOOD SAFETY SYSTEMS ALONG WITH MUNICIPAL ABATTOIRS IN ETHIOPIA.

ADVANCED TOPICS IN VETERINARY PUBLIC HEALTH

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CURRENT STATUS OF FOOD HYGIENE PRACTICE AND FOOD SAFETY SYSTEMS ALONG WITH MUNICIPAL ABATTOIRS IN ETHIOPIA

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APPROVAL SHEET

As a seminar advisor, I hereby certify that I have read and evaluated this review prepared under my guidance by Abdurazak Kadi Adem on title review on **current status of food hygiene practice and food safety systems along with municipal abattoirs in Ethiopia** I recommend that it can be submitted as fulfilling the review requirement.

Major advisor signature date

Mohammed Jafar _____ _____

As members of board examiners of the seminar open defense examination, we certify that we have read and evaluated the review prepared by Abdurazak Kadi Adem. We recommend that the review be accepted as fulfilling the review requirement for the post graduate seminar on current veterinary public health topics.

Internal examiner signature date

_____ _____ _____

Chair person

_____ _____ _____

Final approval and acceptance of the review is contingent upon the submission of comment from the board of final copy of CVM after inclusion of comments from board of examiners.

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ABBREVIATIONS AND ACRONYM

CSA	Central statistical agency
FAOSTAT	Food and Agricultural Organization of United Nation statistics
FSMA	Food Safety Modernization Article
GFP	Good Farming Practices
GHP	Good Hygiene Practices
GVP	Good Veterinary Practices
HACCP	Hazard Analysis Critical Control
NCC	National Codex Committee
QSAE	Quality and Standard Authority of Ethiopia
SNNPR	Southern Nation Nationality and People Region
TLU	Tropical Livestock Units
UAE	United Arab Emirates

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SUMMARY

Agricultural development in Ethiopia is considered an important issue dealt with by the Government and Animal production is an essential part of agricultural farming systems. Even though, livestock and meat production status is increasing yearly, Annual per capita of meat consumption in Ethiopia is less than 8.5 kg per person per year, which is the second-lowest in all of Africa. This has a serious impact on the entire livestock value chain from animal breeding up to meat production and consumption. There is low standard farming, veterinary service, and hygienic practice in the slaughtering chain starting from the farm up to preparation and consumption of animal origin food like meat. This results due to many factors such as the absence or scarcity of facilities at farm level, animal transportation, slaughterhouse and retail shop and restaurant. This study indicated that at country level, there is little information concerning public abattoirs found in the country, their facility and operation in conjunction with good hygienic practice in the plant up to the preparation of ready-to-eat food. Most animal products including meat are highly perishable due to bacterial load and handling methods. A cross-contamination from raw meat due to poor handling during production at abattoirs or transportation to retail shop, is a major cause of food borne disease in developing countries including Ethiopia. The food system in Ethiopia is not always as organized and developed as in other developed countries. The regulation of Ethiopian standard was prepared under the direction of the Agricultural and Food Technology Technical Committee and published by the quality and Standard Authority of Ethiopia (QSAE). However, the application of this regulation was not practical especially in public abattoirs. Food shortage and lack of appropriate food safety assurance systems are problems that have become obstacles to the Ethiopian economic development and public health safety. Therefore the public slaughterhouse status and their facility should be indicated by concerning body annually because the abattoirs are a place that is important for disease surveillance and control**.** Also the potential effects of primary production activities on the safety and suitability of food should be considered at all times.

Keywords: slaughterhouse, meat, food safety, public, standard, Ethiopia

1. INTRODUCTION

Agricultural development in Ethiopia is considered an important issue dealt with first by the government for stimulating an overall increase in economic activity, suppressing poverty, and achieving food security (Shapiro *et al.*, 2017). Animal production is an essential part of agricultural farming systems and has been contributing a great portion to the economy of the country. Now a day livestock herd found in Ethiopia is around 70 million cattle, 42.9 million sheep, 52.4 million goats, 2.2 million camels, and others (FAOSTAT, 2020). Meat is one of the most nutritious foods that humans can consume, particularly in terms of supplying high-quality protein (essential amino acids), minerals (iron), and essential vitamins worldwide. However, most animal products including meat are highly perishable due to bacterial load and handling methods (Kiani and Sun, 2011; Gebeyehu *et al.*, 2013). Meat quality is induced mainly by contributing factors such as producers, traders, abattoirs, butchers, processors, and consumers (Alemayehu, 2011). Good Farming Practices (GFP), Good Hygiene Practices (GHP), and Good Veterinary Practices (GVP) need to be implemented to fulfill animal welfare demands and minimize the spread of animal-specific pathogens and food safety-related hazards (Ninios *et al*., 2014).

A slaughterhouse is a place registered by the controlling authority for an inspection of animals, hygienic slaughtering, and the processing of meat products for human consumption (Akpabio *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). Similarly in Ethiopia, various abattoirs have different management and facilities (Mummed and Webb, 2015). According to (FAO, 2021a) report, Ethiopia is currently divided into 10 politically autonomous regional states and two chartered cities (Addis Ababa and Dire Dawa), 12 regional states, 72 zonal, and 810 districts. Even if there is no evidence it is assumed that each woreda in the country has at least one municipal abattoir. A study by (Gebretinsae, 2018) at Shire Enda Selassie municipal slaughterhouse indicated that publically owned small-scale abattoirs controlled by municipalities are the only legally registered meat producer in most of the towns of the Tigray region. Each municipality in the region has one abattoir that mainly slaughters cattle. However, (Eshetie *et al*. 2018) stated that in Ethiopia, there are over 300 local abattoirs that supply meat for

local consumption with different capacities and facilities all with low basic hygienic standards. Meat Hygiene and safety are usually less managed in many developing countries where meat for human consumption is approved based on visual inspection, if at all, without routine microbiological testing (Cook *et al*., 2017).

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 and Hamdi, 2009; Abebe *et al.*, 2020). The main possible sources of contamination are the exterior of the animal and its intestinal tract, contaminated working equipment in general, and personnel (Goja *et al.*, 2013). Serious foodborne disease outbreaks have occurred on every continent in the past decade, often amplified by globalized trade (Krivohlavek, 2018). Local incidents can quickly evolve into international emergencies due to the speed and range of product distribution (Chammem *et al*., 2018). The problem is severe in developing countries due to difficulties in securing optimal hygienic food handling practices (Idiris, 2021). Worldwide more than 600 million people are suffering from eating food contaminated with bacteria, viruses, parasites, toxins, or chemicals, and 420 thousand are estimated to die annually (Ezirigwe, 2018; FAO, 2019).

Food handlers in the food chain often have inadequate knowledge of food safety standard operations checklists (WHO, 2020a).Poor food hygiene and safety management starts on the farms where primary production takes place (Iro *et al*., 2020). Yet a large proportion of foodborne disease incidents are caused by foods improperly prepared or mishandled at home, in food service establishments, or at markets. Food safety is a fundamental public health concern, and achieving a safe food supply poses major challenges for national food safety officials. Changing global patterns of food production, international trade, technology, public expectations for health protection and many other factors have created an increasingly demanding environment in which food safety systems operate (Idiris, 2021). Ethiopian standard was prepared under the direction of the Agricultural and Food Technology Technical Committee and published by the quality and Standard Authority of Ethiopia (QSAE). However, the application of this regulation was not practical especially in public abattoirs in Ethiopia (Temesgen and Abdisa, 2015).

There is a huge number of studies conducted in the country mainly focusing on a major cause of organ condemnation and its economic loss which deals especially with parasitic disease and TB (Zeryehun and Alemu, 2017) at Hawasa municipal abattoirs, (Abatemam *et al*., 2018) at Jimma Municipal abattoirs, and (Molla *et al*., 2020) at Kombolcha ELFORD abattoir. Also, the study dealing with Antimicrobial susceptibility or Antimicrobial resistance of pathogenic foodborne bacteria and its isolation was carried out by (Beyene *et al*., 2016) at Asella, (Wabeto *et al.*, 2017) at Wolaita Sodo municipal abattoirs, and (Hagos *et al*., 2021) at Mekelle. Studies have been conducted focusing on the hygienic practice and safety of animal-origin food products, more or less included (Birhanu and Menda, 2017) at Gojjam, (Gadisa *et al.*, 2019) Adama, Dire Dawa, and Haramaya University, and (Gutema, Agga, *et al.*, 2021) at Bishoftu. However, the study conducted only focused on the physical facility, operation, and management practice or safety of beef but, no study specifies the status of hygienic practice for the slaughtering of beef, small ruminants, and camels in public slaughterhouses and the level of the food safety system, focusing on quality meat products in the country.

Therefore the objective of this review study is: To highlight hygienic practices among slaughterhouse in various public abattoir establishments in the country, To overview the public slaughterhouse facilities, pathogenic microbial most prevalent in the country in conjunction with contaminated meat during the procedure in the establishment or on transportation to retailor shop, and To highlight the food safety system of the country concerning meat hygiene as compared to international standards. Generally, to summarize the hygienic practice in a public slaughterhouse for the production of safe wholesome meat and food safety system of Ethiopia, a word mapping searching system is used. Also reference management was carried out by using Mendeley for decks tope var.1.19.8 software package.

2. REVIEW OF RELATED LITERATURE

2.1. Livestock and Meat Production in Ethiopia

2.1.1. Animal production and veterinary service

Agricultural development in Ethiopia is considered an important issue dealt with first by the government for stimulating an overall increase in economic activity, suppressing poverty, and achieving food security (Shapiro *et al.*, 2017). Animal production is an essential part of agriculture farming systems and has been contributing a great portion to the economy of the country. Now a day livestock herd found in Ethiopia is around 70 million cattle, 42.9 million sheep, 52.4 million goats, 2.2 million camels, and others (FAOSTAT, 2020). The Animal production systems are predominantly categorized as an agro-pastoral system in the lowlands, and a mixed crop-livestock system in the highlands. Traditionally, the fattening of animals in both systems concentrates on male animals and on females which are either infertile or have finished their reproductive cycle. In the lowland agro-pastoral system, grazing is the most common source of feed, with limited use of crop residues, whereas in the highland system, crop residues are the most important source of animal feed (Alemayehu, 2011).

According to (CSA, 2021), Meat animals are animals like beef cattle, small ruminants, and camels reared only for meat either for home consumption and/or for sale. In Ethiopia, more than 300 feedlots are opera, predominantly in East Shoa, Oromia (FAO, 2019). The sheep found in Ethiopia could fall into different breeds and types whose habitat ranges from tropical to temperate environments. Goats in the lowlands are highly valued and reared mainly for milk and meat production while in the highlands, goats are mainly kept for meat (Yami *et al*., 2008). Camel the most climate-resilient livestock, plays a significant role in the livelihood of pastoral and agro-pastoral communities in Ethiopia (Yirda *et al*., 2020). The camel is a multipurpose animal. It can be used for milk, meat, wool, transport, races, tourism, agricultural work, and beauty contests. Meat production is the only one of these purposes that requires the camel to be slaughtered (Faye, 2013).Ethiopia is currently divided into 10 politically autonomous regional states and two chartered cities (Addis Ababa and Dire Dawa). The public veterinary services are decentralized, according to this same political structure, in 12 regional states, 72 zonal and 810 district-based veterinary offices (or clinics), surrounded by a variable number of Animal Health Posts, ideally one post per three kebeles, which adds up to an estimated 5,300 posts. In terms of infrastructure access

versus livestock population, on average, one B-level clinic centers to 200,000 Tropical Livestock Units (TLU), one D-level clinic is for 34,000 TLU, and one veterinary pharmacy for 20,000 TLU (FAO, 2021a).The population density of livestock throughout the country showed in fig.1 as follows (Leta and Mesele, 2014)

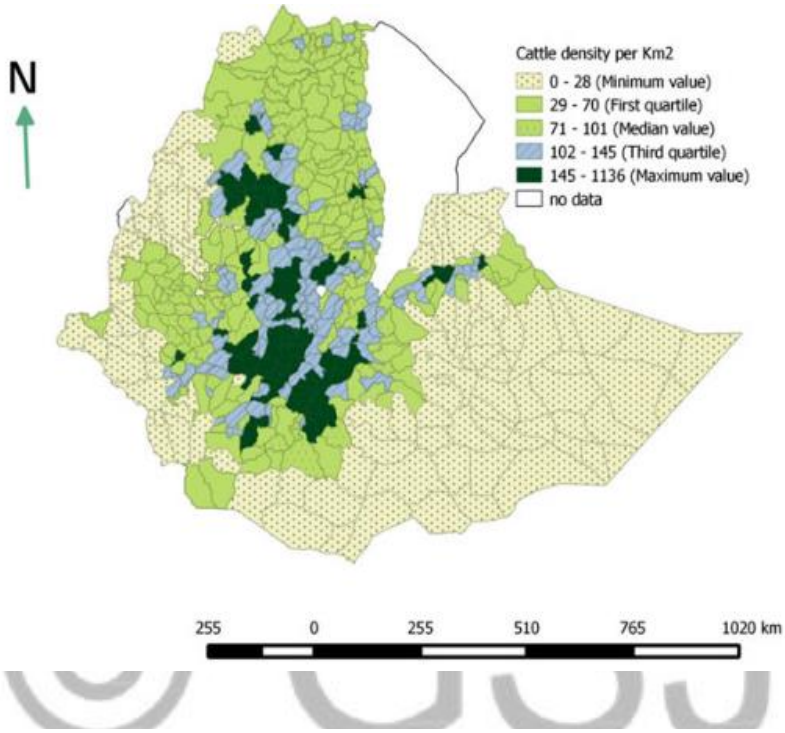

Figure 1: Map of Cattle population density per km2 (based on Agricultural sample survey 2012/13).

2.1.2 Meat production and marketing

Meat is normally regarded as the edible parts (muscle and offal) of the food animals which consume mainly grass and other arable crops (Collins and Huey, 2014). Meat is composed of lean tissue or muscle fiber cells, fat and connective tissue (Joo *et al.*, 2013). Meat is consumed in most parts of the world and it is regarded as a food with high nutritive value. It is a good source of protein, especially essential amino acids, fatty acids, minerals, and vitamins (Biswas and Mandal, 2020). Improving the safety of foods of animal origin involves guidance on good practices in animal feeding, animal husbandry, slaughter, and handling and processing of animal products. Annual per capita meat consumption in Ethiopia is less than 8.5 kg per person per year, which is the second-lowest in all of Africa (AGP-LMD., 2013).This has a serious impact on the entire livestock value chain from breeding to meat production.(FAO, 2019).

Camel meat is a relatively new, emerging meat type that is gaining increasing popularity in the international meat markets (Kadim *et al*., 2006). Dromedary camel slaughtering is rather difficult compared with that of other livestock because of the size of the animal and the amount of manual work involved. There are few specialized dromedary camels slaughtering plants in the world because of the limited production and the low per capita consumption of camel meat. Both male and female dromedary camels are slaughtered for meat, with more males slaughtered than females (Faye, 2013).

International meat prices declined in 2020 due to the impact of COVID-19, which temporarily curtailed meat demand by some leading consuming and importing countries given logistical hurdles, reduced food service, and reduced household spending due to lower incomes (FAO, 2020). Domestic meat consumption is segmented by taste, point of purchase, and cut. The domestic demand for meat increases during traditional and religious festivities. However, demand sharply declines during the fasting seasons of Orthodox Christianity, particularly in the 55 days before Easter festivities. The country's livestock and meat production status is increasing annually as indicated in the table.1 below (FAOSTAT, 2020).

Ethiopia has got more advantages to market livestock and livestock products to wider parts of the world than most African countries because of having diverse livestock resources to gather with its strategic location (Eshetie *et al*., 2018). Meat and live animals are exported to the Middle East and some African countries. Chilled/frozen beef, goat meat, mutton, chilled veal, chilled camel meat, and red offal are mainly exported to the United Arab Emirates (UAE), Saudi Arabia, Angola, Egypt, Bahrain, Turkey, and Kuwait. All of the exported meat is sold through formal channels, due to regulations of the importing countries. Live animals are exported to Somalia, Kenya, Sudan, Djibouti, Egypt, UAE, Saudi Arabia, and Yemen (Alemayehu, 2011).

Table 1. The status of livestock and meat production in Ethiopia (2016-2020)

Year	Species	Stock population	Slaughtered animal /head	Meat produce /tonnes	edible offal
2016	Cattle	59486667	3575831	387928	77586
	Sheep	30697942	9853967	98657	23678
	Goat	30200226	10098462	85789	24957
	Camel	1209321	140000	28050	7013
	Cattle	60392019	3579773	387928	77676
2017	Sheep	31302257	10034838	100461	24111
	Goat	32738385	10924592	92773	26988
	Camel	1418457	160000	29000	7250
2018	Cattle	61510258	3594643	387928	78019
	Sheep	33020392	10583310	105910	25418
	Goat	38963879	12975115	110190	32055
	Camel	1760870	200000	35538	8885
2019	Cattle	65354090	3764649	387928	81708
	Sheep	39894394	12790560	127991	30718
	Goat	50501672	16782397	142517	41460
	Camel	1827112	195763	36152	9038
2020	Cattle	70291776	3990324	387928	86605
	Sheep	42914865	13767007	137752	33061
	Goat	52463535	17398152	147741	42979
	Camel	1637223	221463	39768	9942

Source: (FAO/STAT. 2020)

2.1.3. Good Hygienic Practice along slaughtering process

2.1.3.1. Animal Transportation

Pre-slaughter handling refers to the interaction between humans and animals during the phases of preparation for transport, loading, transportation, unloading, lairage, and moving to the point of stunning (Lloveras *et al*., 2014). The slaughter animals were exposed to different conditions during production and transportation to abattoirs daily (Njisane and Muchenje, 2017). Animal welfare is an important pillar of sustainability in meat production and is associated with other aspects such as animal health, productivity, food safety, food quality, and efficiency from a cost of production (Velarde *et al*., 2015).

Almost all livestock in Ethiopia are transported by people on foot in rare cases during longer distances by un-designed vehicles like Isuzu, but usually not preferred since trekking is cheaper (Gebremedhin *et al.*, 2007). Traders prefer the vehicles, to avoid weight loss and declined body condition (Bulitta *et al.*, 2012) The education of the stakeholders during transport is varied and a license is only required in some areas of Ethiopia. In Tigray, Oromia, and Southern nations no license is needed for the transport of animals due to the difficulty to control the trading business as the traders are mobile from place to place (Gebremedhin *et al.*, 2007).

2.1.3.2. Lairaging

Lairage is a place where animals can lie down and rest to facilitate animals' recovery from transportation stress just before slaughter. It serves as a holding area to provide a reservoir of animals that are readily available to be taken for slaughter (Tarrant *et al*., 1992; Cockram, 2020). In lairage, animals need enough time to recover from transportation stress and other management practices of pre-slaughters (Chulayo *et al*., 2012). The timing of deliveries concerning the timing and speed of slaughter can increase the duration that animals need to be held in the lairage. Limitations on the capacity of a lairage can reduce the duration that animals can be kept before slaughter. Also, there are animal welfare, meat quality, and food safety issues that can influence this duration. The design capacity of a lairage is affected by the number and type of animals required to be present at any one time, the number and size of pens required for holding animals while the slaughter line is operational, the space required to provide facilities for resting, drinking and feeding overnight, and the capacity of

the ventilation system .Effective ventilation in the lairage is important to remove waste gases and avoid the build-up of metabolic heat and moisture in the lairage (Cockram, 2020).

Although lairaging is to enable animals to rest and recover from transportation stress, it can be a major cause of meat quality problems (Adzitey, 2011) Animals may also suffer from different degrees of bruising and injury as a result of fighting or overcrowding. Unhygienic lairage can also act as reservoirs of infectious pathogenic bacteria with the risk of carcass contamination (Warriss, 2003; Adzitey, 2011). Conditions in the lairage, therefore, need to be conducive to prevent infections and the animals from being stressed further after vigorous transportation (Gallo *et al.*, 2003; Addis, 2015).The management of the lairage is influenced by food safety protocols to reduce the risk of contamination of the meat with bacteria such as Escherichia coli O157, salmonella, and campylobacter (Cockram, 2020). Cleaning and disinfection procedures are undertaken in the lairage to reduce surface contamination (De Busser *et al*., 2013).

Ante-mortem inspection is an examination carried out on all animals before slaughter, aiming at identifying sick or abnormal animals before they are slaughtered. The inspection usually takes place within 24 hours, less than 24 hours before slaughter or at any other time when the official veterinarian requires it after animal arrival at the slaughterhouse (Ninios *et al.*, 2014). A veterinary inspection of meat for domestic consumption is mostly carried out by local district veterinary or veterinary para-professional staff to lower standards. Food safety controls and traceability of livestock products require attention (FAO, 2021). The finding of (Mummed and Webb, 2015) indicate that veterinarians inspect live animals some hours or a day before slaughter at Adama, Hawasa, and Mekelle municipal abattoir. Based on the anti-mortem inspection, animals were accepted, condemned, or remained for some more days of observation in the lairage. In the public abattoirs, animals reach abattoirs 2 to 3 h before slaughter (Mummed and Webb, 2015).

2.1.3.3. Operation and Facilities of the Abattoir

A slaughterhouse is a place registered by the controlling authority for an inspection of animals, hygienic slaughtering, and the processing of meat products for human consumption (Akpabio *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 with lockers, Laboratory, laundry, and toilet, (Obidegwu *et al*., 2019). Similarly in Ethiopia, various abattoirs have different management and facilities (Mummed and Webb, 2015). The following basic facilities are required for the slaughter of cattle, sheep, goats, and camel: Adequate lairage, large enough slaughter premises, a room for evisceration, rooms for the storage of fat, hides, horns, and hooves, room for edible offal, isolation room for sick or suspected animals, emergency slaughter room for such animals, the storage of detained meat and the storage of seized meat, chilling or refrigerating rooms, facility for the staff. In addition, a room for the samples for residue and disease surveillance, changing rooms, wash basins, showers and flush lavatories, materials for cleansing and disinfecting the hands, and hand towels. Facilities for veterinary, means of controlling access to and exit from the plant. Adequate separation between the clean and the contaminated parts of the building. Waterproof flooring which is easy to clean and disinfect, rat-proof and slightly sloping a suitable drainage system, washable coating or paint, adequate ventilation, and steam extraction, adequate natural or artificial lighting which does not distort colors or cause shadows, an adequate supply of hot potable water and wastewater disposal system. In the workrooms, adequate equipment for cleansing and disinfecting hands and tools. Equipment for dressing, where flaying is carried out on metal cradles and, an overhead system of rails for the further handling of the meat. Appropriate protection against pests, instruments, and working equipment of non-corrodible and easily cleaned material. A special section for manure, adjacent to the lairage and livestock lorry wash, a place, and adequate equipment for cleansing and the disinfecting vehicle should be present (Collins and Huey, 2014).

In Ethiopia the study conducted by (Haileselassie, Taddele, and Adhana, 2012) at Mekelle municipal abattoirs indicated that the abattoir has no basic facilities like stunning, bleeding, evisceration, and cooling rooms. Another study conducted at shire by (Gebretinsae, 2018) stated that the shire abattoir has one main building and one shed used for lairage. The main building has three compartments; the first two are used for slaughtering cattle, and the third is supposed to be used for slaughtering sheep and goats. The abattoir was equipped with hoisting and hanging systems and was designed for line slaughtering. However, these hanging and hoisting systems were not functional. The abattoirs lack showers as well as changing rooms. The result of (Teshome *et al*., 2020) indicated that there is poor hygienic conditions in slaughter house, transportation and butcher shops in Dukem, Burayu, and Kara public abattoirs . In private abattoirs the facilities are fulfilled. Lack of many facilities

in some public abattoirs in Ethiopia have been indicated in table 2 (Haileselassie, Taddele, Adhana, et al., 2012; Mummed and Webb, 2015; Gebretinsae, 2018).

Table 2 facility of some municipal abattoirs in Ethiopia

Public abattoirs	**Components of abattoir facilities**							
	Lairage	Stunning	Slab	Evisceration section	inspection section	carcass quartered	Water and electricity supply	
Adama	(+)	Knife	(+)	+	(+)	Manual	(+)	
H U	(+)	Knife	(+)	(-)	(+)	Manual	(+)	
Hawasa	(+)	Knife	(+)	(-)	(+)	Manual	(+)	
Mekelle	(+)	hammer	(+)	(-)	(+)	Manual	(-)	
Shire	(+)	Hammer	(+)	(-)	(+)	Manual	(-)	

Note that: (+) indicate the facility present, (-) indicate the facility absent or not found

The transfer of animals from lairage to slaughter hall is easy if the abattoir is well designed. The size and type of slaughter hall depend upon the species to be slaughtered, the maximum possible capacity, and the slaughter and dressing systems to be adopted. Cattle and sheep can readily be driven up a ramp. Sufficient space must be provided to allow hygienic processing, to avoid cross-contamination. The Stunning area is the area in front of the stunning pen where the bovine animal falls should be at least 3m in width to the opposing wall or bleeding trough and be fitted with upright bars 5 cm in diameter and 1.2m high, spaced at 40 cm intervals, for safety purposes, should improperly stunned animals regain their feet. The floor or the dry landing area must be properly drained and possess high-impact and non-slip properties to aid the work of the operative who must enter this high-risk area to apply a shackle for hoisting (Collins and Huey, 2014). The bleeding trough should be at least 1.5m wide and possess a good gradient, side walls of the same height, and two drains, one for blood only and the other for water when cleansing. The bleeding trough has two points for the reception of blood: one at the actual point of sticking where the greater volume of blood will be handled and thereafter a longer gradual slope that collects ‘drip’ blood classified as inedible. Post-mortem inspection must be followed immediately by

chilling in the slaughterhouse. Hind leg, hide removal, evisceration, carcasses splitting, inspection, kidney, and channel fat removal and carcasses washing stations must have platforms at suitable positions and heights for operatives and inspectors to work efficiently and without unnecessary stooping and labor (Collins and Huey, 2014).

Carcasses detained for further examination should be routed by a special rail to the detained meat room, which should be located adjacent to the main slaughter hall inspection points to achieve close management over disease findings. From this detained meat room, the overhead rail must reconnect with the main slaughter line for the direction of carcasses either to the chill rooms or to the condemned meat room. Cutting must be carried out in a cutting establishment. During the cutting process, the temperature of the building should not exceed 12°C, and the rooms should have sufficient refrigeration accommodation to keep meat at an internal temperature of not more than 7°C, offal 3°C. The fresh meat dispatch area must be sited away from the dirty part and access to it restricted to vehicles associated with meat and offal for human consumption (Collins and Huey, 2014).

In Ethiopia the slaughtering started with the stunning of the animals by stabbing at the atlanto-occipital region using a sharp edge of a knife, immediately followed by bleeding and removal of the head and the feet with the carcass in a horizontal position on the floor (Gebretinsae, 2018; Gutema *et al.*, 2021). The remaining slaughter steps (de-hiding, evisceration, post-mortem inspection, and carcass labeling) were performed in a vertical position after manually hanging the carcass by hooks and sliding it over the rail system. Finally, the carcasses were stored and transported at room temperature (Gutema, Agga, *et al*., 2021). In some of West Hararghe Zone municipal abattoirs, bleeding, de-hiding, and evisceration of the carcass were carried out on the floor which indicated the substandard hygienic condition (Nurye and Demlie, 2021). The finding of (Hassan *et al*., 2018) along the Asella Beef Abattoir line shows that the presence of poor hygienic practices of the meat handlers during the processing stage, lack of equipment and working surfaces sterilization, insufficient water supply for the abattoir, poor awareness of meat handlers and lack of safety rule in abattoir are the major challenges.

The processing of carcasses and the resultant by-products give rise to large amounts of highly polluting wastewaters, semi-solids, and solids, which must be separated and treated before being discharged into the environment (Collins and Huey, 2014). The main sources of solid waste in abattoirs include animal holding areas, slaughterhouses, and processing

areas, waste treatment plants, unwanted skin pieces, and condemned carcasses and carcass parts (Yunus, 2019).

2.1.3.4. Meat transportation

In developing countries, Food borne diseases occur because of poor food handling and sanitation problems (Haileselassie *et al*., 2013). The standard and hygienic methods of handling and processing meat are given less attention even though part of the country's rules and regulations on animal meat production and process in most developing countries (Adzitey, 2011). Foods can be mishandled during preparation, processing, transportation, or storage (Sani and Siow, 2014). It has been shown that most outbreaks of food poisoning result from improper food handling practices that implicate the food handlers (Tegegne and Phyo, 2017). According to the Codex Alimentarius Commission, improper food handling is a major cause of foodborne diseases, and poor hand hygiene is a significant risk factor in the occurrence of food contamination (Al-Shabib *et al.*, 2016). Informal methods of meat handling and marketing meat by butcheries undermine meat quality and safety (Adzitey, 2011), which is shared by the similar socioeconomic conditions of Ethiopia. Because meat is a highly perishable food, the knowledge, and level of training of meat handlers in the meat industry in hygiene and food safety are of particular importance in ensuring the health and safety of the consumer (Jianu and Goleţ, 2014).

One Ethiopian study claims that contamination of beef while transferring from the abattoir to the butcher shops with the highest source of contamination attributed to abattoir workers (Tolera *et al*., 2022).Carcasses were quartered immediately before being loaded on the vehicles. The distance between the conveyer bar and the vehicle was 1 to 10 m. The distance between the conveyer bar and the vehicle was relatively longer at Hawasa abattoir about 10 m and relatively shorter at Adama abattoir, about 1 m. Between the two points, workers transport carcasses on their shoulders. Carcasses were suspended in the vehicle to be transported to butcheries. In most cases, carcasses were touching the floor of the vehicle during transport (Mummed and Webb, 2015). Carcasses are transported from the slaughterhouses to the retail shops using closed vehicles without a cooling facility (Gutema, Agga, et al., 2021). Transporting and delivering meat to clients: Processed meat is delivered to clients in a three-wheeled taxi (Bajaj) or sometimes in an open truck. This step can contaminate the carcass and cause risks to consumers, since eating raw meat is a common tradition in the local community (Gebretinsae, 2018).

2.2. Food-Borne Pathogenic Microbial Prevalent in Ethiopia

Food-borne disease outbreaks remain a major global health challenge, a cross-contamination from raw meat due to poor handling is a major cause in developing countries (Adesokan and Raji, 2014). Foodborne disease arises from the contamination of food by microbiological contaminants, naturally produced toxins, or chemicals. Enterotoxigenic *E. coli, Campylobacter jejuni,* and other bacterial enteropathogens were the most common cause of acute diarrhea (Sanders *et al.*, 2019). Diarrheal disease agents that caused the highest number of deaths were non-typhoidal *Salmonella enterica*. Other major causes of foodborne deaths were *Salmonella typhi, Taenia solium,* hepatitis A virus, and aflatoxin (WHO, 2015). Inadequate facilities and improper handling of the animals at the slaughterhouses further aggravate the microbial contamination of beef which can result in the transmission of foodborne pathogens to humans (Cook *et al*., 2017).

Consumption of contaminated beef and beef products is one of the transmission routes of Salmonella and E. coli O157 to humans (Pires *et al*., 2019) and has been implicated in many foodborne outbreaks (Plumb *et al.,* 2019).This is particularly important in Ethiopia where consumption of raw or under-cooked beef in the form of steak ("kurt") or beef tartare ("kitfo") made from raw minced beef, is common (Seleshe *et al.*, 2014)). Consumption of raw beef products can be a source of Salmonella and E. coli O157 infections in Ethiopia. During slaughter, beef carcasses can become contaminated with *Salmonella* and/or *E. coli 0157* due to direct contamination of carcasses by feces and hide of positive animals (Gutema, Abdi, *et al.*, 2021). Study of (Ayenew *et al.*, 2021) stated that swab samples taken from the carcass of cattle slaughtered at the Bahir Dar municipal abattoir, were found contaminated with virulent E. coli O157:H7 as indicated in table 3. The carcasses associated with the Jimma municipal abattoirs were highly contaminated with *Salmonella* as shown in table 3, and also 18% carriage rate of *Salmonella* species among personnel working at the Jimma municipality abattoir (Takele *et al.*, 2018).

The unhygienic conditions or improper handling carried out during slaughter as well as post slaughter activity resulted in higher limits of bacterial load in slaughterhouse of Bahir Dar, Adama, Jijiga and Bishoftu, , Dukem, Burayu and Kara, Chiro and Hirna towns of Ethiopia (Bersisa *et al*., 2019; Teshome *et al*., 2020; Nurye and Demlie, 2021).The most prevalent of pathogenic bacteria isolated from meat sample taken from public slaughter house and retail

shops such as E.coli O157:H7, salmonella species, staphylococcus aureus shawed that there is increment in magnitude for E. coli O157:H7 and S. aureus, but fluctuating in case of salmonella species annually as indicated in table.3 below (Bersisa *et al*., 2019; Ayenew *et al*., 2021;Alemu *et al*., 2022).

Table 3. Meat origin food borne bacterial pathogens prevalent in Ethiopia.

Pathogenic bacteria	**Sample**	**Prevalence (%)**	**Region**	**Reference**
S. aureus	Meat	9.4	Addis Ababa	(Adugna *et al*., 2018)
	Camel Carcass	12.1	Jijiga	(Tegegne *et al*., 2019)
	Meat (beef)	22.5	Bishoftu	(Bersisa *et al*., 2019)
	Raw camel meat	35.3	S. Oromia	(Hassen *et al*., 2021)
E.coli O157:H7	Camel carcass	4.3	Jijiga	(Tegegne and Phyo, 2017)
	Meat	4.4	Jimma	(Sebsibe and Asfaw, 2020)
	Carcass	7.1	Bishoftu	(Gutema, Abdi, *et al*., 2021)
	Meat	7.2	Ambo	(Nega Desalegn *et al*. 2021)
	carcass swab	8.9	Bahir Dar	(Ayenew *et al*., 2021)
Salmonella	Carcass	12.5	Wolaita	(Wabeto *et al*., 2017)
	carcass swab	11.3	Jimma	(Takele *et al*., 2018)
	Meat	14.3	Central Ethiopia	(Bersisa *et al*., 2019)
	Meat	5.6	Ambo	(Gebremedhin *et al*., 2021)
	Carcass	6.67	East Shewa	(Alemu *et al*., 2022)

2.3. Food Safety System in Ethiopia

According to the CAC, food safety is the assurance that food will not cause harm to the consumer when it is prepared and/or eaten according to its intended use (Uçar *et al*., 2016). Keeping food safety is a complex process that starts on the farm and ends with the consumer. A Food Safety System is a system that is implemented according to the Food Safety Plan by a facility to meet its food safety needs. The concept of a food safety system approach is superior to both reactive programs to fix problems and to end-product testing. Preventive

control–based systems were embraced in the Hazard Analysis Critical Control Points (HACCP) and are further expanded in the rules of the Food Safety Modernization Act of 2011 (FSMA) in the USA (Barach, 2017).

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). HACCP was one of the first truly global food safety systems. It 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 ISO 22000 (2005) and the Global Food Safety Initiative (2017) (Fung *et al.*, 2018). The HACCP plan consists of the following seven steps: conducting a hazard analysis; determining critical control points (CCP); establishing critical limits; establishing a system to monitor CCPs; establishing corrective actions to be taken when monitoring indicates that a particular CCP is not under control; establishing procedures for verification to confirm that HACCP system is working effectively, and establishing documentation concerning all procedures and records appropriate to these principles and their application (Barach, 2017).

According to the Meat and Seafood Regulatory Authority guide, implementation of a HACCP plan in slaughtering and dressing of cattle requires meeting certain prerequisites such as sanitary design; water quality and availability; sanitation and cleanup procedures for edible areas and food contact surfaces; personnel hygiene and training; hygienic dressing; food contact materials, repairs and maintenance of equipment; control of chemicals; pest control; waste disposal, and cleanliness of animals (Gebretinsae, 2018). After the farm, slaughterhouses represent the second critical point in the food production process and the potential for cross-contamination at various key stages in the slaughter process. These included: the presentation of animals in a clean and dry condition, deskinning and evisceration of the animal, end-of-process treatments, the transportation of carcasses and meat; more general issues related to the good hygiene standards achievement and enforcement within abattoirs (Brown, 2000).

In building a Food Safety System, several elements are essential. It starts with prerequisite programs that manage the basic environment where safe and wholesome food can be produced. These programs set the stage for the facility and its workers to be able to practice

Good Manufacturing Practices (GMPs) (Barach 2017). Throughout the globalization of food safety, many developed countries have implemented robust regulatory food safety systems. Focus areas of an expanding food safety view are management of hazard risk throughout the farm-to-fork continuum, implementation of suitable practices and traceability, addressing food terrorism and intentional adulteration, vulnerability to food fraud, and the rise of antibiotic resistance. Australia and New Zealand, Canada, the United States, and the E.U. have all refined their food safety practices in recent years (Weinroth *et al*., 2018).

Food safety is a critical challenge in Ethiopia because it is unclear which solutions are best suited to the Ethiopian context. Most Ethiopian foods are sold in traditional market i.e., informal or wet markets, which generally Consumers often favor and have lower prices than formal markets and are closer to consumers' homes (Global Alliance, 2022). The food system in Ethiopia is not always as organized and developed as in other developed countries. Moreover, problems of growing population, urbanization, lack of resources to deal with pre- and post-harvest losses in food, and environment and food hygiene issues mean that food systems in the country continue to be stressed, adversely affecting the quality and safety of food supplies (Wendafrash, 2010).

Though the country is endowed with enormous potential for the production of agricultural and industrial food products, its competitiveness in the world market has been so far very low (Kalekidan *et al.*, 2014). Due to high proportion of illiterate and primary school level meat handlers in Jijiga abattoir and town, they had unsatisfactory knowledge mainly on food borne pathogens, time temperature control, cross contamination, and difference between cleaning and sanitation(Tegegne and Phyo, 2017). The production of good quality food is accomplished through implementation of quality control measures by workers who have adequate educational level, training on personal hygiene and food handling and who practice environmental and food contact surface hygiene. These are among the top priority areas to have a positive impact on food quality and public health (Nurye and Demlie, 2021).

Food quality standards, and regulations in Ethiopia

The first national standardization body in Ethiopia was formally established in 1970 (Abebe and Kassem, 2018).Food regulation in Ethiopia is a shared responsibility of the Ministry of

Health, Ministry of Agriculture and Rural Development, Ministry of Trade and Industry, and Quality and Standards Authority of Ethiopia (Clark, 2017).

In the last decade, large efforts have been made on the national level toward the development and implementation of food regulation management systems to assure food regulation in the agro-food chain (Teferi, 2020). The Ethiopian Standards Agency (ESA) is the country's sole standard body, which represents Ethiopia at the international level and protects the country's interest in international standardization, particularly in food and agriculture. ESA is a member of the International Organization for Standardization (ISO), the Codex Alimentarius Commission (CAC), the African Regional Organization for Standardization (ARSO), and (WTO) (Abebe and Kassem, 2018).Ethiopian standard regulation was prepared under the direction of the Agricultural and Food Technology Technical Committee and published by the Quality and Standard Authority of Ethiopia (QSAE). However, the application of this regulation was not practical especially in public abattoirs in Ethiopia (Temesgen and Abdisa, 2015).An unsuccessful try has emerged as made to set up a Technical Committee to coordinate and liaison the foods protection activities performed with the beneficial useful resource of using different ministries and corporations, after which a National Food Safety Council have emerge, with participants drawn from the private and non-private sectors (Mustefa, 2021).

There is meat inspection proclamation No. 274/1970, and its modification proclamation No. 81/1976 which offers the management and inspection of meat and meat products. Under proclamation No, 274/1970, and its modification proclamation No. 81/1976, the animal health officer is empowered to work inspection on meat and meat merchandise to figure out whether or not they meet the standards set by government; and, on the identical time, it prohibits the sale or disposal of meat and meat merchandise. This is to make sure that domestically produced meat and meat merchandise are secure and correct high-satisfactory and suited for human consumption (EFNG, 1970).

The major activities of the National Codex Committee (NCC) are the adoption of recommended Codex standards as Ethiopian standards, conducting a national awareness program on food regulation and codex standards, issuing the country's needs at international Codex meetings, differentiating concerning areas on food regulation and developing fundable projects (Yalemtsehay, 2010). But, the food control system in Ethiopia is somewhat less developed and is not able to support the production, supply, and distribution of safe food both for the local community and the export market. At a national level, however, both food shortage and lack of appropriate food safety assurance systems are

problems that have become obstacles to the Ethiopian economic development and public health safety (WHO, 2020b).

3. CONCLUSION AND RECOMMENDATION

In Ethiopia, Animal production is an essential part of agricultural farming systems and has been contributing a great portion to the economy. The country's livestock population and their product foods such as meat are increasing annually. However, there is low standard farming, veterinary service, and hygienic practice in the slaughtering chain starting from the farm up to preparation and consumption of animal origin food like meat. This results due to many factors such as the absence or scarcity of facilities at farm level, animal transportation, slaughterhouse and retail shop and restaurant. This study indicated that at country level, there is little information concerning abattoirs found in the country, their facility and operation in conjunction with good hygienic practice in the plant up to the preparation of ready-to-eat food. Due to the unhygienic handling of animal and their product, there are much food borne diseases prevalent in the country. At the national level unhygienic food production, food shortage, food-born infection and lack of appropriate food safety assurance systems are the major problems that have become obstacles to the Ethiopian economic development and public health safety.

Therefore based on the above conclusion the following recommendation are forwarded

- The public slaughterhouse status and their facility should be indicated by concerning body annually because the abattoirs are a place that is important for disease surveillance and control**.**
- There is a gap of research on the facility and operation of public abattoirs found in the country and also about food born infection focused on sheep and goats slaughtered in municipal abattoirs.
- The potential effects of primary production activities on the safety and suitability of food should be considered at all times.
- The country has established and declared the food quality standard and some food safety, quality, and standard proclamation such as meat inspection proclamation. However, there is no meat safety regulation, in the country so the concerned body should deal with this issue because there is huge number of society suffering from animal-origin food-borne diseases.

4. REFERENCE

Abatemam, M., Taye, E., Urji, A., and Belina, D. 2018. Survey on pathological lesion and its financial Losses in ovine slaughtered at Jimma municipal abattoir, Jimma, Ethiopia. *Concepts of Dairy and Veterinary Sciences*, *1*(1):1–12.

Abebe, E., Gugsa, G., and Ahmed, M. 2020. Review on major food-borne zoonotic bacterial pathogens. *Journal of Tropical Medicine 2020*: 4674235.

Abebe, G. K., and Kassem, I. I. 2018. *Food Safety Regulations and Enforcement in Ethiopia*.

Addis, M. 2015. Major Causes Of Meat Spoilage and Preservation Techniques: A. *Changes*, *41*.

Adesokan, H. K., and Raji, A. O. Q. 2014. Safe meat-handling knowledge, attitudes and practices of private and government meat processing plants' workers: implications for future policy. *Journal of Preventive Medicine and Hygiene 55*(1):10.

Adugna, F., Pal, M., and Girmay, G. 2018. Prevalence and antibiogram assessment of Staphylococcus aureus in beef at municipal abattoir and butcher shops in Addis Ababa, Ethiopia. *BioMed Research International 2018*:7.

Adzitey, F. 2011. Effect of pre-slaughter animal handling on carcass and meat quality. *International Food Research Journal 18*(2):485-491.

AGP-LMD. 2013. *Value Chain Analysis for Ethiopia: Meat and Live Animals, Hides, Skins and Leather, and Dairy. Agricultural Growth Program - Livestock Market Development (AGP-LMD). U.S. Agency for International Development*.

Akpabio, U., Kalu, E., and Babalola, S. A. 2015. Assessment of facilities and slaughter practices in Aba abattoir, Abia State, Nigeria. *Journal of Veterinary Advances 5*(6): 957–961.

Al-Shabib, N. A., Mosilhey, S. H., and Husain, F. M. 2016. Cross-sectional study on food safety knowledge, attitude and practices of male food handlers employed in restaurants of King Saud University, Saudi Arabia. *Food Control 59*:212–217.

Alemayehu, K. 2011. Value chain assessment of beef cattle production and marketing in Ethiopia: Challenges and opportunities of linking smallholder farmers to the markets. *Livestock Research for Rural Development 23*(12):255–265.

Alemu, A., Regassa, F., Kebede, N., Ambachew, R., Girma, M., Asefa, Z., and Tsegaye, W. 2022. Magnitude and Antimicrobial Susceptibility Profile of Salmonella Recovered from Export Abattoirs Located in East Shewa, Ethiopia. *Infection and Drug Resistance 15*: 1353.

Ayenew, H. Y., Mitiku, B. A., and Tesema, T. S. 2021. Occurrence of Virulence Genes and Antimicrobial Resistance of E. coli O157: H7 Isolated from the Beef Carcass of Bahir Dar City, Ethiopia. *Veterinary Medicine International 2021*:8046680–8046680.

Barach, J. T. 2017. *FSMA and food safety systems: Understanding and implementing the rules*. Atrium, Southern Gate, Chichester, West Sussex, England: John Wiley & Sons, Ltd.

Bersisa, A., Tulu, D., and Negera, C. 2019. Investigation of bacteriological quality of meat from abattoir and butcher shops in Bishoftu, Central Ethiopia.*International Journal of Microbiology*, https://doi.org/10.1155/2019/6416803

Beyene, T., Yibeltie, H., Chebo, B., Abunna, F., Beyi, A. F., Mammo, B., Ayana, D., and Duguma, R. 2016. Identification and antimicrobial susceptibility profile of Salmonella isolated from selected dairy farms, abattoir and humans at Asella town, Ethiopia. *J Vet Sci Technol 7*(3):320.

Birhanu, S., and Menda, S. 2017. Hygienic handling and processing of raw beef meat at slaughter houses and meat stalls in Gojjam area, Ethiopia. *International Journal of Veterinary Health Science & Research 5*(8):213–218.

Biswas, A. K., and Mandal, P. K. 2020. Current perspectives of meat quality evaluation: Techniques, technologies, and challenges. In *Meat Quality Analysis* , pp. 3–17. Elsevier.

Brown, M. 2000. *HACCP in the Meat Industry*. Cambridge, England: Woodhead Publishing.

Bulitta, F. S., Gebresenbet, G., and Bosona, T. 2012. *Animal handling during supply for marketing and operations at an abattoir in developing country: the case of gudar market and ambo abattoir, ethiopia*. *5(1)*, 59–68.

Chammem, N., Issaoui, M., De Almeida, A. I. D., and Delgado, A. M. 2018. Food crises and food safety incidents in European Union, United States, and Maghreb Area: current risk communication strategies and new approaches. *Journal of AOAC International 101*(4): 923–938.

Chulayo, A. Y., Tada, O., and Muchenje, V. 2012. *Research on pre-slaughter stress and meat quality: A review of challenges faced under practical conditions 5(1)*: 1–6.

Clark, L. F. 2017. Implementing Multilevel Food and Nutrition Security Frameworks in Sub-Saharan Africa: Challenges and Opportunities for scaling up pulses in Ethiopia (A Research Note). *Journal of Rural Social Sciences 32*(1): 5.

Cockram, M. 2020. Condition of animals on arrival at the abattoir and their management during lairage. *The Slaughter of Farmed Animals: Practical Ways of Enhancing Animal Welfare. T. Grandin and M. Cockram, Ed. CABI Publ., Wallingford, Oxon, UK, 10*(9781789240573.0049), 49–77.

Collins, D. S., and Huey, R. J. 2015. *Gracey's meat hygiene 11th edition*. Atrium, Southern Gate, Chichester, West Sussex, England: John Wiley & Sons, Ltd.

Cook, E. A. J., de Glanville, W. A., Thomas, L. F., Kariuki, S., de Clare Bronsvoort, B. M., and Fèvre, E. M. 2017. Working conditions and public health risks in slaughterhouses in western Kenya. *BMC Public Health 17*(1):1–12.

CSA. 2021. *Federal Democratic Republic of Ethiopia Central Statistical Agency Agricultural Sample Survey 2020 / 21 [2013 E . C .] Volume 2 Report On. 2(March)*. *2*(March), 10.

Debusser, E. V, Dezutter, L., Dewulf, J., Houf, K., and Maes, D. 2013. Salmonella control in live pigs and at slaughter. *The Veterinary Journal 196*(1): 20–27.

EFNG. 1970. Meat Inspection Proclamation No.274/1970; Negarit Gazeta, 29th Year, No.15; Berhanena Selam Printing Enterprise: Addis Ababa, Ethiopia, 1970. *Negarit Gazeta*, *29th*(No.15).

Eshetie, T., Hussien, K., Teshome, T., and Mekonnen, A. 2018. Meat production, consumption and marketing tradeoffs and potentials in Ethiopia and its effect on GDP growth: a review. *J Nutr Health Food Eng 8*(3):228–233.

Ezirigwe, J. 2018. Much ado about food safety regulation in Nigeria. *Journal of Sustainable Development Law and Policy 9*(1):109–132.

FAO. 2019. *The Future of Food Safety. There is no food security without food safety 1(4)*:19.

FAO. 2020. *Food Safety in the time of COVID-19. Rome*. *1(4)*: 20.

FAO. 2021a. *Animal health services at work in Ethiopia – Evidence from Ada'a and Sululta districts. Africa Sustainable Livestock 2050. Rome.*

FAO. 2021b. *Food Outlook: Biannual Report on Global Food Markets*. Rome.

FAOSTAT, F. 2020. Agriculture Organization of the United Nations FAO statistical database Available from: http://faostat. fao. org. *(Assessed Date*

26.5.2022), 30.

Faye, B. 2013. Camel meat in the world. *Camel Meat and Meat Products*, *7*.

Fung, F., Wang, H.-S., and Menon, S. 2018. Food safety in the 21st century. *Biomedical Journal 41*(2): 88–95.

Gadisa, B., Yusuf, Y., and Kurtu, M. Y. 2019. Evaluation of physical Facilities, Operation and Management Practice in Selective Public Abattoirs in Eastern Oromia, Ethiopia. *International Journal of Agricultural Science and Food Technology 5*(1): 43–49.

Gallo, C., Lizondo, G., and Knowles, T. G. 2003. Effects of journey and lairage time on steers transported to slaughter in Chile. *Veterinary Record 152*(12):361–364.

Gebeyehu, A., Yousuf, M., and Sebsibe, A. 2013. Evaluation of microbial load of beef of Arsi cattle in Adama Town, Oromia, Ethiopia. *J Food Process Technol 4*(6):1–6.

Gebremedhin, B., Hoekstra, D., and Jemaneh, S. 2007. Heading towards commercialization? The case of live animal marketing in Ethiopia. *IPMS Working Paper*.

Gebremedhin, E. Z., Soboka, G. T., Borana, B. M., Marami, L. M., Sarba, E. J., Tadese, N. D., and Ambecha, H. A. 2021. Prevalence, risk factors, and antibiogram of nontyphoidal Salmonella from beef in Ambo and Holeta Towns, Oromia Region, Ethiopia. *International Journal of Microbiology 2021*: 13.

Gebretinsae, G. G. and T. 2018. Evaluating the Implementation of Hazard Analysis Critical Control Point (HACCP) in Small Scale Abattoirs of Tigray Region , Ethiopia. *38*(4), 250–257.

Global Alliance. 2022. *Consumer and Vendor Perspectives on and Practices Related to Food Safety in Ethiopia: A Review. A USAID Eat Safe Project Report*.

Goja, A. M., Ahmed, T. A. A., Saeed, S. A. M., and Dirar, H. A. 2013. Isolation

and identification of Staphylococcus spp. in fresh beef. *Pakistan Journal of Nutrition 12*(2): 114.

Gutema, F. D., Abdi, R. D., Agga, G. E., Firew, S., Rasschaert, G., Mattheus, W., Crombe, F., Duchateau, L., Gabriël, S., and De Zutter, L. 2021. Assessment of beef carcass contamination with Salmonella and E. coli O 157:H7 in slaughterhouses in Bishoftu, Ethiopia. *International Journal of Food Contamination 8*(1): 1–9.

Gutema, F. D., Agga, G. E., Abdi, R. D., Jufare, A., Duchateau, L., Zutter, L. De, and Gabriël, S. 2021. *Assessment of Hygienic Practices in Beef Cattle Slaughterhouses and Retail Shops in Bishoftu , Ethiopia : Implications for Public Health*.

Hagos, Y., Gugsa, G., Awol, N., Ahmed, M., Tsegaye, Y., Abebe, N., and Bsrat, A. 2021. Isolation, identification, and antimicrobial susceptibility pattern of Campylobacter jejuni and Campylobacter coli from cattle, goat, and chicken meats in Mekelle, Ethiopia. *PloS One 16*(2):246755.

Haileselassie, M., Taddele, H., and Adhana, K. 2012. Source of contamination of raw and ready-to-eat foods and their public health risks in Mekelle City, Ethiopia. *Journal of Food and Agricultural Sciences 2*(2):20–29.

Haileselassie, M., Taddele, H., Adhana, K., and Kalayou, S. 2012. *Study on food safety knowledge and practices of abattoir and butchery shops and the microbial profile of meat in Mekelle City , Ethiopia*. 1–6.

Haileselassie, M., Taddele, H., Adhana, K., and Kalayou, S. 2013. Food safety knowledge and practices of abattoir and butchery shops and the microbial profile of meat in Mekelle City, Ethiopia. *Asian Pacific Journal of Tropical Biomedicine 3*(5):407–412.

Hassan A, Hiko A, Bogale K, Abera B, Tsegaye B (2018) Antimicrobial Resistance Profiles of Staphylococcus aureus Isolates along Asella Municipal Beef Abattoir Line, South Eastern Ethiopia. J Vet Sci Technol 9: 539. doi:10.4172/2157-7579.1000539.

Hassen, K. A., Omer, S. A., and Hassen, N. A. 2021. Assessment of Hygienic

Practice on Camel Meat Handlers, and Identification of Bacterial Contamination in Abattoir and Butcheries of Nagelle Town, Southern Oromia, Ethiopia. *International Research Journal of Science and Technology 2*(2): 384–397.

Idiris, A. 2021. *Occurrence and Associated Risk Factors of Salmonella in Slaughtered Cattle Carcass and Slaughter House Environment at Maandeeq Slaughterhouse , Hargeisa , Somaliland*. *123456789*, 12938.

Iro, O. K., Enebeli, U. U., Iloh, G. P., Azuama, Y., Amadi, A. N., Amadi, C. O., Ezejindu, C., Ingwu, J., and Ogamba, S. E. 2020. Food hygiene and safety management in Nigeria. *Int J Res Sci Innov 7*:101–109.

Jianu, C., and Goleţ, I. 2014. Knowledge of food safety and hygiene and personal hygiene practices among meat handlers operating in western Romania. *Food Control 42*:214–219.

Joo, S. T., Kim, G. D., Hwang, Y. H., and Ryu, Y. C. 2013. Control of fresh meat quality through manipulation of muscle fiber characteristics. *Meat Science 95*(4):828–836.

Kadim, I. T., Mahgoub, O., Al-Marzooqi, W., Al-Zadjali, S., Annamalai, K., and Mansour, M. H. 2006. Effects of age on composition and quality of muscle Longissimus thoracis of the Omani Arabian camel (Camelus dromedaries). *Meat Science 73*(4): 619–625.

Kalekidan, T., Behailu, K., and Rediet, H. 2014. The Ethiopian perception on food safety system. *Advances in Food Science and Technology 2*(9): 260–268.

Kiani, H., and Sun, D.-W. 2011. Water crystallization and its importance to freezing of foods: A review. *Trends in Food Science & Technology 22*(8): 407–426.

Kishore, P. 2020. HACCP Concepts (Hazard Analysis and Critical Control Point). *Training Manual*, 55.

Krivohlavek, A. 2018. Food Safety, standards and norms against bioterrorism:

Food safety and hazards. In *Defence Against Bioterrorism* , pp. 239–248. Springer.

Leta, S., and Mesele, F. 2014. Spatial analysis of cattle and shoat population in Ethiopia: Growth trend, distribution and market access. *SpringerPlus 3*(1): 1–10.

Lloveras, J. P., Calvo, A. V., and Bueno, A. D. 2014. Requisitos religiosos en relación al sacrificio de animales para carne Halaly Kosher: Puntos críticos sobre el bienestar animal. *Eurocarne: La Revista Internacional Del Sector Cárnico 225*: 48–64.

Molla, D., Nazir, S., Mohammed, A., and Tintagu, T. 2020. Parasitic infections as major cause of abattoir condemnations in cattle slaughtered at an Ethiopian abattoir: 10-year retrospective study. *Journal of Helminthology*, *94*.

Mummed, Y., and Webb, E. C. 2015. Operation, facilities and management in public and private abattoirs in Ethiopia. *African Journal of Agricultural Research 10*(7): 623–630.

Mummed, Y. Y., and Webb, E. C. 2015. *Operation , facilities and management in public and private abattoirs in Ethiopia*. *February*.

Mustefa, W. S. 2021. Review on application of hazard analysis critical control point in ethiopian slaughtering plant. *International Journal of Veterinary Science and Research 7*(1): 40–56.

Ninios, T., Lundén, J., Korkeala, H., and Fredriksson-Ahomaa, M. 2014. *Meat inspection and control in the slaughterhouse*. John Wiley & Sons.

Njisane, Y. Z., and Muchenje, V. 2017. Farm to abattoir conditions, animal factors and their subsequent effects on cattle behavioural responses and beef quality—A review. *Asian-Australasian Journal of Animal Sciences 30*(6):755.

Nouichi, S., and Hamdi, T. M. 2009. Superficial bacterial contamination of ovine and bovine carcasses at El-Harrach slaughterhouse, Algeria.

European Journal of Scientific Research 38(3):474–485.

Nurye, M., and Demlie, M. 2021. Assessment of Hygienic Practices and Microbial Quality of Meat at Slaughterhouses and Butcher's Shops in West Hararghe Zone, Ethiopia. *Abyssinia Journal of Science and Technology 6*(2):32–41.

Obidegwu, C. S., Chineke, H. N., Ubajaka, C. N., and Adogu, P. O. 2019. Public Health Challenges in Somachi Main Abattoir Owerri, Nigeria: A Review and Field Activity Report. *European Journal of Medical and Health Sciences*, *1*(2).

Pires, S. M., Majowicz, S., Gill, A., and Devleesschauwer, B. 2019. Global and regional source attribution of Shiga toxin-producing Escherichia coli infections using analysis of outbreak surveillance data. *Epidemiology and Infection*, *147*, e236–e236.

Plumb, I. D., Schwensohn, C. A., Gieraltowski, L., Tecle, S., Schneider, Z. D., Freiman, J., Cote, A., Noveroske, D., Kolsin, J., and Brandenburg, J. 2019. Outbreak of Salmonella Newport infections with decreased susceptibility to azithromycin linked to beef obtained in the United States and soft cheese obtained in Mexico—United States, 2018–2019. *Morbidity and Mortality Weekly Report*, *68*(33), 713.

Sanders, J. W., Riddle, M. S., Taylor, D. N., and DuPont, H. L. 2019. Epidemiology of Travelers' Diarrhea. In *Travel medicine* , pp. 187–198. Elsevier.

Sani, N. A., and Siow, O. N. 2014. Knowledge, attitudes and practices of food handlers on food safety in food service operations at the Universiti Kebangsaan Malaysia. *Food Control*, *37*, 210–217.

Sebsibe, M. A., and Asfaw, E. T. 2020. Occurrence of multi-drug resistant Escherichia coli and Escherichia coli O157: H7 in meat and swab samples of various contact surfaces at abattoir and butcher shops in Jimma town, Southwest district of Ethiopia. *Infection and Drug Resistance*, *13*, 3853.

Seleshe, S., Jo, C., and Lee, M. 2014. Meat consumption culture in Ethiopia. *Korean Journal for Food Science of Animal Resources 34*(1): 7.

Shapiro, B. I., Gebru, G., Desta, S., Negassa, A., Nigussie, K., Aboset, G., and Mechale, H. 2017. Ethiopia livestock sector analysis: A 15 year livestock sector strategy.*ILRI Project Report.*

Takele, S., Woldemichael, K., Gashaw, M., Tassew, H., Yohannes, M., and Abdissa, A. 2018. Prevalence and drug susceptibility pattern of Salmonella isolates from apparently healthy slaughter cattle and personnel working at the Jimma municipal abattoir, south-West Ethiopia. *Tropical Diseases, Travel Medicine and Vaccines 4*(1): 1–7.

Tarrant, P. V, Kenny, F. J., Harrington, D., and Murphy, M. 1992. Long distance transportation of steers to slaughter: effect of stocking density on physiology, behaviour and carcass quality. *Livestock Production Science 30*(3):223–238.

Teferi, S. C. 2020. A review on food hygiene knowledge, practice and food safety in Ethiopia. *Jornal of Food Sci Nutr 5*(1): 23–29.

Tegegne, H. A., Berhanu, A., Getachew, Y., Serda, B., Nölkes, D., Tilahun, S., and Sibhat, B. 2019. Microbiological safety and hygienic quality of camel meat at abattoir and retail houses in Jigjiga city, Ethiopia. *The Journal of Infection in Developing Countries 13*(03):188–194.

Tegegne, H. A., and Phyo, H. W. W. 2017. Food safety knowledge, attitude and practices of meat handler in abattoir and retail meat shops of Jigjiga Town, Ethiopia. *Journal of Preventive Medicine and Hygiene 58*(4): 320.

Temesgen, M., and Abdisa, M. 2015. Food standards, food law and regulation system in Ethiopia: a review. *Public Policy and Administration Research 5*(3): 58–73.

Teshome, G., Assefa, Z., and Keba, A. 2020. Assessment of microbial quality status of raw beef around Addis Ababa city, Ethiopia. *African Journal of Food Science 14*(7); 209–214.

Tolera, S. T., Alemu, F. K., and Mengistu, D. A. 2022. *Knowledge , Attitude , and Practice of Abattoir Workers Toward Abattoirs Waste Management in Eastern Ethiopia*.

Uçar, A., Yilmaz, M. V., and Cakiroglu, F. P. 2016. Food safety–problems and solutions. *Significance, Prev Control Food Relat Dis*, *3*.

Velarde, A., Fàbrega, E., Blanco-Penedo, I., and Dalmau, A. 2015. Animal welfare towards sustainability in pork meat production. *Meat Science*, *109*, 13–17.

Wabeto, W., Abraham, Y., and Anjulo, A. A. 2017. Detection and identification of antimicrobial-resistant Salmonella in raw beef at Wolaita Sodo municipal abattoir, Southern Ethiopia. *Journal of Health, Population and Nutrition 36*(1):1–7.

Warriss, P. D. 2003. Optimal lairage times and conditions for slaughter pigs: a review. *Veterinary Record 153*(6): 170–176.

Weinroth, M. D., Belk, A. D., and Belk, K. E. 2018. *History , development , and current status of food safety systems worldwide*. *8*(4).

Wendafrash, A. 2010. Food safety and codex activities In Ethiopia. *Food-borne Diseases December*, 14–15.

WHO. 2015. *World health statistics 2015*. World Health Organization.

WHO. 2020a. *Meeting of member states on framework for action on food safety in the WHO South-East Asia Region*. World Health Organization. Regional Office for South-East Asia.

WHO. 2020b. *Safety evaluation of certain food additives: prepared by the eighty-sixth meeting of the Joint FAO/WHO Expert Committee on Food Additives (JECFA)*.

Yalemtsehay. 2010. Food safety and codex activities in Ethiopia. *Performance of the National Codex Committee of Ethiopia*.

Yami, A., Sheep, E., and Merkel, R. C. 2008. *Sheep and goat production handbook for Ethiopia*.

Yirda, A., Eshetu, M., and Babege, K. 2020. Current status of camel dairy processing and technologies: A review. *Open Journal of Animal Sciences 10*(3): 362–377.

Yunus, M. K. 2019. *Environmental Implications of Abattoir Waste in Ethiopia*. *6*(3).

Zeryehun, T., and Alemu, B. 2017. Major gross lesions of lung in cattle slaughtered at hawassa municipal abattoir, Southern Ethiopia. *Journal of Veterinary Medicine 2017*: 1702852.