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EVALUATION OF CHILLED GOAT CARCASS QUALITY ALONG THE COLD CHAIN LOADED FROM TWO EXPORT ABATTOIRS IN ETHIOPIA

MSc Thesis

BY

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Bishoftu, Ethiopia

EVALUATION OF CHILLED GOAT CARCASS QUALITY ALONG THE COLD CHAIN LOADED FROM TWO EXPORT ABATTOIRS IN ETHIOPIA

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 masters of Science in Tropical Animal Production and Health

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As members of the Examining board of the final Msc open defense, we certify that we have read and evaluated the thesis prepared by **Yebchaye Degefa** titled **'evaluation of chilled goat carcass quality along the cold chain loaded from two export abattoirs in Ethiopia'** and recommended that it be accepted as fulfilling the thesis requirement for the degree of masters of science in Tropical Animal Production and Health.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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DECLARATION

I, Yebchaye Degefa Tessema, hereby declare that the work on which this thesis is based is original and that neither the whole work nor part of it has been, is being, or is to be submitted for another degree at this of any other university.

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SIGNATURE DATE

ABBREVIATIONS

^0C	Degree centigrade
CDC	Centers for Disease Control and Prevention
CFU	Colony forming Unit
Cm^2	Centimeter square
CSA	Central Statistical Authority
DFD	Dark firm Dry
E.Coli	Escherichia coli
EMDTI	Ethiopian Meat and Dairy Technology Institute
ETB	Ethiopian Birr
EXAB1	Export Abattoir one
EXAB2	Export Abattoir two
FAO	Food and Agriculture Organization
GDP	Gross Domestic product
GHP	Good Hygienic practice
GIT	Gastro Intestinal tracts
GMP	Good Manufacturing Practice
HACCP	Hazard Analysis Critical Control point
HACCP	Hazard Analysis Critical Control Point
ILRI	International livestock research institute
ISO	Organization for Standardization
KSA	Kingdom of Saudi Arabia
Ml	Mili litre
Mm	Mili meter

MOA	Ministry of Agriculture
MOARD	Ministry of Agriculture and Rural development
NVI	National Veterinary Institute
pH	Power of Hydrogen
PSE	Pale soft Exudative
SD	Standard Deviation
SPS-LMM	Sanitary and Phytosanitary livestock and meat marketing program
SSOP	Standard sanitary operating procedures
UAE	United Arab Emirates

ABSTRACT

The study was conducted to determine factors that affect meat quality during storage, loading, transport, unloading and microbial quality of the goat carcasses slaughtered in two export abattoirs in Modjo, Ethiopia. A total of 224 samples were selected randomly from the two export abattoirs to determine the carcass temperature, pH and coliform bacterial count. 111 and 113 goat carcass was selected from the first and second export abattoirs respectively. The log mean temperatures of carcass before loading were +0.55^{o}C and -1.03^{o}C and unloading were 0.091 and 0.96^{0}C for the first and second export abattoirs respectively. Independent t-test statistical analysis for mean of temperature readings from the two export abattoirs showed significant difference ($P<0.05$). Independent samples t-test for mean of chilled carcass temperature at unloading point from the two export abattoirs showed significant difference ($P<0.05$). The log mean of pH value of the carcass were 6.12 and 5.69 for the first and second abattoir respectively, which were taken from the chilled goat carcass stayed in the cold room for 24 hrs at a temperature of 2±1^{o}C. Independent t-test statistical analysis for mean of chilled carcass pH readings from the two export abattoirs showed significant difference ($p<0.05$). The paired t-test between the two abattoirs on the difference in animal holding time and pH were statistically significant ($p<0.05$). Packaging quality were determined subjectively and mean value were 1.62 and 0.6 for the first and second export abattoirs respectively. The log mean of *E. coli* count before acetic acid (2.5%) spray for the first and the second abattoirs were 49.63 $\log_{10}$ CFU/cm^2 and 41.85 $\log_{10}$ CFU/cm^2 respectively. Independent samples t-test for the mean of *E. coli* load on the carcass before acetic acid pray (2.5%) showed no significant difference ($p<0.05$). The log mean of *E. coli* load after acetic acid spay were 3.5 $\log_{10}$ CFU/cm^2 and 0.00 $\log_{10}$ CFU/cm^2 for the first and second abattoirs respectively. Independent samples t-test for the mean of *E. coli* load on the carcass after acetic acid pray (2.5%) showed no significant difference ($p<0.05$). The mean of *E. coli* counts from aprons, workers palm, knife and carcass washing water were compared using independent t- test; statistically, the result were no significantly different ($p<0.05$). It could be suggested that 2.5% acetic acid spray could reduce *E. coli* load and lowers the

pH. And also cold trucks to maintain the temperature required for the carcass could be one of the critical points.

Key words: *Temperature, E. coli, Export abattoirs, pH, Goat carcass*

1. INTRODUCTION

In today's world food economy must be linked to food security, a concept that has acquired a new approach arising from globalization in the food trade, where HACCP (Hazard Analysis Critical Control point) systems have been introduced to produce safe food, according to the sanitary requirements of population (Likar and Jevsnik, 2006).

About half of the food produced in the world are perishable and the reasons for this lie in the physical-chemical, enzymatic and microbial-altering products. In order to inhibit or slow down these processes in food, engineering has developed several conservation systems, acting essentially in chemical or physical processes. Among these, the cold application is one of the most used processes for food preservation.

Ethiopia is the largest livestock producer in Africa and ranks eighth in livestock ownership in the world. According to the Central Statistical Authority CSA (2011), livestock population in Ethiopia is estimated at 53.4 million heads of cattle, 25.5 million heads of sheep, 22.78 million heads of goats and 2.5 million heads of camels. Livestock is central to the Ethiopian economy, contributing for 20% of the GDP, supporting the livelihoods of 70 % of the population and generating about 11% of annual export earnings. And meat production is the most important function of these animals in the country. There is high demand for live animals as well as meat from small ruminants by consumers in the Middle East and North and West African countries. There is also a high domestic demand for small ruminant meat, particularly during religious festivals. The country has been earning foreign currency by exporting meat (mainly chilled shoats' carcass) and live animals namely cattle, sheep, camels and goats to major destination markets of UAE, KSA, Yemen and Egypt. Given the large porous border, a large amount of cross-border exports also go un-recorded. Therefore, the official estimates of foreign exchange earnings do not necessarily reflect the actual volume of exports. As the country has the largest number of livestock in Africa, Ethiopia has much to gain from the growing global market for livestock products (SPS-LMM, 2010).

Recently, several large scale meat processing abattoirs have been established in Ethiopia in response to the emerging meat export opportunities to the Middle East and North African Countries. There are also several meat export abattoirs under construction and more are planned to be established in the near future in different regions of the country. These developments are in the right direction towards diversifying and increasing Ethiopia's foreign exchange earnings and improving the livelihoods of livestock producers and other actors engaged in the livestock related activities (Asfaw and Mohamed, 2007).

Meat exports from Ethiopia, (mostly chilled but some frozen and some canned), grew from almost nothing in the early 1990s to an average of about 2000 tons by the year 2002. The expansion on trade was mainly due to the emergence of the private slaughterhouses and their ability to meet the sanitary standards of Saudi Arabia and the UAE. In principle, Ethiopia has a strong comparative advantage in the region, because of its proximity to those markets with chilled meat in customer tailored quantities, with short delivery times in contrast to countries such as Australia which supply mostly frozen meat in bulk, provide preferred products and in particular meat from the favoured fat-tail sheep such as the Black Head Ogaden and serve niche markets such as that for the fifth quarter (organs, other offal, etc) in West Africa (MOARD, 2007).

Ethiopian meat export volume increased from 870 tons in 2000/01 to 17,666 in 2011/12. The Country's export performance reached its peak in 2011/12 by exporting 17,666 tons of meat. In the same period under review, the meat export (chilled shoats carcass) value has picked up from USD 1.7 million to USD 79.1 million (EMDTI, 2012).

Available research suggests that with economic growth, consumption patterns tend to change towards high value and high protein foods, such as those derived from livestock (Delgado *et al*., 1999).

Meat is susceptible to contamination from a wide variety of physical, biological and chemical hazards. Because of its moisture, pH levels and high protein content, meat provides ideal environments for the growth of bacteria. Hence, meat is highly vulnerable, particularly, to microbiological (germ) hazards and must be carefully handled, transported and stored to prevent contamination. During transportation and storage, the key issue is to maintain proper refrigeration temperatures and to keep the cold-chain from breaking during steps such as loading, unloading, palletization, etc (MOA, 2010).

Currently, sheep and goat meat is transported from export abattoirs to the airport by trucks. Meat is then held at handling facilities at the airport. Because transportation and storage are vital links in meat quality and safety, effective control measures are essential at each point to prevent contamination and quality loss. Shoat carcasses are generally perishable products that need to be stored and transported under the cold chain, if this does not occur organoleptic changes can originate or develop pathogens that can cause alterations in quality of the product and affect the health of people. Because of unavailable information and lack of research on compliance of the meat quality along the cold chain to national guideline and international standards, this study was intended;

- To assess factors that affect meat quality during storage, loading, transportation and unloading of goat carcasses for export purpose;
- To evaluate the packing quality of goat carcass
- To identify key areas of quality deterioration and
- To evaluate the microbiological quality of the meat, E. coli count on workers facility, hand, apron and water of the two export abattoirs

2. LITERATURE REVIEW

2.1 Meat Quality

Meat is one of the most nutritious foods that humans can consume, particularly in terms of supplying high quality protein (essential amino acids), minerals (especially iron) and essential vitamins. Meat is defined as all animal tissues suitable as food for human consumption. This includes all processed or manufactured products prepared from animal tissues. The majority of meat consumed comes from domestic and aquatic animals, but a number of lesser known species and products are continuously added to the list (Sebsibe, 2008).

The International Organization for Standardization (ISO) universally defines the quality of a product as: "The totality of features and characteristics of a product, process of service that bear on its ability to satisfy stated or implied needs". Therefore quality, mainly referred to foodstuffs, is a concept which depends on a great number of variables, many of which are subjective or bound to ethnic or even family tradition factors (Centoducati *et al*., 1996), but it can also be modified by the contemporary consumer's trend to demand standardized products, above all by the influence of advertising (Vergara and Gallego, 1999).

The fulfillment of the above mentioned demand is extremely complex and linked to a multifactorial whole of health, nutritional, technological and organoleptic components (Panella *et al.*, 1995), which is very difficult to define in an unequivocal way and which is however extremely variable in space and time.

The quality traits to be preliminarily assesses are the hygienic and sanitary ones, such as the origin of meat from living animals not suffering from diseases, the absence in the meat of parasites and pathogenic microorganisms, the keeping behind the tolerance limits fixed by the laws in force for the concentration of drugs, antibiotics, pesticides,

radioactive elements residues, and the total absence of traces of substances with an hormonal or antihormonal effect (Manfredini,1992).
The HACCP system, that is Hazard Analysis Critical Control Point, is used to detect and remove any possible source of hazard for human health that could be met along the production process (Silliker,1989).

Beyond hygienic and sanitary factors, quality is also defined by sensory parameters, assessed on the raw product, which therefore affect mainly the consumer's choice to buy or not the product, like colour, flavour, grain, marbling, water holding capacity. Other parameters can be instead valued at the moment of employment that is on the cooked product, like taste, juiciness, tenderness, cooking loss and overall satisfaction (Panella *et al*., 1995) and can be determined in a laboratory with instrumental methods or by panel tests.

A panel test is an organoleptic assessment performed by a panel of selected tasters trained in specially organized training courses (Panella *et al*., 1995), that make use of several kinds of evaluation scales, with a highly variable number o degrees for the different parameters considered: for instance 8-point scales up to 100-point scales can be used (Young *et al*., 1997).
It has been however noticed that not necessarily the panel tests results reflect the real consumers' likings, so much so that recent researches used as tasters the members of ordinary families, not trained as tasters.

2.1.1 Meat pH

A key determinant of meat quality is pH. The ultimate PH is determined 24 hours post-slaughter, using a pH meter. Good quality meat usually has a pH of 5.4–5.7. The muscle of a living animal has a pH of 7.1. The extent to which pH is lowered after slaughter depends on the amount of glycogen in the muscle prior to the animal’s death. The pH value determines environmental microbial balance. Low pH has a bacteriostatic effect on

the meat. Accordingly, meats with pH values above 6 are generally considered unsuitable for storage because of the favorable development of proteolytic microorganisms (Sebsibe, 2008).

In order to yield meat of good quality the pH must decrease after slaughtering, for the increase of lactic acid in the muscle, originated by the post-mortem glicogen glycolysis; this decrease must be gradual because, if it was too quick, protein denaturation and water holding capacity lowering would take place (Lawrie, 1966).

The pH is also modified by the storage method: freezing determines a pH decrease compared to the mere refrigeration (Moore *et al.,* 1998).Moreover if the animal finds itself in stress conditions, above all immediately before the slaughtering, the glicogen muscular reserves are reduced, cutting the pH decrease down. due to glycolysis: the pH can't thus reach low enough values and the meats appear DFD, that is dark, firm and dry (Dell'Orto and Sgoifo Rossi, 2000), whereas a too fast pH decrease can yield PSE (pale, soft and exudative) meat (Moore e*t al*., 1998).

Each of the enzymatic complex which are active post mortem in the muscle, shows peculiar optimum values of pH, and therefore meat tenderness, flavour, water holding capacity and colour are influenced by pH, that therefore takes a relevant importance in muscle transformations after slaughtering (Panella *et al*., 1995;).

2.1.2 Meat color

Meat color is an important parameter in meat quality. It can be measured numerically using a colorimeter or subjectively. Several factors affect meat color such as species/breed, age, sex, cut of meat, surface drying of the meat and surface spoilage. Meat color is largely determined by the content of myoglobin and its derivatives. It is normal for meat to change color depending on the presence or absence of air. For instance, exposed meat changes color due to reactions occurring between myoglobin and

oxygen. Meat color changes in response to both the quantity of myoglobin it contains, and chemical changes in the myoglobin itself. The more myoglobin in the meat, the darker the color exhibited. Older sheep contain more muscle myoglobin and hence have darker meat than lambs.

Color is also greatly affected by muscle pH. At a high pH, muscle has a closed structure and, hence, appears dark and the meat tends to be tough. Meat color is also affected by diet. Meat can also become discolored before reaching a retail outlet if too much drying occurs. Hence, butchers prefer carcasses to have at least some fat cover (subcutaneous fat) evenly distributed over the carcass because it aids in maintaining quality and an attractive appearance by preventing the meat from drying (Sebsibe, 2008)

2.1.3 Tenderness

This parameter is intuitively clear for the consumer but it's however difficult to give a definition for it: Grau (1978) proposed: "chew ability, softness, pastiness, juiciness, amount and sort of the residue after the mastication, in addition to the opposite traits as firmness, strength and fibres length". It's generally defined as Shear Force, measured in kg/cm2 and it's determined with devices as bitetenderometer and Instron universal with Warner Bratzler Shear (Panella *et al.,* 1995); it consists of the force needed to go through a piece of meat of a certain thickness or to penetrate in it down to a certain depth, but it can also be measured as crushing force of a meat sample (Lawrie, 1966).

Tenderness is closely linked to the connective tissue amount in the muscle and to its features (Grau, 1978), in particular to collagen, to its solubility and to the branching degree of its structures, so much so that the measurement, with various methodologies, of the collagen amount, can give us useful information on meat tenderness (Avery and Bailey, 1995). A further method for tenderness evaluation is the measurement of collagen thermal solubility (Grau, 1978).

In a panel-test tenderness is evaluated as the opposite of the force needed to bite through a meat sample with the molar teeth: a greater tenderness corresponds to a lesser force used (Campo *et al.*, 1999). Tenderness is related to grain and texture, which are in their turn defined by the diameter of muscular fibers bundles, in which the muscle is divided by the connective tissue (Lusetti, 1983).

Grain is valued as the appearance of the cross-section of a cut of meat, perpendicular to muscular fibers. When the cut surface appears soft and velvety, the grain is defined as fine and it's indicative of a reduced diameter of fiber bundles, while if the cut surface is rough and dry, the grain is defined as coarse, and it's ascribable to a large diameter of the bundles and it's characteristic of aged animals; it must furthermore remark that different muscles have as a rule different grains (Lusetti, 1983).

Texture is instead assessed dissecting the muscle along the fibres and slightly stretching it: a firm texture is found in young and well fed animals while a loose texture is found in very young or aged, underfed or poorly fed animals. Even texture depends, besides, on the type of muscle (Lusetti, 1983).

According to Carlucci *et al*. (1999) the meat with regard to texture, can be defined as:

- Tender, when low force is needed to chew the product,
- Stringy, when fibres are perceived during the mastication,
- Juicy, when water is perceived during the mastication,
- Cohesive, when it's difficult to swallow.

In a panel test texture is evaluated as fibre perceived by the taster on a sample after four chews; also residue is evaluated, defined as the amount of connective tissue perceived by the taster before swallowing (Campo *et al*., 1999).

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2.2 Concept of Value Chain

Basically, a value chain describes the range of activities from the producer to the consumer. In its analysis, it is broken into networks of activities controlled by categories of functionaries and distinguishes the stages in the supply process and support services to accomplish the tasks. Various dimensions are analyzed in the chain:

- Input-output structure and geographical coverage and by analyzing the value-added in the chain, the level of economic rent can be stabilized. In livestock marketing, the chains have a wide geographical coverage and margins vary by region.
- Institutional framework which identifies key players in the livestock sub sector. These include producers, assemblers, middlemen, traders, brokers, transporters, providers of services (regional offices, veterinary department and other government agencies) and consumers.

2.3 Meat Value Chain Actors

Most of the export abattoirs and live animal exporters collect animals either through their own purchasing agent assigned in major livestock markets or through other small and large scale traders. Sometimes livestock trading cooperatives are also directly supplying animals to the exporters. Exporters' purchasing agents in turn collect animals either from collectors, small traders, livestock trading cooperatives, farmer groups or directly from producers. Producers have the option of selling their animals to the collectors in their village, small traders, and livestock trading cooperatives or directly to the exporters. Some farmers also form groups and supply animals to the market (Getachew *et al.,* 2008).

2.3.1. Producers

The producers of live animal especially goat and sheep for meat export are found in the lowland areas such as Low lands of Oromia, Afar, Somali and South Omo. The marketing behavior of producers varies from place to place. Pastoralists consider larger herd size as symbols of prestige. Sales of live animals are taken as a last resort and animals are generally sold when the producers face financial shortage and drought. When there is rain fall/summer season, there is shortage of live animal in the market due to over flooding of rivers and road problem. In addition, the pastoralists want to reproduce their animals in order to increase their animal wealth (Adugnaw M. et al., 2009).

2.3.2 Live animal Traders

The live animal suppliers/agents (especially sheep and goat) are mostly found in Metehara , Borena and Afar. They buy live animals either directly from the farmers /producers/ pastoralists or buy from other traders at different village markets. The process of supplying the live animals to companies passes through different channels. These are:

- The agent directly buys from the producers/pastoralists at the open markets held around their villages and transport to his/her staying center by Isuzu or on foot.
- The agent also buys from other small traders/collectors who buy either from the Producers /pastoralists directly or from primary, secondary and tertiary markets. In this case, more than one, two, three or even four traders/ middlemen may participate in live animal trading before the agent forwards the animals to the abattoir. The term small trader refers the amount of live animal he/she can buy directly from the producers and resell to other traders or the agent/supplier to the abattoir with marginal profit.
- The agent keeps the live animals/sheep and goat he/she bought from the traders or directly from the producers in his/her feedlot for three days-to rehabilitate- and transports them to the abattoir by Isuzu. The agents buy sheep and goats either by visual guess or by weighing them using balance. But, the abattoir buys the animals by

Weighing them using balance. The live weight of sheep and goats, on average, ranges from 14kg to 30kg.

2.3.3 Animal Feed suppliers

There are different millers which supply animal feed for the fattening centers and abattoirs. Most of the time the abattoirs use grass only for the animals, because they keep their animals for the maximum of three days in the abattoir compound. The abattoirs get grass from Selale, Sululta and sendafa.

2.3.4 Abattoirs/Butchers

Among the existing nine export abattoirs, only 5 are currently functional (Table 1). All of the existing abattoirs have facilities for sheep and goats, but facilities for cattle are limited in all of the abattoirs and none of the export abattoirs are currently exporting beef. These abattoirs get their animals supplied by traders or through their agents. When the demand is high and the supplies are limited from their usual sources, some of them buy animals from big traders at their factory gate. Upon arrival animals undergo physical examination and are rested for two to three days in a holding area where they receive feed and water. Before slaughtering, they are held in lairage for 12 to 24 hours with access to water but not feed. During their stay in the lairage, animals undergo ante mortem or pre-slaughter examination. Animals that pass the examination are slaughtered using the Halal procedure. Afterward the carcass is chilled at -2 to 2 degrees Celsius for 24 hours. In most cases slaughtering is done when abattoirs receive orders from their customers. The only processing that local abattoirs do is putting the carcass in stocknet for shipping. Depending on demand and availability of freight, carcasses are loaded onto trucks fitted with coolers and transported to the airport. All of the export abattoirs have their own trucks which they use for transporting. Upon arrival at the airport, the chilled carcasses are transferred to cold stores and held there until loaded onto the airplane shortly before the flight time.

All export abattoirs have networks in destination markets through which they sell their product. Mojo Modern even has a retail outlet in each of Riyadh and Dubai from which they sell meat directly to consumers as well as being an outlet for their wholesale business in Saudi Arabia and the UAE, respectively.

Abattoirs in Ethiopia sell both meat and meat by-products. Contrary to the approach taken by abattoirs elsewhere, the abattoirs in Ethiopia try to sell as much of the by-product as they can because it is by selling the by-product of the animals – hides, skins, blood, intestines, organs, etc that they make enough money to break even. Consistently selling the meat into the market is the road to profitability for the abattoirs in Ethiopia.

In Ethiopia, some of the by-products are being exported; however, there is an active domestic market for by-products as well. These include rumen gastro intestinal tract (GIT), liver, kidney and lung. Of these products the lung is usually sold as a pet food (cat) and other products are used in some dishes preferred by consumers in the market. Some export abattoirs have recently started exporting by-products like kidneys, brain and intestines. There seems to be a prospect for expanding the export of by-products as new markets for these products are appearing.

Two by-product processing plants which are located in Dukem (Turkish Company) and Debre Zeit (Chinese Company) process intestines and other GIT products and export to various countries including Vietnam, China, Turkey and the Gulf states. It is notable that the cost of these by-products have increased to 10 ETB per kg, up from just 2 ETB/kg only two years ago (Getachew *et.,al*. 2008)

Table 1: Export abattoirs operating in Ethiopia

Abattoir name	Type of process	Type of export	Certifications	Location	Remark
Mojo Modern	Slaughter and Chill	Sheep and goat carcass	HACCP; Halal	Mojo, Oromiya	Also export kidneys and brains. Has an adjacent tannery.
Organic	Slaughter and Chill	Sheep and goat carcass	HACCP; Halal	Mojo, Oromiya	Also export Kidney,brain, tangue, liver, heart
Helmix	Slaughter and Chill	Sheep and goat carcass	HACCP in process; Halal	Debre Zeit, Oromiya	Has facility for slaughtering cattle but currently not exporting.
Elfora	Slaughter and Chill	Sheep and goat carcass	HACCP in process; Halal	Debre-Zeit, Oromiya	Has facility for slaughtering cattle and chilled carcass is destined for local market.
Luna	Slaughter and Chill	Sheep and goat carcass	HACCP in process; Halal	Mojo, Oromiya	Has a facility for slaughtering cattle and chilling, but supply the supermarket in Addis.
Melge-Wondo Meat Factory	Slaughter and Chill	Cattle carcass	HACCP in process; Halal	Wondo, SNNP	Used to export quartered carcass to Egypt but not operating currently.
Methara	Slaughter and Chill	Sheep and goat carcass	HACCP in process; Halal	Metehara, Oromiya	Currently not operational.
Abergelle	Slaughter and Chill, freezing	Sheep, goat and cattle meat	HACCP in process; Halal	Mekele, Tigray	Currently not operational.
Ashraf	Slaughter, chill, freeze, and by-product process	Sheep, goats and cattle	HACCP in process; Halal	Bahir dar, Amhara	Currently not operational.

Source ; Getachew *et., al,* 2008.

2.4. Microbiological quality of meat

Meat is not only highly susceptible to spoilage, but also frequently implicated in the spread of food borne illness. Contaminated raw meat is one of the main sources of food borne illness (Bhandare *et al*., 2007; Podpecan *et al*., 2007). During slaughter and processing, all potentially edible tissues are subjected to contamination from a variety of sources within and outside animal. In living animals, those surfaces in contact with the environment harbor a variety of microorganisms. The contaminating organisms are derived mainly from the hide of the animal and also comprise organisms that originate from both feces. The external contamination of meat constitutes a major problem in most developing countries' abattoirs where they are potential sources of infection as microbial surface contamination of carcasses has been repeatedly reported to have a significant effect on the meat (Elmossalami, 2003).

In addition, processed meat foods are more prone to contamination with pathogenic microorganisms during the various stages of processing. Meat and meat products are important sources of human infections with a variety of food borne pathogens, i.e. Salmonella spp., Campylobacter jejuni/coli, Yersinia enterocolitica, verotoxigenic Escherichia coli and, to some extent, Listeria monocytogenes. Some pathogens in meats (eg. Salmonella spp., Campylobacter spp.) are most efficiently controlled by the main interventions applied in the primary production combined with the optimization of the slaughter hygiene.

The sheep and goat slaughter process begins by Halal slaughtering of the animal, bleeding, legging and skinning. The skin is removed, and the carcass is eviscerated and trimmed. The carcasses are washed and then cooled to refrigeration temperatures. The initial research on carcass washing was with washing the eviscerated carcass which, as the final step before chilling, was intended to remove as much of the total physical and microbiological contamination as possible. Manual washing was refined with equipment that automatically washed the carcasses. The automated systems were more consistent in operation than a manual system, and also reduced the amount of water used in washing.

A further refinement of the automated systems was the inclusion of a sanitizing rinse immediately after washing. The sanitizing rinse uses food grade antibacterial compounds to inhibit the growth of any bacteria remaining after the initial wash. The sanitizers typically are organic acids, such as acetic (vinegar) or lactic acid (naturally occurring in cheese) (CAC, 2005).

2.4.1 *E.Coli* contamination of meat

E. coli O157:H7 is a Gram negative, facultative anaerobe, non-spore forming rod shape bacterium. Diseases caused by *E. coli* O157:H7 vary from non-bloody diarrhea and bloody diarrhea through haemorrhagic colitis. *Escherichia coli (E. coli)* bacteria normally live in the intestines of people and animals. Most *E. coli* are harmless and actually are an important part of a healthy human intestinal tract. However, some *E. coli* are pathogenic, meaning they can cause illness, either diarrhea or illness outside of the intestinal tract. The types of *E. coli* that can cause diarrhea can be transmitted through contaminated water or food, or through contact with animals or persons (CDC, 2012).

E. coli O157:H7 is most commonly found in cows, although chickens, deer, sheep, and pigs have also been known to carry it. Meat becomes contaminated during slaughter, when infected animal intestines or feces come in contact with the carcass. Ground or mechanically tenderized meats are considered riskier than intact cuts of meat because *E. coli* bacteria can be mixed throughout the meat in the grinding process or during tenderization. Other foods that sometimes become contaminated with *E. coli* bacteria include unpasteurized milk and cheese, unpasteurized juices, alfalfa and radish sprouts, lettuce, spinach, and water. However, any food is at risk of becoming contaminated with *E. coli* through cross-contamination. One can also get *E. coli* bacteria from contact with feces of infected animals or people (Marler C., 2013).

While *E. coli* typically harmlessly colonizes the intestinal tract, several *E. coli* clones have evolved the ability to cause a variety of diseases within the intestinal tract and

elsewhere in the host. Those strains that cause enteric infections are generally called diarrheagenic *E. coli* strains, and their pathogenesis is associated with a number of virulence attributes, which vary according to path type (Vidal, M. *et al.,* 2005). The behavior of this bacterium at different storage temperatures and incubation periods shows resistance and multiplication at low temperatures, especially when stored at 12-22 ºC (Arias *et al.* 2000).

2.4.2 Organic acid spray for meat decontamination

During slaughter and processing all edible tissues are subject to contamination from a variety of sources within and outside the animal. Microbial growth is generally confined to the outer surfaces where bacteria become irreversibly attached. The microbiological quality of raw meat is critical to the quality of the final product, as fresh meat presents an environment which is ideal for the growth of many microbes. With respect to health and economic problems caused by these bacteria, it is very important to reduce the initial microbial population on meat. Various intervention strategies have been developed to reduce the level of bacteria on. Solutions of organic acids (1-3%) such as lactic and acetic acids are the most frequently used chemical interventions in commercial plants for both beef and lamb dressing. Many other organic acids, however, have been researched either separately or as a mixture for use in chemical washes, including formic, propionic, citric, fumaric, and L-ascorbic acid (MIS, 2006).

The mechanism of action of organic acids on the microbial cell is not completely understood, but it is hypothesized that it is the un dissociated molecule of the acid that is responsible for the antimicrobial activity. There is a lot of variability in the literature in terms of the cited reductions that can be achieved. This is mainly due to differences in the concentrations of the acids used by different researchers, the method of application, and the types of samples tested. There is also some evidence that organic acids may enhance the shelf life of modified atmosphere packaged product, mainly because they increase the lag phase of the microorganisms. Several intervention strategies have been tested and/or

adopted for use in eliminating both pathogenic and spoilage bacteria from carcass surfaces. For example, solutions of acetic acid are commonly used by the slaughter industry as antimicrobial spray wash interventions to reduce the microbial load on freshly slaughtered carcasses (Berry and Cutter, 2000). The acetic acid is generally recognized as safe substance with no upper limit of daily intake for humans (FAO, 1965). Substantial increases in the occurrence of food poisoning outbreaks and commercial requirements to extend the safe, high quality shelf-life of food have focused attention on decontamination system. Researchers have shown significant reduction of microbes on fresh meat carcass surfaces after the use of an acetic acid spray (Islam *et al*., 2008; Canibe *et al*., 2001).

It is known that acetic acid inhibits mainly yeasts and bacteria as Bacillus spp., Clostridium spp., Pseudomonas spp., Campylobacter jejuni, Escherichia coli, Listeria monocytogenes, Salmonella sp. and Staphylococcus aureus (Davidson; Taylor, 2007); it also inhibits mesophilic enteric bacteria, which are more sensitive to organic acids than the pathogenic bacteria species (Sofos *et al*., 1999).

A positive point of organic acid decontaminate interventions is that the antimicrobial action of acids goes beyond their spraying on carcasses. Their action after spraying may be of particular importance for the control of pathogens because rapid proliferation of pathogens can take place in decontaminated carcasses. Acid washing with acetic acid imparts residual inhibition of pathogens from a short-term bactericidal effect for about 2 days after washing. (Carpenter, Smith and Broadbent, 2011).

3. MATERIALS AND METHODS

3.1. Study area

The research is conducted in export abattoirs which are found in Modjo town from Oct 2013 to April 2014. Modjo is a town in central Ethiopia, located in the East Shewa zone of Oromia Regional Estate at a distance of 70kms South East of Addis Ababa. The latitude and longitude of the town is $8^{0}39^{'}$N and $39^{o}5^{'}$E, respectively, with an altitude of between 1788 and 1825 meters above sea level. The average minimum and maximum temperature is 18^{o}C and 28^{o}C, respectively and has an experience of bimodal rain fall pattern in which the main rainy season occurs between June and September and Short rainy season from March to May. The average anuall rain fall is of 800mm (ILRI, 2005). The study was conducted in purposively selected two export abattoirs in Modjo. These export abattoirs are selected because of two criteria. The first criterion was based on currently optimum production and export to ensure the random distribution of samples that would be monitored for carcass temperature control, carcass pH and stockinet condition. The second criterion was the number of slaughter houses that were more available to the same place that is Modjo city. On these export abattoirs 700 to 2500 sheep and goats were slaughtered every day depending on the demand from customers, availability of supply of animals and air cargo space but for ethical reason the names of the export abattoirs will not be mentioned.

3.2. Study animals

Ethiopian indigenous goat types which are originated from the low lands of the country areas including Borena, Afar, Bale (Ginir), Somalie, Wollo and Jinka were used in the abattoir as slaughter animals. Traditional management condition of feeding and watering of these goats were considered and from these breeds Borena goat breeds apparently healthy ones that were rested in the lairage for 24 hrs were used as study animals.

3.3. Study Design

A cross sectional study was conducted on meat carcass on the abattoirs. A total of 224 samples were selected randomly from the two export abattoirs to determine the carcass temperature, pH and coliform bacterial count. 111 and 113 goat carcass was selected from the first and second export abattoirs respectively. From these carcasses, 84 and 86 carcasses were taken to determine carcass temperature, pH, and packaging quality for the first and second abattoirs respectively. Twenty seven types of swabbed samples from each abattoir were taken from hind limb, abdominal area, forelimb, neck area before washing, after washing, after organic acid spray, after 24 hrs of chilling at 2±1 ^{0}C, from workers hand, apron, water and knife were taken. Each sample was tagged for easy identification.

3.2.1 Effect of Temperature and pH

Analyzed cooling links of the chilled carcass chain were; the cooling storage at abattoirs, cold trucks and air port cold store. Temperature and pH variation in cold rooms and cold trucks were taken using Lutron YK-2001 pH intelligent meter. Transportation time from the abattoirs to the Bole airport took in around 2.5 hrs. The pH of the carcass was determined after the carcasses chilled at 2±1^{o}C for 24 hrs with a hand held Lutron YK-2001 Intelligent meter.

3.2.2 Bacteriological sample processing

Swabbing at the time of sampling was done at the area of 50 cm^2 that were delineated by sterile aluminum template (10mm X 5mm) (ISO 17604, 2003). The swab was first soaked in 10ml of peptone water in a test tube and rubbed first horizontally and then vertically several times on the site within the aluminum template. After completion of rubbing process, the swabs were then put into sterile test tube filled with 10 ml of 0.1%

sterile peptone water and transported using an insulated ice box at 4^{o}C to National Veterinary Institute (NVI), Bishoftu for Microbiological analysis of the samples.

3.2.3 Meat packaging quality

Carcass is packed using stockinet. The packaging qualities of the carcass were determined by visual judgment of the blood stain on the stockinet. Score 0 was given for no blood stains, score 1 for slight blood stains, score 2 for moderate blood stains and score 3 for high blood stains on the stockinet.

3.3 Data Analysis

Data were entered in to Microsoft excel. The data were transferred to SPSS 20 windows version program. After normalizing the data by using the descriptive statistics such as mean, standard deviation and graphs were performed. The means of specific *E. coli* counts, pH, packaging and temperature were compared using t-test at 95% confidence interval.

4. RESULTS

4.1 Temperature

The temperatures of the 170 samples from the two export abattoirs after 24hrs of chilling at 2±1^{o}C before loading to cold trucks and after unloading from cold trucks were determined. The mean temperature of carcass of one of the export abattoir before loading was +0.55^{o}C and at unloading 0.091^{o}C. The respective minimum and maximum values were 0^{o}C and 4^{o} C for temperatures at loading respectively. And the minimum and maximum unloading carcass temperatures were -0.6 and 1.7^{o}C, respectively.

The mean temperature of the second export abattoir at loading was -1.03^{o}C and at unloading 0.548^{o}C. The respective minimum and maximum values were for temperature at loading -1.7 ^{o}C and 0.03 ^{o}C; whereas the respective minimum and maximum unloading carcass temperature were -1 ^{o}C and 3.2 ^{o}C respectively (Table 2).

Table 2. The summary of descriptive statistics for the temperature of the carcass from the two export abattoirs

Abattoirs	**Sample size**	**Mean of Tem at loading**	**SD**	**Min**	**Max**
EXAB 1	84	0.55	1.33	0	4
EXAB 2	86	-1.03	0.266	-1.7	0.03
Abattoirs	**Sample size**	**Mean of Tem at unloading**	**SD**	**Min**	**Max**
EXAB 1	84	0.091	0.6	-0.6	1.7
EXAB 2	86	0.96	0.96	-1	3.2

EXAB1= Export Abattoir 1, EXAB2= Export Abattoir 2

4.2 The pH of the Carcass

The mean pH value of the carcass of the first abattoir was 6.12 with minimum and maximum value of 5.11 and 8.39 respectively, which were taken from the chilled goat carcass stayed in the cold room for 24 hrs at a temperature of 2±1^{o}C; whereas the mean pH value of the carcass of the second abattoir is 5.69 with minimum and maximum value of 4.6 and 6.5 respectively(Table3).

Table3. The summary of the pH value of the meat carcasses from the two export abattoirs

Abattoirs	Sample size	Mean of pH	SD	Min	Max
EXAB 1	84	6.12	0.68	5.11	8.39
EXAB 2	86	5.69	0.4	4.6	6.5

EXAB1= Export Abattoir 1, EXAB2= Export Abattoir 2

4.3 Packaging Quality

The packaging quality of the carcass was determined. The mean of packaging quality of the first and the second abattoir was 1.62 and 0.6 respectively (Table 4).

Table 4. The summary of the packaging quality of the carcass of the two export abattoirs

Abattoirs	Sample size	Mean of packaging quality	SD	Min	Max
EXAB 1	84	1.62	.993	0	3
EXAB 2	86	0.6	.756	0	2

EXAB1= Export Abattoir 1, EXAB2= Export Abattoir 2

Figure 1. Packaging quality of the carcass of the two export abattoirs

4.4 The *E. coli*

The *E. coli* load of 54 samples before carcass washing, after washing, just after being organic acid sprayed and after chilled for 24 hrs at a temperature of 2±1^{o}C and after 48hrs of incubation was determined. The log mean of *E. coli* count before acetic acid (2.5%) spray for the first and the second abattoirs were 49.63 $\log_{10}$ CFU/cm^2 and 41.85 $\log_{10}$ CFU/cm^2 respectively. The respective minimum and maximum values of the first abattoir were 0 and 460 $\log_{10}$ CFU/cm^2 and for the second abattoir 0 and 660 $\log_{10}$ CFU/cm^2 respectively.

The log mean of *E. coli* count before acetic acid spray for samples from the first abattoir was 12.75 $\log_{10}$ CFU/cm^2 (SD= 13.52); whereas from the second abattoir it was 2.5 $\log_{10}$ CFU/cm^2 (Table 5). The number of *E. coli* counts before acetic acid spray was higher for samples taken from the first abattoir.

Table 5. The summary of descriptive statistics for the *Escherichia coli* count before acetic acid spray

Abattoirs	Sample size	Mean of $\log_{10}$ CFU/cm^2	SD	Min	Max
EXAB 1	8	12.75	13.52	0	40
EXAB 2	8	2.50	7.07	0	20

EXAB1= Export Abattoir 1, EXAB2= Export Abattoir 2

The log mean of *E. coli* load after acetic acid spay was also determined. For samples taken from the first abattoir was 3.5 $\log_{10}$ CFU/cm^2 (SD= 7.23); whereas from the second abattoir it was 0.00 $\log_{10}$ CFU/cm^2 (SD= 0.000) (Table 6). The number of *E. coli* counts after acetic acid spray was higher for samples taken from the first abattoir.

Table 6. The summary of descriptive statistics for the *Escherichia coli* count after acetic acid spray

Abattoirs	Sample size	Mean of $\log_{10}$ CFU/cm^2	SD	Min	Max
EXAB 1	8	3.52	7.23	0	20
EXAB 2	8	0.00	0.000	0	0

EXAB1= Export Abattoir 1, EXAB2= Export Abattoir 2

The log mean of *E. coli* count from aprons, palm, knife and water from different areas were determined. The log mean of *E. coli* count from the first abattoir were 110 $\log_{10}$

CFU/cm^2 (SD= 178.718) where as from the second abattoir it were 100.91 $\log_{10}$ CFU/cm^2 (SD= 203.59) (Table7). The number of *E. coli* count was higher on the first abattoir especially on samples taken from knife taken from the dirty area.

Table 7. The summary of descriptive statistics for the *Escherichia coli* count workers facility and water

Abattoirs	**Sample size**	**Mean of** $\log_{10}$ CFU/cm^2	**SD**	**Min**	**Max**
EXAB 1	11	110	178.718	0	460
EXAB 2	11	100.91	203.59	0	660

EXAB1= Export Abattoir 1, EXAB2= Export Abattoir 2

4.5, The Mean Temperature at Loading at Export Abattoirs

Independent t-test statistical analysis for mean of temperature readings from the two export abattoirs showed significant difference (P<0.05). The independent t-test on the mean of temperature at loading between the two export abattoirs were statistically significant (Table 9).

Table 8. Group Statistics of temperature at loading of the two export abattoirs

	Temperature at loading	N	Mean	Std. Deviation	Std. Error Mean
Temperature	EXAB1	84	.55	1.333	.145
	EXAB2	86	-1.03	.266	.029

EXAB1= Export Abattoir 1, EXAB2= Export Abattoir 2

Table 9. Independent samples test of temperature at loading between the two export abattoirs

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Tempratu re at unloading	Equal variances assumed	19.930	.000	-3.747	168	.000	-.4596	.1227	-.7017	-.2174
	Equal variances not assumed			-3.766	143.162	.000	-.4596	.1220	-.7008	-.2184

4.6 The Mean Temperature at Unloading at Export Abattoirs

Independent samples t-test for mean of chilled carcass temperature at unloading point from the two export abattoirs showed significant difference ($P<0.05$). The mean temperatures of the goat carcass at unloading for the first export abattoir were $0.091^{o}C$ whereas for the second export abattoir was $0.96^{0}C$. The independent t-test on the mean of chilled carcass temperature at unloading between the two export abattoirs was statistically significant (Table 11).

Table 10. Group statistics of temperature at loading of the two export abattoirs

	Abattoirs	N	Mean	Std. Deviation	Std. Error Mean
Temprature at unloading	EXAB1	84	.088	.5979	.0652
	EXAB2	86	.548	.9563	.1031

EXAB1= Export Abattoir 1, EXAB2= Export Abattoir 2

Table 11. Independent samples test of temperature at loading between the two export abattoirs

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Temprature at unloading	Equal variances assumed	19.930	.000	-3.747	168	.000	-.4596	.1227	-.7017	-.2174
	Equal variances not assumed			-3.766	143.162	.000	-.4596	.1220	-.7008	-.2184

4.7 The Mean pH of the Carcass of the Export Abattoirs

Independent t-test statistical analysis for mean of chilled carcass pH readings from the two export abattoirs showed significant difference ($p<0.05$). The mean chilled carcass pH value of the first abattoir was 6.126 and the second abattoir was 5. 691. The independent t-test on the mean of chilled carcass pH between the two export abattoirs was statistically significant (Table 13).

Table 12. Group Statistics of pH of carcass of the two export abattoirs

	Abattoirs	N	Mean	Std. Deviation	Std. Error Mean
pH	EXAB1	84	6.126	.6798	.0742
	EXAB2	86	5.691	.4009	.0432

EXAB1= Export Abattoir 1, EXAB2= Export Abattoir 2

Table 13. Independent Samples Test of pH of carcass between the two export abattoirs

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
pH	Equal variances assumed	13.029	.000	5.094	168	.000	.4348	.0854	.2663	.6033
	Equal variances not assumed			5.065	133.884	.000	.4348	.0858	.2650	.6046

4.8 Effect of Animal Holding Time on Carcass pH

The mean pH value of the goat carcass and animal holding time for the first abattoir was 6.13 and 7.08 hrs respectively and for the second abattoir it was 5.69 and 40 hrs respectively. The paired t test between the two abattoirs on the difference in animal holding time and pH were statistically significant ($p<0.05$).

Table 14. Paired samples statistics of animal holding time on pH

		Mean	N	Std. Deviation	Std. Error Mean	correlation
Pair 1	Animal Holding time (hrs)	24.11	170	21.980	1.686	-0.416
	Ph	5.9062	170	.59606	.04572	

Table 15. Paired samples test of animal holding time on pH between the two export abattoirs

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Animal Holding time (hrs) - Ph	18.20553	22.23476	1.70533	14.83904	21.57202	10.676	169	.000

4.9 The Mean *E. coli* Load of Goat Carcass at the Export Abattoirs

Independent samples t-test analysis for mean of *E. coli* counts on the first and second export abattoir showed no significant difference ($p<0.05$). The independent t-test on the mean of *E. coli* count between the two export abattoirs were statistically no significant difference ($p<0.05$) (Table 17).

Table 16. Group Statistics of *E. coli* of the two export abattoirs

	Abattoirs	N	Mean	Std. Deviation	Std. Error Mean
log10CFU/cm2	EXAB1	27	49.63	122.324	23.541
	EXAB2	27	41.85	135.818	26.138

EXAB1= Export Abattoir 1, EXAB2= Export Abattoir 2

Table 17. Independent samples test of *E. coli* load between the two export abattoirs

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
log10CFU /cm2	Equal variances assumed	.038	.847	.221	52	.826	7.778	35.177	-62.809	78.365
	Equal variances not assumed			.221	51.441	.826	7.778	35.177	-62.827	78.383

4.9.1. The mean *E. coli* load on goat carcass before acetic acid spray

Independent samples t-test for the mean of *E. coli* load on the carcass before acetic acid pray (2.5%) showed no significant difference ($p<0.05$). There were no significant differences on *E. coli* load on carcass before acetic acid spray between the two export abattoirs (Table 19).

Table 18. Group Statistics of *E. coli* load on the carcass before acetic acid spray

	abattoirs	N	Mean	Std. Deviation	Std. Error Mean
log10CFU/cm2	EXAB1	8	12.75	13.520	4.780
	EXAB2	8	2.50	7.071	2.500

EXAB1= Export Abattoir 1, EXAB2= Export Abattoir 2

Table 19. Independent Samples Test of *E. coli* load on carcass before acetic acid spray between the two export abattoirs

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
log10CFU /cm2	Equal variances assumed	3.403	.086	1.900	14	.078	10.250	5.394	-1.320	21.820
	Equal variances not assumed			1.900	10.563	.085	10.250	5.394	-1.683	22.183

4.9.2. The mean *E. coli* load on goat carcass after acetic acid spray

Independent samples t-test for the mean of *E. coli* load on the carcass after acetic acid pray (2.5%) showed no significant difference ($p<0.05$). There were no significant differences on *E. coli* load on carcass after acetic acid spray between the two export abattoirs (Table21).

Table 20. Group Statistics of *E. coli* load on carcass after acetic acid spray

	abattoirs	N	Mean	Std. Deviation	Std. Error Mean
log10CFU/cm2	EXAB1	8	3.50	7.231	2.557
	EXAB2	8	.00	.000	.000

EXAB1= Export Abattoir 1, EXAB2= Export Abattoir 2

Table 21. Independent Samples Test of *E. coli* after acetic acid spray between the two export abattoirs

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
log10CFU/cm2	Equal variances assumed	10.608	.006	1.369	14	.193	3.500	2.557	-1.983	8.983
	Equal variances not assumed			1.369	7.000	.213	3.500	2.557	-2.545	9.545

4.9.3 The mean *E. coli* load on the materials and water

The independent samples t-test analysis for mean of *E. coli* counts from aprons, workers palm, knife and carcass washing waters showed no significant difference ($p<0.05$). There were no significant difference on *E. coli* load on aprons, workers palm, knife and carcass washing water between the two export abattoirs (Table 23).

Table 22. Group Statistics of *E. coli* load on the materials and water

	abattoirs	N	Mean	Std. Deviation	Std. Error Mean
log10CFU/cm2	EXAB1	11	110.00	178.718	53.885
	EXAB2	11	100.91	203.590	61.385

EXAB1= Export Abattoir 1, EXAB2= Export Abattoir 2

Table 23. Independent Samples Test of *E. coli* load on materials and water between the two export abattoirs

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
log10CFU/cm2	Equal variances assumed	.063	.804	.111	20	.912	9.091	81.681	-161.292	179.474
	Equal variances not assumed			.111	19.670	.913	9.091	81.681	-161.476	179.657

5. DISCUSSION

5.1. Temperature

Temperature control does not apply to live animal production but begins at the slaughter process. Temperature control is one of the most effective tools in producing a safe product. Controlling the temperature of carcasses during the slaughter process has been proven to not only help control microbial growth, but also to assist in creating a quality meat product (MOARD, 2009). To understand the effects of stress on final meat quality, it is important to understand the relationship of glycogen and lactic acid to pH decline in meat after slaughter. An animal which has not been stressed will have normal levels of glycogen in its body. When the animal is slaughtered, the metabolic process continues but oxygen no longer circulates. In the absence of oxygen, the breakdown of glycogen/glucose results in a buildup of lactic acid, which then causes a drop in pH of the meat (Amha, 2008).

In this study the mean temperature readings of the carcass at loading from the two export abattoirs showed significant difference at $p<0.05$. The mean temperature of the carcass of the first abattoir before loading was $+0.55^0$C while the second was -1.7^0C. According to the ministry of Agriculture of Ethiopia (MOA), the chilled carcass for export should be reached between 0 and 4^0C. The results indicate that the first abattoir which the animal holding time in the abattoir compound was much less than the second one shows it may have affected by the cold room management, over stocking and too much water in the body of the carcass (osmosis) will lead to a higher relative humidity in the cold room and the internal meat temperature takes longer time to reach to 0^0C as (MOARD, 2009) indicated that the time taken to cool product to 0^0C in chilling depends on the temperature of the air, the rate of airflow past the product and level of insulation provided by the package. Cooling rate is also a function of the weight and fat cover of a given side.

The mean temperature readings of the carcass at unloading at bole international air port cargo area for the first and second export abattoir were 0.088^0C and 0.96^0C (Table 3).

The temperature of the carcass for the second export abattoir was high. The difference in the mean of temperature between these two sampling sites were statistically significant ($p<0.05$). This variation may be due to transport refrigeration vehicles. The results indicates that the cold trucks for the second export abattoir were not working properly, specially the refrigeration evaporation units which create the cold air necessary to maintain the temperature required for the carcass (AFGC, 2013).

5.2 Carcass pH

The mean pH value of the chilled goat carcass of the first and second export abattoirs were 6.12 and 5.69 respectively. The pH value of the second abattoir was lower which indicates that the animal handling and holding time was good as compared to the first abattoir. The difference in mean pH value of the chilled goat carcass between the two export abattoirs was statistically significant ($p<0.05$). As indicated on (Amha, 2008), good quality meat usually has a pH of 5.4-5.7. Lower pH after slaughter depends on the amount of glycogen in the muscle prior to the animal's death. Low pH has a bacteriostatic effect on the meat. Accordingly, meats with pH values above 6 are generally considered unsuitable for storage because of the favorable development of proteolytic microorganisms. If initial glycogen is limited, the pH stays high and the meat remains Dark Firm and Dry (DFD), as it is in the live animal. If the pH decline is rapid (affecting muscle proteins while still warm) or extensive (giving a low ultimate pH), the meat becomes Pale Soft and Oxidative (PSE). Thus, the pH of meat has a profound effect on color, firmness and water-holding capacity, as well as subtle effects on taste, tenderness and rate of post-mortem conditioning (MOARD, 2009).

The mean pH value of the goat carcass and animal holding time for the first export abattoir was 6.13 and 7.08 hrs respectively and for the second export abattoir it was 5.69 and 40 hrs respectively. The paired t test between the two abattoirs on the difference in animal holding time and pH were statistically significant ($p<0.05$). This result indicates that the second export abattoir had much better animal management practice and as

(MOARD, 2009) indicates that animals which reach to export abattoir at least should rest for 72 hrs in the reception area to recover from the transportation and change of place.

5.3 Packaging Quality

The mean value of packaging quality of the carcass from the first and second export abattoirs were 1.62 and 0.6 respectively. The values were given on subjective basis and scores were given to the values. (Score 0 for no blood stain, score 1 for slight blood stain, score 2 for moderate blood stain and score 3 for high blood stain on the packaging (stockinet)). The difference in packaging quality between the two export abattoirs were statistically significant ($p<0.05$). The difference could be due to the packaging materials. The first abattoir used stockinet made of polyester and the second abattoir used stockinet made of cotton. It is observed that stockinet made of polyester had less water absorbing capacity than the cotton made. Even though the mean temperature of the first abattoir at unloading had lower temperature than the second one, its packaging material made of polyester made it to be lower than the packaging quality of the second export abattoir.

5.4 Bacteriological Quality

In the current study, the $\log_{10}$CFU/cm^2 mean of *E.coli* load before acetic acid (2.5%) spray, after acetic acid spray and other materials used in the process were determined. The log mean of *E. coli* count before acetic acid spray for samples from the first abattoir was 12.75 $\log_{10}$ CFU/cm^2; whereas from the second abattoir it was 2.5 $\log_{10}$ CFU/cm^2. The carcass may be contaminated by fecal material, dirt from the skin and unwashed workers hands during slaughtering operation. High total *E. coli* count indicates poor hygienic practice in the slaughter house and also manual rail system also leads to the increment of *E. coli* load because of the contact of on carcass to another on the rail. As reported on (Amsalu *et al*., 2013), the $\log_{10}$CFU/cm^2 mean of *E. coli* count before 2.5% acetic acid spray ranging from 2.2 $\log_{10}$ CFU/cm^2 to 2.9 $\log_{10}$ CFU/cm^2 was comparable

with this study. The first export abattoir had relatively higher mean of *E. coli* load before spray because of the rail system of the abattoir is manual and it may led to more contamination of the carcass. While the second export abattoir had automatic conveyor rail system which may led to minimal contamination of the carcass.

The $\log_{10}$ CFU/cm^2 mean of *E. coli* count before 2.5% acetic acid spray from the first and second export abattoirs were 12.75 and 2.5 $\log_{10}$ CFU/cm^2 respectively. The number of *E. coli* count before acetic acid spray on the first export abattoir was high. There were no significant difference on *E. coli* load on carcass before acetic acid spray between the two export abattoirs ($p<0.05$). This similarity may be due to little variations on distribution of the contaminants. The first and second export abattoirs had the same process flows and contamination of carcass may be occurred from the gut, skin, equipment, personnel and splashes of water from the floor during cleaning and slaughtering process (Assegid, 2008).

The $\log_{10}$ CFU/cm^2 mean of *E. coli* count on goat carcasses after acetic acid spray from the first and second export abattoirs were 3.5 and 0.00 $\log_{10}$ CFU/cm^2 respectively. Relatively low number of *E. coli* count were obtained from carcasses sprayed with acetic acids than not acetic acid sprayed from the first abattoir 12.75 $\log_{10}$ CFU/cm^2 and second export abattoir 2.5 $\log_{10}$ CFU/cm^2. This result was comparable with previous works reported by (Hftman, 2002), indicating that decontamination with organic acid solution reduces the number and prevalence of food borne pathogens and microbial load of meat. There were no significant differences on *E. coli* load on carcass after acetic acid spray between the two export abattoirs ($p<0.05$).

The mechanism of action of organic acids on the microbial cell is not completely understood, but it is hypothesized that it is the undissociated molecule of the acid that is responsible for the antimicrobial activity. There is a lot of variability in the literature in terms of the cited reductions that can be achieved. This is mainly due to differences in the concentrations of the acids used by different researchers, the method of application, and the types of samples tested. There is also some evidence that organic acids may enhance

the shelf life of modified atmosphere packaged product, mainly because they increase the lag phase of the microorganisms (Podolak *et al*., 1996). The antimicrobial effect of the organic acids is due to reduction of pH below the growth range and metabolic inhibition by the undissociated molecules (Beyaz and Tayar, 2010).

The $\log_{10}$ CFU/cm^2 mean of *E. coli* count on from aprons, workers palm, knife and carcass washing waters showed no significant difference between the two export abattoirs ($p<0.05$). But the aprons from the dirty area of the two export abattoirs showed highest number of *E. coli* count 460 $\log_{10}$ CFU/cm^2 and 660 $\log_{10}$ CFU/cm^2 for the first and second export abattoirs respectively. This increase may be due to cross contamination of from skin, from blood and failure to meet proper hand washing procedure. And also inadequate number of water hose, which impair difficulty for workers to wash their aprons after each skinning may lead to high amount of *E. coli* loads on the aprons.

E. coli occurs naturally in the digestive tract of healthy animals and can also be found on the animal's hide, fleece, feathers and skin. The bacteria are shed from the animal in their faecal matter and can contaminate the surfaces of raw meat during slaughter, dressing and packaging. While the pathogen is most commonly associated with red meat from ruminant animals (cattle, sheep and goats), it has also been isolated from pork and chicken. The mincing of meat can spread surface contamination throughout the product and provides an opportunity for the growth of bacteria (FSA, 2011).

6. CONCLUSIONS AND RECOMMENDATIONS

The study has shown, temperature monitoring in the meat cold chain is one of the most effective tools in producing a safe product. Although there were a significance difference in the mean of temperature between the two export abattoirs at loading and unloading temperature of the carcass, controlling the temperature of carcasses during the cold chain process has been proven to not only help control microbial growth, but also to assist in creating a quality meat product. In addition, reducing the temperature of the carcass during loading, transporting and unloading time gives better packaging performance and the quality of the packaging or the stockinet will be in good quality. Therefore, in order to reduce the growth of bacteria, it is imperative that meat should not be allowed to remain at a temperature of above 10^0C for very long time.

Chilled goat carcass pH of the two export abattoir showed that, there were a significant difference in the mean of pH between the two export abattoirs ($p<0.05$). It is noted that proper animal handling and rest before slaughtering may lead to this difference. Therefore, meat export abattoirs should improve the safety and the quality of the meat through management of animal handling and proper resting of the animals before slaughter. Animals before slaughter should rest up to 72 hrs in the abattoir reception area to come to normal physiological status.

Independent samples t-test analysis for mean of *E. coli* counts on the first and second export abattoir showed no significant difference ($p<0.05$). Even though the mean bacterial count result after acetic acid spray showed 3.5 and 0.00 log10CFU/cm2 for the first and second export abattoirs respectively, it is evident that (GHP) good hygienic practice and (GMP) good manufacturing practice should be practiced. All export abattoirs should implement Food Safety Management System/ Hazard Analysis and critical control points incorporating animal management, temperature monitoring, and acetic acid spray as safe product production.

Based on the above conclusions, the following recommendations are forwarded:

- Moving a shipment of meat across the supply chain without suffering any setbacks or temperature anomalies requires the establishment of a comprehensive logistical process. This process concerns several phases ranging from the preparation of the shipments to final verification of the integrity of the shipment at the delivery point
- Legislation could be defined in terms of process criteria (time-temperature combinations) and/or performance criteria (pathogen growth) and the requirement that these be achieved in the slaughterhouse before carcass loading could be removed if a process of efficient chilling can be demonstrated (including continuous monitoring, corrective actions, etc) during transportation and operated as part of the HACCP or GMP systems at the different stages along the cold chain.

- It is necessary for animals to be stress and injury free during operations prior to slaughter, so as not to unnecessarily deplete muscle glycogen reserves. It is also important for animals to be well rested during the 24-hour period before slaughter. This is in order to allow for muscle glycogen to be replaced by the body as much as possible. It is important that the glycogen levels in the muscles of the slaughtered carcass are as high as possible, to develop the maximum level of lactic acid in the meat. Lactic acid in the muscle has the effect of retarding the growth of bacteria that have contaminated the carcass during slaughter and dressing

- Data on ambient and carcass surface temperatures in the export slaughterhouses and during transportation in the country should be collected to evaluate current commercial chilling conditions

- Abattoirs need to be aware of presence of high level of contamination in carcasses and must comply with written sanitation standard operating procedures (SSOP),

good hygienic practice (GHP) and have to implement food safety management system

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APPENDIX I

Personal Information

Name: Yebchaye Degefa Tessema

Year of Birth: 1983G.C

Place of Birth: Debre Zeit

Nationality: Ethiopian

Gender: Male

Marital Status: Married

Physical fitness: Excellent

Work Experience (Overview)

Sep 2013 to date: Organic Export Abattoir P.L.C

Job Title: **Managing Director**

Task:

- Managing the overall activities of the abattoir
- Communicating with animal suppliers to get enough amount of animals for export
- Work together with all stakeholders for the effectiveness of the meat export
- Manage the Food safety management system (ISO 22,000: 2005)
- Initiate and support the workers with facilitation of peaceful work environments

- Communicate with importers periodically for improvement of export

Oct, 2009 - 2013 Ethiopian Meat and Dairy Technology Institute (EMDTI)

Fostering the meat and Live animal production for export market

Job Title: **Meat Technologist**

Task:

- Supporting the private sector and commercial unions in the value chain of meat and Live animal production

Objective:

- capacity building (providing training)
- consultancy service
- analytical service

June2009 to Oct 2009, Organic export abattoir, Modjo, Ethiopia

Job Title: Production Head

Task:

Head of production and logistics

Objectives:

- Controlling of the productive capacity and profitability of the work
- Controlling and optimization of the entire production flow
- Guidance, development and motivation of subordinate employees
- Organization of the Ranges production, technology and logistics

April 2007 to March 2009, Elfora Agro industries, Debre Zeit Export Abattoir

Job Title: **Production Head**

Task:

Head of production

Objectives:

- Controlling of the productive capacity and profitability of the export abattoir
- Organization of the ranges production, technology and logistics
- Guidance, development and motivation of subordinate employees
- Controlling and optimization of the entire production flow

Education and Qualifications

2012 to 2014: Addis Ababa University. Master of Science on Tropical Animal Production and Health.

2012: Ethiopian Management Institute. Certificate of training on project planning, implementation, monitoring and Evaluation.

2011: Ethiopian Management Institute. Certificate of training on Balanced score card.

2011: Farmer's Choice ltd. Kenya. Certificate of attendance on Practical Meat processing.

2007: Ethiopian Sanitary and phytosanitary standards and Livestock and Meat Marketing program, Texas Agricultural Experiment station, Texas A&M University System: Certificate of Technical training in the fabrication of Ethiopian Beef Export cuts.

2004: Debre Zeit Ana-Gsc General Computer Service Computer Diploma

2002 to 2006, Mekelle University, Tigray, Ethiopia

Bsc Degree in Animal, Rangeland and Wildlife Science

Publication

Biruk Getachew, Yebchaye Degefa and Habtamu Yilfashewa.2010. Training Manual on **Feedlot Establishment,** 'Amharic Version'. Ethiopian Meat and Dairy Technology Institute (EMDTI), Debre Zeit, Ethiopia.

Languages

English:-speaking very good, Reading and writing Excellent

Amharic: - Fluent

References

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