بسم الله الرحمن الرحيم

Sudan University of Science and Technology

College of Graduate Studies

Assessment of the Microbial Qualities of Exported Sheep and Goats' Carcasses and the Hygiene Conditions of an Export Slaughterhouse in Khartoum State –Sudan.

تقييم الجودة المكروبية والشروط الصحية لذبيح الضان والماعز من مسالخ الصادر بولاية الخرطوم- السودان

A thesis Submitted to College of Graduate Studies, Sudan University of Science and Technology in Fulfillment of the Requirement for the Degree of Ph D. in Preventive Medicine (Food Safety).

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2020

الايـــــــــــة

بِسْمِ اللهِ الرَّحْمَنِ الرَّحِيْمِ

﴿يَا أَيُّهَا الَّذِينَ آمَنُوا كُلُوا مِنْ طَيِّبَاتِ مَا رَزَقْنَاكُمْ وَاشْكُرُوا لِلَّهِ إِنْ كُنْتُمْ إِيَّاهُ تَعْبُدُونَ﴾

(البقرة : 172)

صدق الله العظيم

Dedication

To my parent, and my family

Acknowledgment

I wish sincerely to express my profound thanks to. Prof. Mohamed Abdelsalam Abdellah and Dr. Siham E, Suliman for their encouragement, motivation, guidance, technical advice and valuable comments during this work.
I would like also to thank the meat inspector's team at the export Slaughterhouse for their cooperation while collecting samples.
My thanks extend to Nagwa Abdella and Asmail Kamal the laboratory assistants of the Faculty of Veterinary Medicine, Sudan University of Sciences and Technology for their cooperation during the laboratory work.

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Abstract

The study was conducted to determine the levels of contamination in exported sheep and goats carcasses during September 2018 to January 2019 in an export slaughterhouse and at Khartoum airport in Khartoum state, Sudan. A total of 250 swab samples were collected (slaughterhouse 130 samples, Khartoum airport 120 samples).The total viable count (TVC) was used to evaluate the levels of contamination in the four parts of the carcasses namely neck, forelimb, flank and hind limb at different operational control points during the slaughtering process (skinning, evisceration, washing, and chilling) and at Khartoum air port. Also, 40 samples were taken from hands of the workers and contact surfaces from both slaughterhouse and at airport. TVCs of sheep and goats carcasses in slaughterhouse and airport ranged between 8.39±0.10 $\log^{10}$ cfu/cm^2 and 8.58±0.06 $\log^{10}$ cfu/cm^2, the TVCs of the butcher's hands and loaders in the slaughterhouse were 8.43±0.10 $\log^{10}$ cfu/cm^2 and 8.44±0.06 $\log^{10}$ cfu/cm^2 respectively, while the hands of the workers in the airport were 8.21 ±0.12 $\log^{10}$ cfu/cm^2. The percentages of pathogenic bacteria isolated at the export slaughterhouse were 39.88% *E.coli,* 19.02% *Salmonella spp* and 41.10% *Staphylococcus areus,* while the percentages of pathogenic bacteria isolated at the Khartoum air port were 38.0% *E.coli,* 9.02% *Salmonella spp* and 71.7 % *Staphylococcus areus*. The questionnaire among 40 slaughter workers revealed that the respondents had acceptable levels of knowledge, excellent attitudes and good practices toward food hygiene measures. Only 35.0% of workers had received one training session 2 years ago, where as 67.5% of the participants have a valid health certificate. The study showed that the levels of contamination on the exported sheep and goats carcasses were higher than the acceptable values set by the Sudanese and international standards. For providing hygienic meat, it is important to maintain high standards of hygiene in the slaughterhouse by continuous monitoring and imposing the hazard analysis critical control points system (HACCP).

ملخص الدراسة

أجريت هذه الدراسة لتحديد مستوى التلوث الباكتيرى في ذبائح الضان والماعز المصدرة في الفترة من سبتمبر 2018م إلى يناير 2019م وذلك فى احدى المسالخ بولاية الخرطوم والتى تعمل فى مجال صادرات اللحوم , وكذلك فى مطار الخرطوم فى السودان.تم جمع عدد250 عينة مسحات عشوائية (المسالخ 130 ، مطار الخرطوم 120).استخدم العد الباكتيرى (T.V.C) لتقييم مستوى التلوث في اربع اجزاء من الذبيحة وهى الرقبة ، الاطراف الأمامية ، الخصر والأطراف الخلفية عند نقاط التحكم التشغيلية المختلفة أثناء عملية الذبح (السلخ ، نزع الاحشاء ، الغسيل والتبريد) ايضا اخذت العينات من الذبائح فى مطار الخرطوم. تم أيضا أخذ 40عينة من أيدي العمال والأسطح الملامسة للذبائح فى كل من المسلخ والمطار.تراوح العد الباكتيرى فى ذبائح الضان في المسلخ والمطار $8.21 \pm 0.12 \log^{10} cfu/cm^2$ الى $8.58 \pm 0.06 \log^{10} cfu/cm^2$ ، والعد البكتيرى من أيدي الجزارين وعمال رفع الذبائح في المسلخ تراوح بين $8.43 \pm 0.10 \log^{10} cfu/cm^2$ و $8.44 \pm 0.06 \log^{10} cfu/cm^2$ على التوالي ، في حين كان العد البكتيرى لأيدي العمال في المطار $8.21 \pm 0.12 \log^{10} cfu/cm^2$. كانت النسب المئوية للباكتريا المسببه للامراض والتى تم عزلها فى مسلخ الصادر كالأتى 39.88٪ الاشريكية القولونيه , 19.02٪ السالمونيلا و41.10٪ العنقودية الذهبية. في حين كانت النسب المئوية في مطار الخرطوم كالأتى 38.0٪ الاشريكية القولونيه , 9.02 % سالمونيلا و 71.7٪ العنقودية الذهبيه. كشف الاستبيان الذى اجرى لعدد 40 عاملاً من عمال المسلخ أن الأفراد لديهم مستوى مقبول من المعرفة والمواقف الممتازة والممارسات الجيدة تجاه قياس صحة الغذاء. حوالى 35%من العمال تلقوا دورة تدريبية واحدة فقط منذ سنتين ، 67.5٪ من المشاركين كانت لديهم شهادة صحية ساريه.أظهرت الدراسة أن مستويات التلوث على ذبائح الضان المصدرة كانت أعلى من القيم المقبولة التي حددتها المواصفات السودانية والعالمية. لتوفير اللحوم الصحية ، من المهم الحفاظ على مستويات عالية من النظافة في المسالخ من خلال المراقبة المستمرة وفرض نظام نقاط التحكم الحرجة لتحليل المخاطر (الهسب).

Abbreviations

a_w	Water activity.
APC	Aerobic Plate Count.
C.jejuni	*Campylobacter jejuni.*
CAC	Codex Alimentarius Commission.
CDC	Center for Disease Control and Prevention.
Cfu/cm^2	Colony forming unit per square centimeter.
CFU/g	Colony forming unit per gram.
E. coli	*Escherichia coli.*
E_h	Redox potential.
EPEC	*Enteropathic E. coli.*
ETEC	*Enterotoxigenic E. coli.*
EU	European Union.
FAO	Food and Agricultural Organization.
FSOs	Food safety objectives.
FDA	Food and Drug Administration.
GMP	Good Manufacturing Practices.
HACCP	Hazard Analysis of Critical Control Point.
ISO	International Standard Organization.
OIE	International Animal Health Organization.
PCR	Polymerase chain reaction.
PH	A measure of acidity or alkalinity.
SPSS	Statistical Package For Social Sciences.
SSMO	The Sudanese Standards and Metrology Organization.
TPC	Total Plate Count.
TVC	Total Viable Count.
WHO	World Health Organization.

INTRODUCTION

Sudan has a livestock wealth of more than 163 million heads of livestock, including livestock, poultry and equine as well as 76000 tons of fish stock and a good number of wild animals, most of the animals in the Sudan are raised on natural pastures by nomadic tribes, so Sudanese animals are almost free from feed additives, hormonal and chemical residues, which give special preference to the Sudanese animal products. Livestock sector in Sudan as a renewable resource plays a critical role in the Sudanese economy and the welfare of the whole population. MOAR (2017).

Despite the relative progress of this sector, it is still far from achieving the desired targets for exports of meat compared to the size of the resources it possesses; There are challenges facing the export of animal meat, including the external competition in addition to the growing specifications from importers .Although Sudan has the advantage of being near the Gulf markets for sheep and sheep meat; it faces competition from Australia and New Zealand in terms of price, ability to comply with new standards and reliability of supply and terms of trade, MOAR (2018).

Food safety is defined as an assurance that food will not cause harm to the consumer when it prepared and/or eaten according to its intended use (FAO, 2004). Food safety plays a significant role in the national economy and health development by safeguarding the health of the nation, enhancing tourism, national and international trade for production, preventing avoidable losses and conserving natural resources. Thus countries with well-established food safety assurance systems can export and trade their products without any barriers and become competitive in global trade (FAO/WHO 2005[2]).

Food safety in developing countries and especially in Africa is weak, unable to protect human health, because of stringent food safety laws of developed nations; many African countries are unable to export their potential raw or processed food. These nations not only lose foreign exchange earnings, they also overstretch the national health services as a result of preventable foodborne illnesses and death. (FAO/WHO 2005[1]).

Supply of safe and quality meat is essential for the protection of public health and access to regional and international market opportunities. The problem that faced by Sudan is enhancing its competitiveness in the Middle East markets for sheep and sheep meat in order to increase and maintain its market share. This would entail improving the efficiency of internal marketing systems and livestock export procedures, and improving product quality. With regard to quality, serious attention needs to be given to grades, standards, in compliance with international agreements, so establishing a hygienic program for exported meat is required in order to enable the Sudan to face the international trade parameters

This study was conducted to evaluate the microbial qualities of exported sheep and goat carcasses and to assess the sanitation and hygienic practice in an export slaughterhouse in Khartoum state-Sudan. The purpose is to provide information to promote meat hygiene and to establish and maintain regionally acceptable meat quality standards required by meat export trade.

Objectives:

The objectives were:-

1. To determine the levels of microbial contamination of sheep and goats carcasses exported from a selected export slaughterhouse.
2. To determine the incidence of certain bacteria of public health significance.
3. To identify the critical control points and the risk factors associated with contamination of meat along the meat production chain.
4. To assess the knowledge, attitudes, and practices of the workers in a selected export slaughterhouse.

Chapter one
1.LITERATURE REVIEW

1.1. Meat as food:-

Meat is flesh of an animal that is eaten as food (Lawrie and Ledward, 2006). Meat is also defined by the Codex Alimentarius as all parts of an animal that are intended for or have been judged as safe and suitable for human consumption from the nutritional point of view (CAC, 2005).

The primary unit of meat is called carcass. It represents the ideal meat after removal of the head, hide, intestine and blood (Rao *et al.,* 2009). Most often meat refers to the skeletal muscle , associated fat and other tissues, but it may also describe other edible tissues such as offals (i.e. meat other than meat flesh, including brain, heart, kidney, liver, pancreas, spleen, thymus, and tongue) (Lawrie and Ledward, 2006).

The advent of civilization allowed the domestication of animals such as chickens, sheep, pigs and cattle, and eventually their use in meat production on an industrial scale (Robert *et al.,* 2000).

Meat is produced by killing an animal and cutting flesh out of it. These procedures are called slaughter and butchery respectively. There is ongoing research into producing meat in -vitro that is, outside of animals (Twum, 2016).

1.1.1. The compositions of meat:-

Meat can be broadly classified as "red" or "white" depending on the concentration of myoglobin in the muscle fiber. When myoglobin is exposed to oxygen, reddish oxymyoglobin develops, making myoglobin-rich meat appear red. The redness of meat depends on species, animal age, and fiber type. Red meat contains more narrow muscle fibers that tend to operate over long periods without rest, while white meat contains more broad fibers that tend to work in short fast bursts. The meat of adult mammals such as cows, sheep, goats, and horses is generally considered red, while chicken and turkey meat is generally considered white (Lawrie and Ledward, 2006).

1.1.2. Nutritional values of meat:-

The nutritional compositions of red meat changes depending on breed, feeding, season and meat cut. However lean red meat shows consistency in high protein content, essential vitamins and minerals, relatively low-fat content and moderate in cholesterol (Williams, 2007).

Meat is a nutritious food as the protein of the meat required by man and also is an excellent source of iron, phosphorus, potassium, and sodium (Rao *et al*., 2009), meat is also an important source of the B vitamins, particularly B1 (thiamine), niacin (nicotinic acid), B2 (riboflavin), B6 and B12 (cyanocobalamin) and vitamin A (retinol). It is a major source of iron, copper, zinc, and some selenium (Warriss, 2010).

Butcher meat is a valuable part of the human diet because (a) it is the most concentrated and is a good source of first-class protein that is, it contains those amino acids which are essential for human life; (b) it stimulates metabolism due to its high protein content, that is to say, it assists the body in the production of heat and energy; (c) it is satisfying, for the presence of fat in the diet delays emptying of the stomach (Eroclini *et al*., 2006).

1.1.3. Meat qualities:-

The term meat quality is used to describe a range of attributes of meat. Many factors determine the quality of meat. It includes requirements of food safety and animal welfare. It also includes the sensory appeal of meat such as palatability (visual appearance, smell, firmness, juiciness, tenderness, and flavor) and perceived healthiness, especially in relation to the amount and type of fat and other fatty components (Aberle *et al.,* 2001).

Quality of meat describes how attractive the meat is to consumers. Meat must look good to consumers before satisfying their palate when they decide to buy it. The expectations of the consumer in terms of aroma, tenderness, juiciness, flavor, color, wholesomeness and nutrition must be met once the meat is bought, cooked, and served, (Aberle *et al.,* 2001).

Flavor is interwoven with an aroma to bring out the sensation the consumer has during eating. Flavor and aroma are perceptions and depend on the ability to smell through the nose and on the sensations of salty, sweet, sour and bitter on the tongue. Meat flavor is affected by the type of species, diet, cooking method and method of preservation (e.g. smoked or cured) (FAO, 2003).

The source of flavor in meat is the fat, the different flavors among a different kind of meat (beef, pork, chicken, turkey, and mutton) come from fatty components. Fat acts as one of the precursors of flavor by combining with amino acids from proteins and

other components when heated. The aroma and juiciness of meat products can be improved using spices and cooking method. (Dinh Tran Nhat Thu, 2006).

The tenderness depends on textural characteristics, the composition of meat, breeds, sex, and many other factors. Tenderness of meat is also based on ease of chewing, which is contributed by the fibrous nature of muscle (Gerrard and Grant, 2003).

The appearance of meat is the visual meat quality which is based on color, marbling, and water holding capacity. Marbling is small streaks of fat that are found within the muscle and can be seen in the meat cut. Marbling has a beneficial effect on juiciness and flavor of the meat. The color of meat should be normal and uniform when cutting through. Another aspect of meat quality is the smell. This will differ slightly based on species and breeds. Meat product should have a normal smell without any rancid or strange smelling odor (FAO, 2003).

Kauffman *et al*., (1990) reported three levels of meat quality. The first level which has the highest priority requires the meat to be wholesome. It should be safe to eat and have nutritionally adequate levels of proteins, vitamins, and minerals. The second level requires the meat to show minimum shrinkages during processing; including cooking and the third level requires the meat to have maximum attractiveness in terms of appearance, convenience and eating quality.

1.1.4. Meat consumption and related health issues:-

The important meat producing species remain domestic cattle, sheep, pigs, and poultry. Cattle, sheep, and pigs are often referred to as red meat species and poultry as white meat. The importance of the three red meat species in supplying meat protein differs in different parts of the world; beef is most important in the North and South America, Africa and Europe, while sheep are most important in the Near East and pigs in the Far East (Warriss, 2010).

Meat consumption varies worldwide, depending on cultural or religious preferences, as well as economic conditions. Vegetarians choose not to eat meat because of ethical, economic, environmental, and religious or health concerns that are associated with meat production and consumption (Sofos, 2008).

The intake of meat varies widely throughout the world. On per capita basis; the U.S. is the leading meat consumer in the world with 124kg/capita/year higher than the global average of 38kg/capita/year. Africa and South Asia are the least consumers of meat. Their consumption is between 3 and 5 kg/capita/year (Speedy, 2003).

On daily basis in the U.S. and other developed countries, meat takes a significant proportion of the normal diet contributing more than 15% energy, 40% protein, and 20% fat (FAO, 2003; Hiza *et al*., 2008).

The demand for meat in developing countries continues to grow as the production and consumption of meat increases with available income (Walker *et al*., 2005; Speedy, 2003).

In a study by Reicks (2006), it was established that the three most important factors influencing the purchase of meat products are taste attributes, price, and product consistency.

Anachinaba (2015) indicated that meat consumption is influenced by factors such as the wholesomeness of meat, quality of meat and the price of the meat. In a similar study, Damisa and Hassan (2009) listed factors influencing the consumption of poultry meat as income, price, household size, and education.

According to De Silva *et al*., (2010) when people become old they become more conscious of their health and nutrition and as such reduce the intake of some meat products, especially red meat. There is a direct correlation between high meat consumption and high rates of chronic diseases including cardiovascular disease (CVD) and cancer. Cardiovascular diseases (diseases of the heart) are the current leading causes of morbidity and mortality in the U.S. and other westernized countries (Melonie, 2010).

The fat content in red meat and dietary cholesterol has been closely linked to chronic diseases (Lichtenstein *et al*., 2006). A large body of evidence suggests that vegetarians may be at lower risk for CVD, hypertension, diabetes mellitus, obesity, and cancer (Fraser, 2009). In that case, meat should be eaten in moderation and without too much attendant fat so that it can make a valuable contribution to body development and function (Twum, 2016).

Meat cooking and processing techniques such as smoking, curing, salting or addition of chemical preservatives lead to the formation of carcinogenic compounds, such as N-nitroso compounds (NOCs), heterocyclic amines (HCAs) and polycyclic aromatic hydrocarbons (PAHs) (Crossland , 1997).

1.2. Microorganisms and the red meat

1.2.1. Contamination of the meat.

Contamination of animal carcasses and raw meat by microorganisms, including spoilage and pathogenic types, is practically unavoidable. In general, animals may be infected, contaminated or be asymptomatic carriers of microbes, which, together with the environment, serve as sources of contamination of carcasses during the slaughtering process, of meat products during processing, storage and handling, (Koutsoumanis and Sofos, 2004).

According to (Sofos, 2004) Contamination is introduced during growth and production at farms, ranches or feed yards, as well as during shipping, distribution, marketing, lairage, processing, retailing, preparation and consumption. Contamination sources include soil, decaying material and animal waste, which contaminate water, air, animals, plants, processing facilities, equipment, rodents, pests, and humans.

Specific sources contributing to the microbial contamination to animal carcasses and to fresh meat during slaughter and dressing include feces, hides, soil, water, air, intestines, lymph nodes, processing equipment, utensils and humans (Gill, 1998)

All of these contribute to direct or cross-contamination, leading to a complete contamination cycle which is a natural phenomenon that cannot be prevented. Thus, it is impossible to produce raw meat or other animal food products, which are free of contamination (Sofos, 2004).

Microbial contamination of meat and meat products must not exceed levels which could adversely affect the shelf life of meat products and renders it unwholesome and unfit for human consumption. Under tropical conditions, food of animal origin tends to deteriorate more rapidly and become an important vehicle for gastrointestinal infections, thereby endangering consumers' health (Akinro *et al*., 2009).

The microbes cause biochemical and microbiological changes in the meat which lead to production of noxious substances resulting into increased incidence of illnesses and other fatal human diseases (Soyiri *et al*., 2008).

According to James *et al.* (2005), the followings are the primary sources and routes of microorganisms to fresh meats with particular emphasis on red meats:

1. The stick knife. After being stunned and hoisted by the hind legs, animals such as steers are exsanguinated by slitting the jugular vein with what is referred to as a

"stick knife." If the knife is not sterile, organisms are swept into the bloodstream, where they may be deposited throughout the carcass.

2. Animal hides. Organisms from the hide are among those that enter the carcass via the stick knife. Others from the hide may be deposited onto the dehaired carcass or onto freshly cut surfaces. Some hide biota becomes airborne and can contaminate dressed out carcasses.

3. Gastrointestinal tract. By way of punctures, intestinal contents along with the usual heavy load of microorganisms may be deposited onto the surface of freshly dressed carcasses. Especially important in this regard is the paunch or rumen of ruminant animals.

4. Hands of handlers. This is a source of human pathogens to freshly slaughtered meats. Even when gloves are worn, organisms from one carcass can be passed on to other carcasses.

5. Containers. Meat cuts that are placed in non-sterile containers may be expected to become contaminated with the organisms in the container. This tends to be a primary source of microorganisms to ground or minced meats.

6. Handling and storage environment. Circulating air is not an insignificant source of organisms to the surfaces of all slaughtered animals.

7. Lymph nodes. In the case of red meats, lymph nodes that are usually embedded in fat often contain large numbers of organisms, especially bacteria. If they are cut through or added to portions that are ground, one may expect this biota to become prominent. In general, the most significant of the above are non-sterile containers. When several thousand animals are slaughtered and handled in a single day in the same abattoir, there is a tendency for the external carcass biota to become normalized among carcasses, although a few days may be required. The practical effect of this is the predictability of the biota of such products at the retail level (Dillonn and Board 1991).

Contamination with spoilage microorganisms may lead to product and economic losses, while presence of pathogens or their toxins may be the cause of food borne disease that may lead to loss of human life. Thus, there is a need to control microbial contamination in animals and animal products in order to enhance the quality and safety of fresh meat, meat products and other foods (Koutsoumanis and Sofos, 2004; Sofos, 2004).

1. 2.2. Meat Spoilage

Spoilage is caused by the practically unavoidable infection and subsequent decomposition of meat by bacteria and fungi, which are borne by the animal itself, by the people handling the meat, and by their implements (Tutenel *et al.,* 2003).

Meat is a complex food ecosystem of which the chemical and physical properties can allow the colonization and development of a great number and variety of organisms (García-Lopez *et al.,* 1998)

Current food microbiology research often focuses on hazards caused by pathogenic micro organisms to humans while neglecting food spoilage (Mohareb *et al.,* 2015). Spoilage of chilled raw meat remains a major challenge to the meat industry, because meat spoilage causes large losses every year. The original muscle tissue of healthy animals is sterile; however, a large number of microorganisms exist in cuts that occur during a series of processing procedures from muscle to meat after slaughter (Sofos, 1994) Therefore, the common goals of the meat industry and meat microbiologists are to determine the origin, the classification, and the distribution characteristics of those meat spoilage-related microorganisms and the factors affecting their growth are also considered. Then, the ultimate purpose is to achieve the accurate and rapid identification, and effective control of these microorganisms.

1.2.2.1. Classification of Spoilage Microorganisms in Meat products:-

Spoilage microorganisms associated with red meat spoilage mainly include bacteria, molds, and yeasts. Bacteria are responsible for some of the most rapid and evident spoilage of the proteinaceous meat (Huis in‘t Veld, 1996). Molds and yeasts preferentially grow on raw meat during late storage and on cooked meat products with low moisture contents. Therefore, bacteria are considered the main organisms that cause the spoilage of fresh raw meat. Various bacteria exist in meat, and more than 200 species of bacteria have been found in vacuum-packed pork (Zhao *et al*., 2015).However, not all bacteria that are present in meat can cause spoilage. Under normal conditions, it is believed that approximately 10% of initial contaminant bacteria can survive in chilled meat during storage, and only a small fraction of these play a role in spoilage (Borch *et al.,* 1996). The main spoilage bacteria are also known as specific spoilage organisms (SSO) or ephemeral spoilage organisms (ESO) (Nychas *et al.,* 2008) and those SSOs and ESOs play the same role in the spoilage of meat no matter the scales and/or the locations of the producing plants.

Spoilage bacteria in red meats include Gram-negative *Pseudomonas, cinetobacter, Psychrobacter, Aeromonas, Shewanella putrefaciens*, and *Enterobacteriaceae* and Gram-positive lactic acid bacteria (LAB) and *Brochothrix thermosphacta* (Ercolini *et al.,* 2011; Borch *et al.,* 1996). The growth of these spoilage microorganisms is closely associated with storage conditions. *Acinetobacter, Psychrobacter*, and *Moraxella* grow well under aerobic conditions while *Pseudomonas spp*. are dominant spoilage bacteria (Molin and Ternstrom, 1986; García-Lopez *et al.,* 1998), whereas LAB and *B. thermosphacta* commonly occur under anaerobic or modified atmosphere packaging conditions (Barakat *et al.,* 2000).

1.2.2.1.1. Pseudomonas:-

Pseudomonas is a genus of strictly aerobic gram-negative, motile, straight, or curved bacilli. Members of this genus are characterized by the ability to reproduce rapidly, grow at low temperatures, and produce large amounts of ammonia and other spoilage products. This genus widely occurs in water, humans, soil, and on hides, mouth, and intestines of animals. And they exist in lots of food products.

Pseudomonas species are typically psychrophiles. Since the 1980s, this group of bacteria has frequently been isolated from chilled meat (Labadie, 1999)The genus is subdivided into five rRNA similarity groups and the most relevant species involved in meat spoilage are located in group I including *Pseudomonas fragi*, *Pseudomonas lundensis, Pseudomonas florescens*, and *Pseudomonas putida* (Nychas *et al.,* 2007).

Among those species, *Ps. fragi* is the dominant spoilage bacterium in chilled meat under aerobic storage conditions with a great incidence on spoilt meat in the range from 56.7% to 79.0% (Nychas *et al.,* 2008), while the isolation rate of *Ps. lundensis* is up to 40% sometimes (Liao, 2006). *Pseudomonas* can fully use carbon and energy sources in meat and produce a series of metabolites to cause the meat spoilage (Casaburi *et al.,* 2015). *Pseudomonas* contamination of meat and meat products often leads to surface spoilage, forming slime, and an unpleasant odor, especially, *Ps. fragi* can develop a "fruity sour smell "in meat (Liao, 2006). Due to the spoilage potential of this genus, it is used as target bacteria to establish the shelf-life prediction model of chilled meat (Zhang *et al.,* 2011).

1.2.2.1.2. Lactic Acid Bacteria

LAB comprises a class of Gram-positive, facultative anaerobic bacteria that can metabolize fermentable carbohydrates and produce a large amount of lactic acid.

LAB is extremely widely distributed in nature and exhibits great species diversity. The growth temperature of LAB covers a broad range from lower than 4°C to 45°C (Schillinger and Holzapfel, 2006). This group of bacteria is complex and includes at least 18 genera and more than 200 species, but few LAB types can cause meat spoilage. LAB are dominant spoilage bacteria under anaerobic conditions and are more commonly found in meat stored at low temperatures and in vacuum and modified atmosphere packaging. Various LAB have been associated with meat spoilage, including *Lactobacillus, Lactococcus, Leuconostoc, Carnobacterium, Weissella, Pediococcus, and Enterococcus* (Schillinger and Holzapfel, 2006).

Within the genus *Lactobacillus,* both *Lactobacillus algidus* (Kato *et al*., 2000) and *Lactobacillus fuchuensis* (Sakala *et al.,* 2002) are associated with the spoilage of meat products. *Leuconostoc sp*. (e.g., *Leuconostoc gelidum, L. carnosum, and Leuconostoc mesenteroides*) can produce organic acids (acetic acid), resulting in a cheesy smell and the formation of slime in meat, which are accompanied by gas production and greening (Nieminen *et al.,* 2011). In addition, Lactococcus (e.g., *Lactococcus piscium and Lactococcus raffiolactis*) and Enterococcus (e.g., *Enterococcus viikkiensis and Enterococcus hermanniensis*) are common spoilage bacteria in meat (Pothakos *et al.,* 2015). Great concern is raised by *L. gelidum* as a spoilage microorganism in meat in recent years (Chaillou *et al*., 2014). The processing environment is the main source of contamination, and LAB can be isolated from the carcass during dressing, chilling, and deboning and from contact with work surfaces during slaughter.

1.2.2.1.3 Enterobacteriaceae:-

Enterobacteriaceae is a family of Gram-negative, nonspore-forming, facultative anaerobic bacteria. Members of this family are extensively distributed in water, soil, and animal feces in nature. Thus far, 34 genera, 149 species, and 21 subspecies are identified (Baylis, 2006). These bacteria include a large number of pathogenic bacteria such as *Escherichia* O157: H7, as well as some *Salmonella* and *Yersinia*.

Those with spoilage potential are generally psychrophilic, such as *Enterobacter, Serratia, Hafnia,* and *Rahnella,* as well as *Serratia proteamaculans* and *Hafnia alvei* (Brightwell *et al.,* 2007). *Pantoea agglomerans*, *Escherichia coli,* and *Serratia liquefaciens* are the major spoilage bacteria in minced beef. Moreover, this group of bacteria can cause the rapid spoilage of vacuum-packed dark, and dry beef (Gribble

et al., 2014). Putrid odors are caused by the Enterobacteriaceae: aerobic spoilage results in a sulfide odor, discoloration, slime formation, and an ammonia odor, whereas anaerobic spoilage is associated with a sulfide odor and surface greening (Labadie, 1999).

Coliform bacteria are commonly regarded as indicators of hygiene quality in meat and meat products. This group of bacteria can be used to determine the freshness of meat and reflect the hygiene condition of meat during production, transport, and sale, thereby providing reference data for the timely adoption of effective control measures. Dressing devices are the main source of carcass contamination with bacteria, particularly Enterobacteriaceae (Gustavsson and Borch, 1993).

1.2.2.1.4. Brochothrix:-

Brochothrix are widely present in water, soil, and animal gastrointestinal tracts. This genus of bacteria comprises Gram-positive, facultative anaerobic, non pigmented bacilli that can produce lipase and protease. Two species are known in the genus Brochothrix*, Brochothrix campestris* and *B. thermosphacta.*

B. thermosphacta, a common bacterium in chilled meat, is first isolated from pork sausage in 1951 and has recently been found in pork, beef, mutton, and cured meat (Stackebrandt and Jones, 2006). *B. thermosphacta* has been reported to cause the spoilage of vacuum-packed mutton at temperatures lower than −1.5°C (Gribble and Brightwell, 2013). Meat spoilage caused by *B. thermosphacta* is characterized by an unpleasant odor of cheese or dairy products, gas production, and noticeable discoloration (Gill, 2004a), with greening and production of a green slime (Gribble and Brightwell, 2014). There are many other bacteria associated with meat spoilage.

1.2.2.1.5. Molds and yeasts associated with meat spoilage:-

Not much attention has been paid to yeast and mold spoilage in meat and processed meat products, as yeast and mold spoilage phenomenon occurs very rarely. Most of the yeasts and molds are more resistant than bacteria to low water activity and low pH environments, and they contribute a minor to the spoilage.

Cryptococcus laurentii var *laurentii* has been found predominated in lamb at −5°C (Lowry and Gill, 1984), and *Candida lipolytica, Candida zeylanoides*, and *Yarrowia lipolytica* have been found in spoiled beef and retail meats, which may play a role in spoilage (Hsieh and Jay 1984). It has also been observed that yeasts become the main spoilage agents only in cured meat products preserved by sulfide such as fresh British

sausage (Dalton *et al.,* 1984) or when products are chill-stored aerobically (Samelis and Georgiadou 2000).

1.2.2.2. Characteristics of possible mechanisms associated with spoilage microorganisms:-

1.2.2.2.1. Slime Formation:-

The massive reproduction of microorganisms on the surface of meat can lead to the formation of a slime comprising metabolic products of the reproduced colonies or microorganisms (Nychas *et al*., 2008). When the slime is examined, it appears filiform and is accompanied by a strong off-odor. This phenomenon is caused mainly by Gram-negative bacteria, LAB, and yeasts. When the surface of the meat appears slimy and filiform, the total number of microbial colonies is approximately 7 $\log^{10}$ CFU/cm^2 (Nychas *et al.,* 2008).

1.2.2.2.2. Discoloration:-

Various color changes often occur on the surface of meat during spoilage. The most common such color is green, which is caused when sulfide (resulting from protein degradation) binds to hemoglobin in meat, and the resultant sulfhemoglobin accumulates on the surface of muscle and fat tissues showing a dark green color. In addition, *Serratia marcescens* forms red stains on the surface of the meat, whereas *Flavobacterium* produce yellow color (Nychas *et al*., 2008).

1.2.2.2.3. Off-Odors:-

Meat spoilage is commonly associated with abnormal or unpleasant odors. Putrid odors are generally produced when the total number of colonies on the surface of the meat reaches 7 $\log^{10}$ CFU/cm^2.An off-odor can be noted with 5–6 $\log^{10}$ CFU/cm^2 Gram-negative bacteria. The odors are produced mainly due to highly alkaline metabolic by-products of protein breakdown by bacterial enzymes.

The odorous substances include ammonia, amines, hydrogen sulfide, and other sulfur-containing compounds (e.g., dimethyl sulfide ether). Certain species of the genus *Pseudomonas* first utilize oxygen and glucose in meat as energy sources; when glucose is depleted, the bacteria begin to metabolize protein as a carbon source. *Ps. florescens* can degrade sulfur-containing amino acids including methionine and cysteine. The highly alkaline metabolic by-products produced by the bacteria can increase the pH of the meat to 6.5 or higher in a short period leading to final spoilage of the meat (Ercolini *et al*., 2011)

1.2.2.2.4. Mildew Stain

Molds growing on the surface of the meat often form mildew stains. This phenomenon is more common in dry-cured meat products. For instance, *Thamnidium elegans* and *Thamnidium chactocladioides* produce feathery hypha on the surface of the meat. *Sporotrichum album* and *Geotrichum candidum* form white mildew stains. *Penicillium expansum* and *Penicillium oxalicum* form green mildew stains, and *Cladosporium herbarum* forms black stains (Samelis *et al*, .2006).

1.2.2.3. Spoilage Mechanisms:-

As stated previously, the spoilage of meat and meat products is caused by a small fraction of bacteria including SSO and ESO. Various bacterial populations utilize the substrates in meat in different orders.

Glucose is a preferential substrate of most spoilage microorganisms in meat. When glucose is depleted, other substances including lactic acid, gluconic acid, pyruvic acid, propionic acid, formic acid, ethanol, acetic acid, amino acids, nucleotides, and water-soluble proteins serve as subsequent substrates of most spoilage bacteria (Nychas *et al*., 2007; Pothakos *et al.,* 2015).

Under aerobic conditions, the leading spoilage microorganisms in meat are *Pseudomonas*, followed by *B. thermosphacta*; LAB, and *Enterobacteriaceae* are also present (Koutsoumanis *et al.,* 2008).

Pseudomonas can fully use carbon and energy sources in meat following the indicated order. Under aerobic conditions, *Pseudomonas spp.* preferentially uses glucose in meat through the Entner-Doudoroff pathway, producing gluconic acid and Z-oxo-gluconate. The two acid products accumulate outside the cells and are further metabolized by *Pseudomonas*; however, competing bacteria are unable to use these two acids. When the bacterial density reaches 8 $\log^{10}$ CFU/cm^2, the glucose supply can no longer meet bacterial growth needs, and *Pseudomonas* can begin to use amino acids as a growth substrate, thereby producing odorous sulfur compounds, esters, and acids. In addition, glucose is considered a major internal factor that can describe or predict the level of spoilage (Koutsoumanis *et al*., 2006). This component plays an important role in the level and type of meat spoilage (Nychas, 1998). The initial signs of spoilage are evident when the glucose concentration becomes very low and the limitation of glucose promotes the shift of *Pseudomonas* from carbohydrate to amino acid catabolism. Moreover, studies have shown that *Pseudomonas* can degrade

proteins. This group of bacteria can therefore penetrate deeply into meat to better utilize new nutrients than other bacteria. Under aerobic conditions, more free amino acids are present. This fact is consistent with the finding that *Pseudomonas* preferentially uses amino acids as substrates after glucose depletion, thereby causing spoilage under aerobic conditions (Nychas, 2008).

LAB in meat is obligate or facultative hetero fermentative species. The former type of bacteria produces lactic acid, acetic acid, carbon dioxide, and ethanol and the later type of bacteria breaks down glucose into two molecules of lactic acid. In the presence of pentose, LAB can produce lactic and acetic acids through hetero fermentation without gas production. In the presence of low concentrations of glucose, Lactobacilli that can degrade ribose in meat can transform their metabolism from homofermentation to heterofermentation and produce substantial quantities of acetic acid (Borch *et al*., 1996). When glucose is limited, spoilage LAB can metabolize lactic and pyruvic acids to produce acetic acid during aerobic storage (Samelis *et al*, .2006).High concentrations of acetic acid can endow the meat with a strong acid smell. Other carbon sources and amino acids also support the growth of LAB when glucose is insufficient. For example, Lb. *sakei* can metabolize arginine to ammonia and biogenic amines such as putrescine and spermine (Labadie, 1999)

As for the Enterobacteriaceae, they also preferentially utilize glucose prior to degrading amino acids and then release the amines, sulfides, and H_2S. They have the ability to produce H_2S not dimethyl sulfide, which significantly increases the severity of spoilage. Under anaerobiosis*, S. liquefaciens, H.alvei,* and other enterobacteria may become the main spoilage agents in dark, fim, and dry meat by
producing H_2S and greening such as sulfmyoglobin (Dainty and Mackey, 1992). Generally, Enterobacteriaceae cause the spoilage at the microbial load number at a level of 7 $\log^{10}$ CFU/cm^2. Ammonia is also produced by most pseudomonads in air-stored meat (Dainty and Mackey, 1992). However, not like *Pseudomonas spp.,* which produces ethyl esters as one of their main spoilage by-products, Enterobacteriaceae may produce acids, alcohols, and acetoin/diacetyl (Nychas *et al.,* 1998).

In addition to the role of individual microorganisms, we should also consider the interaction between different microbial populations: the "metabolic spoilage association" (Pothakos *et al.,* 2015; Gram *et al.,* 2002). Various microorganisms can competitively consume nutrients, oxygen, and carbon sources in meat and produce

various metabolites including organic acids, bacteriocins, and volatile compounds, which all mutually affect microbial growth. *Pseudomonas* can produce siderophores and maintain high levels of glucose utilization; thus, this group of bacteria can suppress the growth of *Sh. putrefaciens*, one of the main species promoting meat spoilage (Nychas *et al*., 2007; Nychas *et al*., 2008).

1.2.3. Pathogenic micro organisms and food borne disease:-

Most cases of foodborne illness are a result of pathogens in food. Pathogens are microorganisms that can cause illness in humans. The pathogens that cause foodborne illness do not necessarily cause undesirable changes in food. Many times, pathogens cause food to be unsafe to eat before there are any visible signs of spoilage (Adams and Moss, 2000). Pathogens can cause illness in one of three ways: intoxication, infection or toxic infection (Tafesse *et al*., 2010).

Some microbes can give off a by-product that causes illness. Substances released by microbes that are harmful to humans are called toxins. In this case, it is not the microbe that makes people sick but the toxin it produces. A foodborne illness caused by a toxin released by microbes is called food intoxication. It is important to remember that killing the microbes may not be enough to prevent cases of food intoxication. If the toxin is still present and has not been damaged or altered, the person will still become ill. The severity of the illness will depend on the amount and/or type of toxins present in the food eaten. It will also depend on how susceptible the person is to illness. A number of microbes cause food intoxication some of the most important includes *Escherichia coli, Staphylococcus Aureus, Clostridium Perfringens and Clostridium botulinum* (James *et al.,* 2005)

The second main cause of food borne illnesses is the microbes themselves. The increase in the number of these microbes and their metabolic activity damages the body tissue and causes diseases. This type of foodborne illness is called food infection. A food infection cannot occur if the microbes are killed. Food infections may be caused by bacteria, parasites, fungi, and viruses. A large number of living organisms is usually required to cause these types of illness. Symptoms are related to damage caused by the organisms affecting their hosts. Some of these microbes include *Listeria monocytogenes* and *Salmonella spp.* Texico-infection results when bacteria present in food, such as *Clostridium perfringens*, are ingested and subsequently produce as a toxin in the host (Tafesse *et al.,* 2010).

1.2.3.1. Foodborne disease:-

The foodborne disease has been defined by the World Health Organization as any disease of an infectious or toxic nature caused by or thought to be caused by, the consumption of food or water.' This definition includes all food and waterborne illness and is not confined to those primarily associated with the gastrointestinal tract and exhibiting symptoms such as diarrhea and/or vomiting (Adams and Moss, 2000). Food borne diseases (FBD) are universal public health problems and the implications are great including health and economic losses (Kerouanton *et al.,* 2007).

Foodborne disease outbreak is the occurrence of two or more cases of a similar foodborne resulting from the ingestion of a common food (WHO, 2008).

More than 40 foodborne microbial pathogens are known to cause human illness, including bacteria, parasite, viruses, fungi, and their toxins. Several pathogens were recognized only recently as a cause of foodborne illness. Some foodborne pathogens have not yet been scientifically identified (Tafesse *et al*., 2010).

The World Health Organization (WHO) reports that hundreds of millions of people worldwide suffer from diseases caused by contaminated food and those products of animal origin rank at the top of the list of causes (WHO, 2008).

About two third of all outbreaks involve bacteria. The rest are caused by viruses, parasite, fungi, and chemicals. Despite long-established food quality assurance systems in developed countries, new food contamination risks have now been emerging. According to WHO, seven foodborne pathogens (*Campylobacter jejuni, Clostridium perfringens, E.coliO157: H7, Listeria-monocytogenes, Salmonella-typhimurium, Staphylococcus aureus, and Toxoplasma gondii)* are responsible for an estimated 3.3 to 12.3 million infections and 3.900 deaths annually in the United States (WHO ,1996). Furthermore, global surveys by WHO indicate that foodborne diseases may occur 300- 350 times more frequently than reported (Chris *et al.,* 1999).

Many foodborne diseases are associated with consumption of meat. Some of the meat carcasses on sale might be contaminated with one pathogen or another (Mor-Mur and Yuste, 2010) and this could be very common in developing countries. The pathogens of concern in fresh and frozen meat and meat products include *Salmonella spp., Escherichia coli O157:H7* and other *enterohaemorrhagic E. coli (EHEC), Listeria monocytogenes, Staphylococcus aureus, Yersinia enterocolitica, Campylobacter spp.,Clostridium perfringens* and the potential for *Cl. botulinum* in cured hams and

sausages (Mor-Mur and Yuste, 2010). The most frequent outbreaks associated with the consumption of contaminated meat are caused by *Salmonella spp., L. monocytogenes,* and *Y. enterocolitica* (Sofos, 2008).

Some diseases could be associated with consumption of meat depending on the processing techniques and level of hygiene practices adopted. Shown in Table 4 is a compilation of a brief description of infections caused by bacteria and the reported associated meat sources.

Table (1.1) Description and sources of meat causing infection by bacteria:-

Bacteria	Symptoms / diseases	Sources of infection
Campylobacter jejuni (O:19, O:4, O:1) other *Campylobacter* spp.	Reactive arthritis, pancreatitis, meningitis, endocarditis, Guillain–Barré and Miller meat products Fisher syndromes	Raw and undercooked poultry and poultry products, meat products.
Salmonella Typhimurium (DT104, Gastroenteritis DTU302), *Salmonella Enteritidis* (PT4, PT8, PT13, PT14b)	Gastroenteritis	Poultry, roast beef, ham, pork sausage, salami
Enterohemorrhagic *Escherichia coli* (*E. coli* O157:H7, other serotypes of Shiga toxin producing *E. coli*)	Hemorrhagic colitis, hemolytic uremic syndrome, thrombotic thrombocytopenic purpura	Undercooked ground beef, turkey roll, salami, roast beef, venison jerky
Listeria monocytogenes	Meningitis or meningoencephalitis, septicemia, abortion	Raw meats and meat products (salami), ready-to-eat pork products, unreheated frankfurters, undercooked chicken, organ meat
Arcobacter butzleri, other *Arcobacter* spp	Septicemia, bacteremia	Raw poultry, pork, and beef, meat products
Aeromonas hydrophila, *Aeromonas* spp	Peritonitis, endocarditis, pneumonia	Minced beef, pork, and chicken, smoked sausage liver pâté, boiled ham
Enterobacter sakazakii	Bacteremia, necrotizing enterocolitis, appendicitis	Minced beef, cured meats, sausage meat

Source: Mor-Mur and Yuste (2010)

1.2.3.2. Descriptive features of some pathogens associated with meat:-

1.2.3.2.1. *Escherichia coli:-*

Escherichia coli, also known as *E. coli,* refers to a large group of bacteria commonly found in the intestinal flora of humans and animals. *Escherichia coli* are gram negative, aerobic rod with some strains that are pathogenic and produce an enterotoxin, but many of their strains are harmless. Bacteria only become pathogenic when they reach tissues outside their normal intestinal or other less common normal flora sites. Infections are usually caused by eating contaminated food, drinking contaminated water, or coming into direct contact with someone who is ill or with bacteria-bearing animals. Raw beef can be an important vehicle in the transmission of *E. coli* during slaughter, processing or cross-contamination due to unhealthy food management practices. Its presence in meat is usually the result of fecal contamination or when the intestinal tract is perforated (Doyle and Shoeni ,(1987).

Symptoms of *E. coli* infection usually start between three and four days after exposure, but the incubation period may be as short as one day or up to ten days. The disease most commonly associated with travelers shows a variety of symptoms that can vary from person to person. However, they often include severe stomach cramps, diarrhea, vomiting and fever. Correct hygiene and safe handling of food and good slaughtering techniques, hygienic slaughter and dressing with a short adequate cooling are essential to prevent the spread of all food borne illnesses, including *E. coli* (Church and Wood, 1992).

1.2.3.2.2. *Salmonella* species:-

Salmonella are nonspore-forming, rod-shaped, Gram-negative and is predominantly mobile Enterobacteria with flagella distributed throughout the cell body. They are widespread in nature and are responsible for diseases such as typhoid, paratyphoid fever and food poisoning (Ryan and Ray, 2004).

Salmonella was isolated in 19-54% of beef carcasses, 1.9% of beef samples in retail and 4.2% of chicken samples (Beach *et al.,* 2002).

The largest apparent incidence of *Salmonella* in slaughter animals is generally associated with the transport of animals in dirty vehicles, lack of hygiene in slaughterhouses and contamination of carcasses and intestinal fecal matter. However, according to NACMCF, (1993), the current *Salmonella* presence rates in meat are very low (below 5%). But both low and high will depend on the condition of the

animal and the handling of animals during slaughter (Hogue *et al*., 1993). *Salmonella* can also be introduced into the environment, especially in soil and water through manure and waste, which can persist and contaminate fruit and vegetables on the farm. Cross-contamination in the catering or at home environment during food processing or food handling can also cause Salmonellosis. *Salmonella* bacteria can survive and contaminate foods that have not been cooked properly. Therefore, it is common to have cross-contamination of food after cooking (IFT, 2004).

The symptoms of Salmonellosis are diarrhea, abdominal cramps, vomiting and fever, which develop 12 to 72 hours after infection, and the disease usually lasts one to seven days (Anachinaba ,2015).

A series of measures can be taken to reduce the incidence of *Salmonella* contamination of food. The most common method of eliminating *Salmonella* from food is heating. *Salmonella* is sensitive to heat and common cooking is enough to kill it in foods with high-moisture. The pathogen can also be controlled in the meat by hygienic slaughter and dressing, and an adequate cooling (IFT, 2004).

1.2.3.2.3. *Staphylococcus aureus*:-

For a long time, *Staphylococcus aureus* has been known as one of the most important bacteria that cause disease in humans. It is responsible for many skins and soft tissue infections such as abscesses (boils), furuncles, and cellulitis (Twum, 2016). With the right atmosphere for growth and other conditions such as temperature, pH, water activity (a_w) and adequate time, contaminating *Staphylococcus aureus* may multiply, and many strains may produce enterotoxins when the population exceeds 10^5 cells/g. An estimated 185,000 cases of food borne illnesses associated with *Staphylococcal* food intoxication occurs annually in United States (Mead *et al*., 1999).

More than 50% of healthy individuals carry *Staphylococcus aureus* in the nose and throat, hair and on the skin, especially around the hands and fingertips. Coughs and sneezes of individuals with respiratory infections may carry droplet which can easily spread to the environment and food being handled. Therefore any food which requires handling in preparation may easily become contaminated. Infected wounds, lesions and boils of food handlers may also be sources of contamination. However, the two most important sources of contamination to foods are nasal carries and individuals whose arms and hands are inflicted with boils and carbuncles and are permitted to handle foods. *Staphylococcus aureus* also commonly occurs on the skin

and hides of animals, and may thus contaminate foods from these animals as a result of cross-contamination during slaughter (NACMCF,1993).

Staphylococcal food borne illness may occur between 30 minutes and 8 hours after ingestion of contaminated food. Common symptoms of *staphylococcal* intoxication include nausea, vomiting, retching, abdominal cramping, sweating, chills, prostration, weak pulse, shock, shallow respiration, and subnormal body temperature (Sprenger, 1995).

A number of foods can support the growth of *Staphylococcus aureus* but food which supports growth best is proteinaceous foods such as meat and meat products, poultry, fish and fish products, milk and dairy products, cream sauces, salads (ham, chicken, potato, etc). Often it is lack of sanitation by workers and improper time-temperature combinations that lead to contamination of the product and growth of the microorganism to levels at which toxin is produced (IFT,2004).

This pathogen can be controlled by observing proper sanitation in the meat industry, trimming of carcasses to physically remove microorganism, Asepsis,

The killing of the microorganism using bactericides and temperature –time control which invariably prevents or delays growth and toxin production (Sprenger, 1995).

1.3. Slaughterhouses:-

A slaughterhouse, alternatively known as an abattoir, is a place where animals are killed to provide food. It may also be defined as any premise that is used for the slaughter of animals whose meat is intended for human consumption. (Bello and Oyedemi, 2009)

1.3.1. Type of the slaughterhouses:-

Slaughter premises normally seen in developing countries are of three kinds; modern abattoirs ,old slaughterhouses and slaughter slabs and finally, makeshift premises .Of the three ,modern abattoir represent the most progressive and ideal in the conventional abattoir design, equipping and services, often built and controlled by the central government with foreign technical assistance and management. These abattoirs are operated on industrial lines with a wide range of services featuring cold storage, Processing, by-product utilization and waste recycling activities. Some of them have export objectives primarily in chilled and frozen meat although at times, some of their manufactured products (and by products) are channeled into local sale in substitution for imports. Few modern abattoirs in developing countries slaughter directly for public consumption, as they are commercial or profit-motivated establishments with little inclination for low revenue services (FAO, 2004).

The old slaughterhouses and slaughter slabs handle the bulk of public slaughters. These premises merely make facilities available for use by licensed butchers and traders for the slaughter of livestock at stipulated fee and in accordance with public health, inspection and marketing regulations. Slaughterhouses and slaughter slabs thus operate as service establishments under the management of municipal and local authorities, their field of activities often being limited to the larger towns and built up areas. The third category of slaughter premises, the makeshift that include all kinds of places such as converted buildings or rooms, shade of trees or bare grounds, that a butcher or a community may find convenient for the operation. They are characteristic of village and rural locations (FAO, 2004).

1.3.2. Slaughterhouses in Sudan: number, capacity and current status:-

According to MOAR (2017), there are 9 modern and semi modern red meat slaughterhouses distributed in the three localities of Khartoum State and other states. The responsibilities of the public sector are now limited to regulation, research, planning and investment promotion. The government also has a role to play in

fostering a supportive policy and infrastructure environment by overseeing activities such as public health and food safety in relation to hygiene and sanitation of meat slaughtering and processing facilities for exports; monitoring and control of animal diseases; and documentation. In addition, new federal policies that encourage the export of livestock are being developed.

Table (1.2) Export Slaughter Houses in Sudan:-

Slaughterhouse	Slaughter/Time		Capacity/Ton/Day		Prodution Capacity/Head/Day	
	Cattle	Sheep	Cattle	Sheep	Cattle	Sheep
Kadro	30	200	60	20	300	2000
Ganawa	30	150	60	15	300	1500
Sabaloga	20	150	40	15	200	1500
Gimco	15	200	30	20	150	2000
Karari	15	100	30	10	150	1000
Nyala	15	100	30	10	150	1000
Gadarif	15	100	30	10	150	1000
Atbra	15	100	30	10	150	1000
Radwan	25	-	-	-	150	-
Total	180	1100	310	110	1700	11000

Source MOAR (2017).

The slaughtering processes at the export slaughterhouses in Khartoum state are halal slaughtering, skinning, evisceration, washing, and ante-mortem examination. Then the carcass is chilled for 24 hours, re-inspected, labeled, packed and loaded inside refrigerated trucks with thermo king switched on an hour prior to loading. Carcasses are unloaded at the airport into containers for transport, and then final veterinary inspection is done before clearance for shipping by air, based on schedule of direct flight from Khartoum airport to ensure that the product is delivered at the required temperature, i.e. chilled to 0ºC.

Health and sanitary conditions of export slaughterhouses are well looked after. Regular cleaning and flushing with water is done after each batch is slaughtered and disinfected with safe chemicals (e.g. quadrate ammonia) and, in some slaughterhouses, fumigation is a routine practice.

For export slaughterhouses, the most important sanitary measures to be met according to importers needs are the infrastructure rehabilitation (additional cold stores and vacuum packing machines).

Exporting companies reported airfreight problems as there were no specialized flights for meat. Only cargo or passenger flights carry meat whenever there is space, and with small space available on the planes, there are booking problems and delay in peak season. Also there was no storage or cooling facilities or chilling containers at Khartoum airport, which seriously hamper delivery of meat at right temperature in case of flight delays.

1.3.3. Status of meat hygiene in Khartoum state:-

Some studies conducted to evaluate the status of meat hygiene in beef and mutton abattoirs in Khartoum State. Elamin (2002) assessed the microbial contamination in slaughterhouse in Omdurman and found the bacterial counts exceeded 10^7 CFU/cm^2. This is similar to the studies conducted by (Elhassan *et al*.,2011) and (Ibrahim,2006) who evaluated the hygienic quality of mutton intended for export from Elkadaro slaughterhouse in Khartoum State. The bacterial count revealed higher counts but no critical contamination levels were recorded.

According to (Abdalla *et al* .,2009) this may be due to the high ambient temperatures of the country which promote the growth of microorganisms that can rapidly render meat unsafe for human consumption and also due to the lower hygienic level during killing and preparation (Salman *et al.,*2014).

(Mohamed, 2009) who evaluated the status of meat hygiene in four slaughterhouses (Alkadaro, Ghanawa, Alhuda And Assabaloga) in Khartoum State, the study revealed that each of the slaughterhouses had acceptable diagnostic laboratory, clean, spacious and well ventilated slaughter halls, reasonable number of refrigerators, which were of good condition, and reasonable number of veterinarians and assisting staff. The researcher concluded that meat hygiene status in these slaughterhouses was good.

The authors of these studies recommended that HACCP system should be applied, good sanitary measures during slaughtering processes should be stressed on, sufficient clean heated water and safe disinfectants must be available and extensive education and training programs on hygiene for workers should immediately be started.

1.4. Sanitation in the slaughter house:-

Sanitation may be defined as the process involved in ensuring good health by means of preventing human contact with the hazards of wastes. Such hazards can be physical, microbiological, biological or chemical agents of disease (Hui *et al*., 2002).

The major goal for the food processing industries is to provide safe, wholesome and acceptable food to the consumer and control of microorganisms is essential to meet this objective (Baggen-Ravn *et al*., 2003).

In line with this, a slaughterhouse should be designed to ensure the flow of operations from the live animal holding area through to discharge areas. Meat products should, therefore, proceed progressively through cleaner areas of the operation; primarily there are several key factors that a slaughterhouse should observe to be able to satisfy the necessary conditions which will contribute to adequate sanitation for the prevention of contamination.

1.4.1. Infrastructure and planning of the slaughter house:-

1.4.1.1. Preparation and contents:-

Where possible, a competent architect, engineer, or other person experienced in slaughterhouse design should be employed to prepare drawings and specifications.

Drawings must be to scale and include the following:

a) A plot plan showing the boundaries of the plant property; location of the plant in respect to other buildings or structures; streets; driveways and parking sites including drainage systems and surfacing materials (e.g. gravel, pavement etc.); railway lines; sewer lines; potable water sources (e.g. wells); gas and water mains; and power lines. The scale and the north point should be shown.

b) A floor plan of each level of the plant, showing the purpose for which each room is to be used, location of walls, partitions, windows, doors, posts, conveyor rails and all equipment on the floor or in an elevated position, (e.g. draw-off fans, refrigeration units), hose bibs, sanitizers and hand wash stations.

c) A floor plan showing location and size of floor drains, location and size of direct drains for pieces of equipment using large amounts of water; curbing, gutters and slope of floor towards drains and the hot and cold water outlets.

d) The exterior elevations of the building, showing doors, windows, and platforms.

e) A cross section of the plant showing ceiling heights.

f) A roof plan showing skylights, vents, drainage and other pertinent information.

g) A schedule of room "finishes" must be on or attached to the plans, including a schedule of door sizes, construction and type of door frame; lighting intensity for each room.
h) An equipment layout with accompanying "flow charts" of operations. The design and construction of the equipment must be shown and, where necessary, cross-sections provided to show method of construction and operation.
i) Where the plans refer to alterations or changes within an existing plant, sufficient description should be made of the surrounding rooms as well as those above and below. Copies of plans of the existing layout and construction should be attached to explain the nature, extent, and effect of proposed changes (Critical Design, Operational and Equipment Guidelines for Licensed Abattoirs, 2012).
All areas and equipment where bodies of animals are dressed or meat be offered should be designed and built to allow good hygiene practices and cross-contamination of meat is reduced through effective cleaning, sanitation and maintenance which can be done during and between functional periods. Floors have sufficient slop to grilled water or protected outlets so as to guarantee frequent drainage, Separate rooms are designed for different purposes such as evacuation and cleaning of alimentary tracts, keeping hide and skin, dressing and chilling carcasses which should be equipped with enough tools for washing hands, cleaning and sanitation of implements. Ventilation should be designed to minimize flow of air from unclean areas (slaughter and dressing areas) to clean areas (chilling room) (CAC ,2005).
Buncic (2006) emphasized on materials and equipment to be used in the abattoir, as it should be considered from the point of view of controlling contamination, they should be as durable as possible and be capable of being cleaned and sanitized effectively.

1.4.1.2. Site of Building:-

Ideally the slaughterhouse should be located away from residential areas to prevent possible inconvenience to dwelling-places either by way of pollution from slaughter wastes or by way of nuisance from noise (FAO, 1985). There must be free access for animals to the site by road and the slaughterhouse should be situated in areas where flooding is unlikely to happen. If the slaughterhouse is of regular buildings construction the ground should be free of bushes or vegetation in the vicinity of the structure (FAO, 1985).

1.4.1. 3. Size:-

The number of animals to be slaughtered should take into account the size of slaughter facility and the number of animals to be slaughtered is of great importance to avoid sanitary problems due to overcrowding (Tove, 1985).

1.4.1.4. Building / facility:-

The buildings or facilities involved in such processes are normally described as places which stand for good sanitation and hygiene. According to international norms, such buildings should normally have clean and unclean processes separated (Eriksen, 1978).

Walls and ceilings must be smooth, level, hard and consist of impervious material such as accepted prefabricated panels and, glazed tile, and free from pitting, indentations, cracks, crevices and ledges. All corners and junctions of walls and floors must be coved in kill floor, coolers, condemned and processing areas, and other areas subject to frequent cleaning and moisture. Ceilings should be at least 3.3m in height. Ceilings of rooms intended for livestock receiving, slaughtering and dressing should be at least 4.8m in height. All mortar joints must be smooth and flush. Scoring cement plaster walls should be discouraged. To promote light reflection and sanitation, wall and ceiling surfaces should be white or light-colored. Whenever practical, materials that do not require painting should be used. Materials that are absorbent and difficult to keep clean must not be used. Examples of unacceptable materials include wood, plasterboard and porous acoustic-type boards. Walls should be provided with suitable sanitary-type bumpers or sloped curbs to protect them from damage by hand trucks or lifters (Critical Design, Operational and Equipment Guidelines for Licensed Abattoirs, 2012).

1.4.1.5 .Walls and Floors:-

The flooring of the facility which is one of the major sources of contamination must be hard, free of cracks, evenly leveled and impervious, and sloping adequately towards a drain to allow cleaning with water and disinfection. The walls as well must be smooth enough to be easily cleaned by water, and recommended materials are, for instance, stone, lava blocks, bricks or concrete.

To provide shade, a good environment and finally to keep down the internal temperature in the slaughter line, a roof made up of concrete would be ideal (Eriksen, 1978).

1.4.1.6 .Lighting system:-

As a matter of hygiene, the slaughterhouse should have a proper lighting system inside the slaughter line to allow proper functioning and avoid accidents, moreover will act as a

deterrent to insects and rodents (Critical Design, Operational and Equipment Guidelines for Licensed Abattoirs, 2012).

1.4.1.7. Ventilation system:-

The internal temperature inside the slaughter house shall be maintained to prevent proliferation of unwanted microorganisms and also to cater for a good working environment. Ventilation must be as appropriate as possible to reduce the atmospheric microbial load and to prevent stuffiness in the facility which can induce sweating and sneezing (Critical Design, Operational and Equipment Guidelines for Licensed Abattoirs, 2012).

1.4.1.8 .Equipment:-

Equipment for undergoing such process, normally have to follow certain norms and regulations, it has been reported that such equipments have to be of non-corrosive materials, for example stainless steel (Tove, 1985). Structures like tables, hooks and machines should be positioned such that, they will be easy to relocate to facilitate cleaning and disinfection. The key step for the hygienic handling of carcasses is the equipment for elevating the carcass when slaughtered. In the processing line, cranes are preferred to working tables due to hygienic practices. Procedures that provide for the regular cleaning of hoists should be implemented and should be adhered to. However, the cleaning and disinfection is usually complicated or simply impossible because of the complexity of the machines that may be involved (Tove, 1985). Due to this, equipments that may be easily unassembled for easy relocation are preferred.

1.4.1.9. Water supply:-

Since slaughtering is a process which generates a lot of wastes, to cater for the good running of the processes and minimize contamination, there should be a good supply of water of drinking quality to allow processing and cleaning procedures which will ensure hygienic quality products. Working routines should be planned in such a way as to economically use the consumption of water because of waste water disposal (Kirby *et al*., 2003). It is also important to ensure that water storage vessels are properly covered, and cleaned regularly to maintain the water in a potable state.

1.4.1.10. Sanitary facilities:-

Several water points, sterilizers for hand tools, hoses and cleaning equipment are the keys to providing a good standard of hygiene and these must be sufficiently provided.

The availability of hot water in preference to chemical disinfectants should be emphasized. The facility should also be supplied with sterilizers and hand sanitizers wherever possible (Adler, 1999). Sanitary facilities must also include an adequate number of toilets and arrangements for changing of clothes, hand-washing and even for bathing (showering). Such facilities must be clean and well-kept at all times and the toilets should possess hand wash basins along with soap, disinfectants, antiseptics, nail brushes and clean towels readily available. A room for resting and eating should be provided for the staff. This room should be separated from the processing line to assure that the carcasses and the food for the personnel cannot be mixed (FAO, 1985).

1.4.1.11 .Environmental hygiene:-

As in all sectors of hygiene, the external and internal environment of the slaughter house should be protected against any infestation. Insects, birds and rodents have been recognized as important carriers of pathogens and other microorganisms (Olsen and Hammack, 2000).

To avoid these, a strict control should be exerted over the following:-

1.4.1.11.1. Pests control:-

Good Hygienic Practices (GHP) should be employed to avoid generating an environment favorable to pests. Pest control system for pest must include the following:

· Good Hygienic Practices should be used to avoid creating an environment conducive to pests.

· Pest control programs could include preventing access to principal site, eliminating harborage and establishing monitoring detection and eradication systems.

· Physical, chemical and biological agents should be properly applied by suitably qualified personnel (CAC, 1997).

1.4.1.11.2: Proper fencing:-

Insects, birds and rodents have been recognized as important carriers of pathogens and other microorganisms (Urban and Broce, 2000).

In one interesting case a *Salmonella* outbreak was traced back to amphibians, which had accidentally entered a production facility (Parish, 1998).

The aim is to prevent access of unauthorized persons, the public in general, dogs and other animals around the slaughterhouse premises. The fencing should have direct contact with the ground and should be sufficiently high to prevent access into the premises (Urban and Broce, 2000).

1.4.1.11.3. Bird control:-

Allowing birds to fly inside the slaughter house might cause contamination through its droppings. Birds are often attracted by food supplies, water, special vegetation around buildings, and these attractions should be removed. Fenlon, (1983) demonstrated that some aquatic birds spread for *Salmonella* and other human pathogens in the environment. The best control is to prevent them from accessing the buildings by placing nets on the openings and windows.

1.4.1.12. Slaughtering Processing:-

The hallmark for hygiene principle in processing is that the procedures considered as clean and unclean should be efficiently separated. This requires a well-structured plant layout, where the purpose of any structure should be the protection of the end product against accidental contamination (CAC, 1997).

1.4.1.13. Lairage:-

Lairage is a place where livestock are kept temporarily (Critical Design, Operational and Equipment Guidelines for Licensed Abattoirs, 2012).

This is a specific area inside the premises of a slaughter house where the animals are conveyed for rest. Rest is an important factor because when animals are stressed, carcasses of lower quality result from slaughter. There should be sufficient space for the animals and a good supply of potable water for drinking purposes. A washing system where the animals can be cleaned before passing to the slaughter house is generally recommended (FAO, 1985).

1.5. Meat hygiene and the Good Hygienic Practice (GHP):-

Good Hygienic Practice (GHP) is defined as all practices regarding the conditions and measures necessary to ensure the safety and suitability of food at all stages of the food chain (CAC, 2005).

Good Hygienic Practice consists of practical procedures and processes that return the processing environment to its original condition (disinfection or sanitation programs); keep building and equipment in efficient operation (maintenance program); control of cross-contamination during manufacture (usually related to people, surfaces, the air and the segregation of raw and processed product)

(Raspor, 2008).

Unless the animals are infected the meat of freshly slaughtered animals are generally sterile. The presence of microorganisms in post slaughtered carcasses is due to contamination occurring immediately before, during and after slaughter. The microbial contaminations of carcasses occur mainly during processing and manipulation during skinning, evisceration, processing at abattoir and retailers establishments (Gill, 1998).

The main sources of meat contamination include; animal/carcasses source, on-farm factors, transport factors, abattoir and butchers facilities, parasites and wild animals, meat van, abattoir, and retail meat outlet workers. The hygiene program should aim to protect human health base on the scientific examination of meat-borne pathogens. The hygiene program has to be done by the competent personals (Ntanga, 2013)

1.5. 1. Good hygienic practice at the primary production:

Good hygienic practice (GHP) at the level of primary production should involve for example the health and hygiene of animals, records of treatments, feed and feed ingredients and relevant environmental factors, and should include application of HACCP principles to the greatest extent practicable (CAC.2005).

At the production or pre-harvest level, diseases such as brucellosis, leptospirosis and tuberculosis and in some cases anthrax represent direct hazards for farm workers, and the entry of animals affected with these diseases into meat plants clearly poses an extreme risk for operators and consequently the production of contaminated meat in the food chain (Collins, 2000).

Body condition may affect the pathogens load. Weak animals lie down more often than healthy ones, thereby increasing the likelihood of contaminating hides. Contacts

between animals at auction barns may increase the pathogen load (Galland, 1997). The exterior of the animals harbors large number and different types of microorganisms from the soil, water, feed, manure as well as its natural flora (Mtenga *et al*., 2000).

Animal identification practices should allow trace-back to the place of origin to the extent practicable, to allow regulatory investigation where necessary, the competent authority should systematically analyze monitoring and surveillance information from primary production so that meat hygiene requirements may be modified if necessary (CAC.2005).

1.5. 2. Transportation of the live animal:-

The transport factors such as the type and cleanliness of transport facility, distance traveled and duration of the journey, the harshness of the ride, overpopulation of animals in the conveyance and frequency of stops, may affect and contribute to pathogen load (Galland, 1997).

Transportation means of slaughter animals might be an important link in the spread of *Salmonella typhimurium* among calves (Morrow and Swanson, 2001).

This transportation should be done in a way that does not have a negative impact on safety and quality of meat, the transport vehicles should be designed to ensure cross-contamination with fecal material, dirtiness or soiling is minimize. The spread of disease between animals may well compromise their welfare and the spread of pathogens potentially compromises meat hygiene. (Tove, 1985).

The animals are hauled from pastures or farms to the slaughterhouse. All necessary precautions during transportation should be done:-

· The transport facility should be designed and modified to convey the stock.

· They should provide for sufficient ventilation and lighting.

· For open trucks the top should be covered with a tarpaulin to protect the animals from bad weather conditions.

· They should be equipped with appropriate loading and unloading mechanisms to prevent injuries.

· They should be as comfortable as possible for the animals (Tove, 1985).

1.5. 3. Conditions of lairage:

The sanitary condition of animals has a great effect on the level of microbial cross-contamination of meat during slaughter and dressing. The cleanliness of livestock

depends on husbandry, weather, and climate (rainy, dry), methods of transport (stress causes, defecation, and urination) and holding conditions at the abattoir (Aburi, 2012).

Handling of animals which need to be slaughtered has an influence on many stages of slaughter, dressing, and production of safe meat. The length of time animals is held at the abattoir before slaughter can affect the pathogen load by increasing the probability of exposure and infections. Sanitation of walkways, pen floor, railings, feed, and water affect the pathogen load (Galland, 1997).

Buncic (2006) proved that the lairage should allow recovery of animals from transport stress, abnormal animal behavior, and interaction, cleaning and also effective antemortem inspection by the official veterinary surgeon. A series of requirements appropriate to animal species may be implemented to guarantee that only animals that are adequately clean are slaughtered so that it can help in decreasing microbiological cross-contamination.

1.5. 4. Ante-mortem inspection:-

The slaughter animals should be presented for ante-mortem inspection, where competent authority determining measures and tests to be used, this inspection should include the confirmation that animal is properly identified, tests that considers the behavior, demeanor, appearance as well as symptoms of disease in live animals with the recognition of relevant information on slaughter population (CAC ,2005).

Ante-mortem inspection has three main areas of concern: Public health purposes, animal health and animal welfare. For public health purposes the veterinarian must separate normal animals from those which may be suffering a potentially zoontic disease. The ante-mortem procedure allows the veterinarian to assess the welfare implications of the structures and procedures within the lairage (Gracey *et al*, 1999) The animal health aspect requires the veterinarian to identify notifiable disease. It is an excellent opportunity for notifiable disease surveillance which plays an important part of the process involved in the production of wholesome, safe meat (Buncic, 2006).

1.5. 5. The slaughtering process (Halal slaughter):-

The slaughtering process has a significant impact on the meat safety and hygiene. Several criteria define a good slaughter method from the scientific point of view:

a) Animals cannot be treated cruelly; b) animals cannot be unduly stressed;

c) Bleeding must be done as quickly and as complete as possible; d) carcass bruising must be minimal; e) slaughter must by hygienic, economic and safe for the operators (Swatland, 2000). In addition, the humane conditions must be presented during pre-slaughter handling (Roça, 2002).

The best method of slaughter is the Sunnah method (Halal slaughter), the importance of Islamic slaughter is to facilitate the blood flow from the animal body, as blood represents suitable enrichment medium for growth and multiplication of microorganisms, and therefore its complete removal from the slaughtered animal is vital to protect the consumers from infectious diseases.

Halal slaughter consists of a horizontal cut on the throat of the animal and severing all four vessels of the throat in order to remove all the impure blood from the animal. The halal slaughter of animals has a great role in preventing infectious diseases; this is the only method which ensures that the meat slaughtered is lawful for Muslims of all schools of thought to consume and the method which removes all doubts (Halal advocates of America, 2011a).

1.5. 5. 1.Procedures of the Halal slaughter:-

Here, the present research paper summarizes the standard which was developed by the Standardization Expert Group of the Organisation of the Islamic Conference (OIC).

In case of manual slaughter as used in Sudan:-

a) The animal to be slaughtered has to be an animal that is Halal.

b) The animal to be slaughtered shall be alive or deemed to be an alive at the time of slaughter.

The slaughtering procedure should not cause torture to animals and should be done with animal welfare/rights consideration.

c) The slaughterer shall be a Muslim who is mentally sound and fully understands the fundamental rules and conditions related to the slaughter of animals.

d) If animals have arrived from long distance, they should first be allowed to rest before slaughtering.

e) The animal may be slaughtered, after having been hung or laid preferably on its left side facing Kiblah (the direction of Makkah Al-Mukaramah). Care shall be given to reduce suffering of the animal while it is being hung or laid and not to be kept waiting much in that position.

f) At the time of slaughtering the animals, the slaughterer shall utter “BISMILLAH

WALLAHUAKBAR" which means "In the Name of Allah Almighty Great" and he should not mention any name other than Allah otherwise this make it non-Halal. Mentioning the name of Allah should be on each carcass "Zabaha" (killed by slaughter) or on each group being slaughtered continuously and if the continuous process is stopped for any reasons he should mention the name of Allah again.

g) Slaughtering shall be done only once to each animal. The "sawing action" of the slaughtering is permitted as long as the slaughtering knife shall not be lifted off the animal during the slaughter.

h) The act of Halal slaughter shall begin with an incision on the neck at some point just below the glottis (Adam's apple) and after the glottis for long necked animals.

i) The slaughter act shall sever the trachea (halqum), oesophagus (mari) and both the carotid arteries and jugular veins (wadajain) to hasten the bleeding and death of the animals.

j) The bleeding shall be spontaneous and complete. The bleeding time must be not less than 2.5 minute to insure fully bleeding.

k) Slaughterer should grab the head by left hand, stretching it down tightly and shall cut the throat by a sharp slaughtering knife held in the right hand. The sharp edge of knife which used for slaughter should be not less than 12 cm.

1.5. 5. 2. Effects of the Halal slaughter on the animal and meat safety and hygiene

There are numerous advantages to halal un-stunned meat including complete drainage of blood, better consistency of the meat, and no concern of the animal dying due to the stunning (Halal advocates of America, 2011b).

a) No pain during slaughtering

A sharp blade and skill in slaughtering is required to minimize pain and unnecessary suffering for the animal. This is accomplished by a quick cut to sever the veins and arteries of the neck of the animal, without cutting the nervous system or spinal cord. The massive bleeding makes the animal unconscious in seconds (ISNA Halal Certification Agency, 2010).

b) Complete drainage of blood:-

Bleeding efficiency can be considered as an important requirement of slaughter operations in order to obtain a high quality product (Warriss, 1977). Blood has high pH (7.35 - 7.45) and due to its high protein content, it quickly undergoes putrefaction (Mucciolo, 1985). Therefore, the conservation capacity of improperly bled meat is

very limited. In addition, it causes a visual problem for the consumer (Hedrick *et al.,* 1994).

In case of Halal slaughter, cutting of the blood vessels of the throat facilitate the drain all of the impure blood from the animal body in a short time. Prevention of the neck separation during the Islamic slaughter is very important to maintain the connection of the brain to the rest of the body via the spinal cord in order to send nerve signals and hormonal alerts which are necessary to complete the bleeding process to remove all of the liquid blood from carcasses. Leaving the spinal cord intact allow for convulsions that result from the contraction of the muscles in response to the lack of oxygen in the brain cells. This will allow for the maximum drainage of blood.

c) Improving of meat safety and hygiene:-

The post-mortem changes that take place when muscle is converted into meat have a marked effect on the quality of the meat. The Halal slaughter allow for the maximum drainage of blood, carrying away in part the waste and micro-organisms, thereby improving the meat's taste, shelf-life and healthiness (ISNA Halal Certification Agency, 2010).

d) Protect human beings (consumers) from infectious diseases.

The Islamic halal slaughter of animals has a great role in the prevention of infectious diseases. Islam has meant the development of the legal provisions governing the slaughter of animals for human consumption.

1.5.6. Precautions that have to be maintained during slaughtering

a) Disinfection on entering the premises

Every time an authorized officer or member of staff is to enter the slaughter house, he should undergo a process of disinfection by dipping his boots in a footbath, which is a basin situated at each entrance of the slaughter line, to avoid carrying infectious agents that might stick to the boots via soil particles (Adler 1999).

b) Bleeding and exsanguinations

The knife used to slaughter each animal should be cleaned and rinsed in hot water. It is known that a contaminated knife can pass on bacteria into the animal tissues during the initial stages of bleeding, that is, when the heart is still beating (Reij *et al.,* 2003).

c) Skinning

Knife skinning and the use of bare hands can similarly hosts contaminating organisms on the surface of the carcass. As such washing of the hands is a must after the passage of each carcass to avoid contamination (Reij *et al.,* 2003).

d) Evisceration

Extreme care should be taken not to puncture the intestines. The slaughter men should follow the procedure of tying the end part of the intestine and the severed end of the esophagus, then removing intestine and stomach first, followed by the pluck (heart, liver, and lungs of an animal used as meat (FAO, 1985). As a matter of hygiene, the stomach and intestines should not be processed while carcass dressing is in operation as any minor splash can easily cause contamination of the meat.

f) Trimming of visible contamination-:

During animal slaughter, contaminated carcasses are transferred from a processing to a detaining rail where visible contamination has removed by a procedure called trimming. Trimming is an on-line process used to remove excess fat, small fecal spots, and smears from beef (Sheridan, 2007).

Trimming, which removes enteric pathogens associated with the contaminating matter (Bacon *et al*., 2000), is followed by visual inspection to ensure that contamination has been adequately removed after which the trimmed carcasses are returned to the processing line. Gill and Landers (2004) documented the effectiveness of the trimming of visibly contaminated carcasses on the reduction of both total bacterial counts and of *E. coli* counts on beef carcasses.

1.5.7. Post-mortem Inspection:

Post-mortem inspection of meat and other relevant parts should use information from production at farm level and ante-mortem inspection, to gather with the result from an organoleptic inspection of the head, carcass, and viscera to make a decision on the safety and suitability of meat needed for human consumption. Post-mortem and tests may be integrated and implemented to gather so as to attain public health and animal health objectives. This inspection should be made by a competent personal base on scientific knowledge- and risk-based methods (Wilson, 2005).

1.5.8. Carcass washing:-

Fecal matter is a major source of contamination and can reach carcasses through direct deposition as well as by indirect contact through contaminated carcasses,

equipment, workers, installations and air (Borch and Arinder, 2002). Feces, as well as soil adhering to animals, are carried into abattoir on hair, hides, hooves, and tail of animals. Contact between carcasses and hides allow a mixture of microorganisms to be introduced on the carcasses. These contaminating microorganisms are derived from the animal's preslaughter environment that may be of fecal, soil, water or feed origin (Bell, 1997).

Infected body fluid such as urine, milk, blood, mucus, rumen fluid, intestinal fluid, and fluid from an excised abscess can be another source of carcasses contamination (Galland, 1997).

The carcass is sprayed with cold water to remove all blood, visible soil, slight blood marks, bone dust, and marrow (Bekker , 1998) before going to the cold room for chilling. It is generally recommended that only approved, uncontaminated carcasses should be washed with running water in order to remove from the carcass any bone splinters and blood which might be present thus, improving the appearance of the carcass. Bekker (1998) indicated that washing of the carcasses with cold water does not significantly influence the microbiological load on beef carcasses.

1.5.9. Chilling:-

During animal slaughter, carcasses are placed in the chillers immediately after the final wash until the temperature of the deep round reaches 7 °C or lower to retard bacterial growth. Carcass chilling controls bacterial growth via (extrinsic temperature, relative humidity (RH), airspeed and carcass spacing) and intrinsic factors water activity (a_w). Chilling is monitored by checking the deep round temperature of a number of randomly selected carcasses per rail in the chillers. There have been different reports on the effectiveness of chilling in controlling bacterial growth on beef carcasses. The main reason for chilling meat is to control the proliferation of bacteria and certain other microbes such as yeast (Strydom and Buys, 1995) , molds on meat and to reduce the rate of deteriorative chemical changes e.g. oxidation of fats causing rancidity (James *et al*.,2006).

According to (Savell *et al*., 2005) meat surface temperatures remain in the growth range for *Escherichia* and *Salmonella* flora for a considerable period and Enterobacteriaceae counts of chilled carcasses increase during chilling. This explains the fact that although the initial microbial contamination of meat contains both

mesophilic and cold tolerant bacteria, only the latter will compete successfully at chill temperatures (Strydom and Buys, 1995).

Two methods of preserving meat by low temperatures are chilling and freezing. Where, meat is stored at a temperature of 0° C to 4° C during chilling and for freezing -18° C respectively. The cold temperature slows the enzyme action and the growth and development of bacteria. Thus from the above, it can be said that meat can be stored longer at freezing temperatures than at chilling temperatures. Storage times as indicated above are for meat, which has been correctly packed and sealed airtight. The meat should be stored for shorter periods if the temperature is higher than the given temperatures (SANDA, 2004).

The air temperature in the terminal stages of chilling shall be maintained at a value between −1 and 2 ° C. That for the storage of chilled carcasses, the refrigerated room sides or quarters be maintained within the range of -1 to 5° C and the mean airspeed over the product be maintained above 0.5 meters per second. The relative humidity shall be maintained below 95% and if the product is stored for longer than 72 hours, the relative humidity should be maintained below 90%.

1.5.10. Dispatch and transport of meat from abattoir to sale point:-

Maintaining the cold chain as well as hygiene during the transport of meat is of the utmost importance. Unnecessary contamination and microbiological growth will be the result if there is a breakdown of the cold chain and will have a direct impact on the shelf-life and safety of the meat. According to the Meat Safety Act, 2000 (Act , 2000).

Vehicles should be designed and equipped so that meat does not contact the floor, have door seal that prevents entry of all sources of contamination, it should be equipped to temperature control and humidity, can be maintained and monitored. (CAC, 2005) .

1.5.11. Cleaning operations and the decontamination of the slaughterhouse -

The abattoir environment and slaughtering processes play a vital role in the wholesomeness and meat safety. Unhygienic practices in abattoirs and post-process handling are associated with potential health risk to consumers due to the presence of pathogens in meat and contaminated equipment (Abdullahi *et al*., 2006).

For hygienic reasons abattoir use a large amount of water in processing operations which in turn produce a large amount of wastewater. The major environmental

problem associated with abattoir wastewater is a large number of suspended solids and liquid waste as well as odor generation (Gauri, 2006).

It is necessary that all equipment in the slaughterhouse, that come in contact with food, should be fashioned in such a way as to ensure adequate cleaning, disinfection, and proper maintenance to avoid contamination (CAC ,1997).

For the purpose of sanitation clean water is usually required for the cleaning of equipment, tools floors, and walls. Such operation normally starts with the removal of solid waste of meat and fat trimmings and pieces of bones from the area. Blood clots and other waste materials on the floor may be dealt with by scrubbing them off the floor. High-pressure water cleaning begins from the walls and finally ends with the floors. Hot water hosing under pressure would be ideal for removing sticky waste from corners and drains. For scrubbing of other surfaces such as tables and tools, the use of hard fiber brushes and detergents is suggested. Liquid detergents are more effectual than ordinary soaps since they dissolve easily in water while absorbing dirt, which is finally removed by flushing. Powdered soap may also be dissolved in water and used. Knives also should be sterilized or boiled in water (FAO, 1985).

1.5.12. Hot water sanitation of slaughter equipment:-

One common practice at most meat facilities is to sanitize meat-cutting equipment (knives, neck splitters, bung tiers, and saws) by dipping it into containers of hot water (82 °C) adjacent to processing lines to reduce the carcass-to-carcass spread of pathogenic and spoilage bacteria. Gill and McGinnis (2004) demonstrated the potential of tools used for carcass dressing to contaminate carcasses during slaughter and dressing. However, the presence of organic materials on slaughtering equipment reduces the antimicrobial activity of hot water. Hot water tends to coagulate protein, which allows organic material to adhere to equipment surfaces and leads to a greater difficulty in removing meat residues.

Taormina and Dorsa (2007) found that brief (1 s) dip treatments of slaughter equipment had limited efficacy, compared to longer immersion time (5 s).

Effluent from slaughterhouses are known to contribute in contamination of both surface and ground water since, during processing in abattoir blood, fat, manure, urine and meat tissues are discharged to the wastewater streams (Bello and Oyedemi, 2009).

1.5.13. Waste Management:-

For the safe disposal of liquid and solid waste, the following action should be taken:

· Separation of blood.

· Screening of solids.

· Trapping of grease.

a. The blood from slaughtered animals will coagulate into a solid mass, which may block up both open and closed drains. It is therefore recommended that the blood is collected and used for human consumption; stock feed production or fertilizers, if the religious and cultural traditions allow the use of blood.

b. Solids (meat or skin trimmings, hair, pieces of bones, hooves, etc.) must be screened. This may be done by providing the drains with vertical sieves.

c. Effluents from slaughterhouses always contain small amounts of fat (melted fat or small pieces of fatty tissues). Grease traps should be installed in the drains. The fat solidifies, rises to the surface and can be removed regularly (Ockerman and Hansen 2000).

1.5. 14. Personal hygiene:-

According to Norrung and Buncic (2008), the process of meat handling increases the possibility of microbial contamination because unhygienic practices during handling may lead to transmission of bacteria to the meat from the surfaces. Several studies have further indicated that food borne illnesses occur due to poor handling of food (Van Tonder, 2004).

Workers in the food sector play a key role in ensuring food safety; those who do not practice adequate personal hygiene can contaminate food (Clayton *et al.,* 2002). According to Johns (1991), personal hygiene can be defined as follows: clean as reasonably practical hands, forearms, neck, hair and any garment that may come into contact with food. Personal hygiene is essential to prevent contamination of food and food-borne diseases (Medeiros *et al.,* 2001).

Some aspects of personal hygiene include:

1.5. 14. 1. Education and training:-

Martinez *et al*. (2000) highlight the education of food handlers as a crucial defense line in the prevention of most types of food borne illnesses. To ensure that personnel respect the personal hygiene requirements, two aspects must be considered: the environment in which the staff operates and the quality of the personnel.

From the point of view of food hygiene, the quality of the working environment depends on the facilities or equipment provided, including toilets and protective clothing. The quality of the personnel depends on their health, hygiene, and habits (Johns, 1991).

Meat handlers have been reported lacking meat safety knowledge, adequate training and observed to be frequently engaged in poor handling practices, especially during the slaughter process (Nel *et al*., 2004; Haileselassie *et al*., 2013).

Morrone and Rathbun (2003) indicated that risks along the food chain can be minimized through educate consumers and workers on food safety. Without the knowledge of food safety practices and food handling procedures, food borne illnesses cannot be reduced (Redmond and Griffith, 2003).

Training and food handling instruction regarding basic personal hygiene concepts and needs is an integral part of ensuring a safe product for the consumer.

Adams and Moss (1997) reported that to ensure this, there should be some form of introductory training with regular updating and refresher courses for food handling. Meat handlers must also understand the risks associated with food contamination by microbiological agents, and should be able to prevent meat contamination. Ryser and Marth (1991) concluded that training and education should address a deeper understanding of food hygiene, including sanitation issues.

1.5. 14. 2. The general health of the food handler:-

Personal hygiene is a fundamental issue and no person suffering from, or carrying a disease likely to be transmitted through food, is to be permitted to handle food or enter any food-handling area (CAC, 2003).

Small and Lues (2003) explained that food handlers must undergo medical examinations before employment to assess the general health of the food handler.

Dirty hands, workers clothes, and slaughterhouse equipment may act as intermediate sources of meat contamination. Accordingly, washing and sanitizing agents are effective in reducing bacterial population and the presence of pathogenic bacteria on carcasses (Gill, (2004b).

1.5. 14. 3. Hand washing:-

Hand washing is the removal of soil and transient microorganisms from the hands. Hand antisepsis is the removal or destruction of transient microorganisms (Larson, 1995). Degerming, or hygienic hand disinfection, referred to the reduction of

predominantly transient microorganisms with the use of germicidal agents or antiseptic detergent formulations (Cates *et al*., 2001).

Transient organisms are of concern because they are readily transmitted by hands unless removed by the mechanical friction of washing with soap and water, or destroyed by the use of an antiseptic solution (Larson, 1995). Hands, as well as contaminated gloves, serve as vectors for transmission of transient microorganisms (Fendler *et al*., 1998).

According to Miller *et al.*, (1994), transient bacteria cause great concern to the food service industry because these organisms are loosely attached to the surface of the skin and can easily contaminate food products if employees do not wash their hands adequately (Ansari *et al*., 1991).

Hand washing with plain soap should be sufficient to remove transient microflora from the hands of food service employees (Paulson, 1994). However, antimicrobial soap is statistically more effective in both immediate and residual properties. Increased friction by rubbing hands together or using a scrub brush allows for greater reduction of transient bacteria even with the use of plain soaps or detergents (Restaino and Wind, 1990).

1.5. 14.4. Protective clothing:-

Workers in the clean and dirty areas must be identifiable by different colored protective clothing so as to control the movement of personnel between these areas. This is required by the Red Meat Regulations (SA, 2004).

All employees working in the slaughterhouses must wear hair nets, should wash their hands before and after breaks, visits to the toilets and as necessary during production, clean and sanitize gloves, knives, aprons as necessary during production to minimize contamination and all equipment and tables are cleaned and sanitized throughout the day (Howlett *et al*., 2005).

Van Zyl (1995) proposed that the overalls, hairnets (beard nets if applicable), hard hats, gumboots, and aprons should at all times be worn by meat handlers**.**

1.5.14.5. Facilities for personal hygiene:-

Facilities for personal hygiene should include changing rooms, showers, flush toilets, hand-washing, and hand-drying facilities in the appropriate locations, and separate areas for eating; and protective clothing that can be effectively cleaned and minimizes accumulation of contaminants. All areas, in which exposed meat may be

present, should be equipped with adequate facilities for washing hands that: are located convenient to workstations; have taps that are not operable by hand; supply water at an appropriate temperature, and are fitted with dispensers for liquid soap or other hand cleansing agents; include hand drying equipment where necessary and receptacles for discarded paper towels; and have wastewater ducted to drains (Brendan *et al*., 2006). Current guidelines recommended that there should be at least one toilet and one wash-hand basin for every fifteen male employees and one toilet and one wash hand basin for every ten female employees (Anon, 1997).

1.6. Food safety:-

Food safety" is defined according to Codex Alimentarius Commission as the assurance that food will not harm the consumer when it is prepared and/or eaten according to its intended use (CAC 2003).

Food safety is the utilization of resources and strategies to ensure that foods are properly produced, processed, and distributed so they are safe for consumption.

Food safety is related to the presence of food borne hazards like chemical, physical, and biological hazards in food at the point of consumption (Jevsnik *et al*. 2008a).

A food supply chain is a network of food-related business involved in the creation and consumption of food products, where food products move from farm to table (Selvan, 2008). The introduction of food safety hazards can occur at any stage of the food chain and adequate control throughout the food chain is indispensable (Jevsnik *et al.* 2007)

To ensure that food is safe for human consumption, it should be produced according to the following criteria: it should meet all food safety requirements appropriate to its intended end use; it should meet risk-based performance and process criteria for specified hazards, it should not contain hazards at levels that are harmful to human health (FAO/WHO, 2005[1]) and it should be produced in accordance with Good Manufacturing Practices (GMP), Good Hygiene Practices (GHP),Sanitary Standard Operating Procedures (SSOP), Hazard analysis and critical control point (HACCP) principles. Human capacity building in these areas should be achieved through training of slaughterhouse workers and upgrading meat production facilities, equipment and tools to keep pace with advancing food safety standards (Belk *et al*, 2001).

The main organizations with responsibility for food safety are the Food and Agriculture Organization (FAO), the World Health Organization (WHO), their Codex Alimentarius Commission (CAC) and the World Animal Health Organization (OIE). Food safety is partly addressed by other international organizations including the World Trade Organization (WTO), the United Nations Environment Program (UNEP), the Organization for Economic Cooperation and Development (OECD) as well as by a set of international mechanisms governing co-operation in food safety matters, such as the International Food Safety

Authorities Network (INFOSAN). At the international level, the Codex Alimentarius (FAO UN/WHO) provides guidance to governments in setting food safety regulations, while the International Organization for Standardization (ISO) establishes voluntary norms, from product specification to management systems (Henson and Humphrey 2009).

Motarjemi *et al.* (2001) described the creation of CAC in the period from 1961 to 1963. The aim of the Codex is to protect public health and to support balanced trade relationships in food with developing harmonized international food standards, guidelines, and codes of practice to protect the health of the consumers and ensure fair trade practices in the food trade.

Food safety point of view should be focused on knowledge, constant education, and exchange of information. "From farm to table" approach is a philosophy with an important goal: safe and healthy food for all consumers. With this aspect in mind, we are building the foundation for Good Life Practice (Raspor *et al*., 2013).

1.6.1. Safety management system (FSMS):

The concept of food safety management system (FSMS) consists of "food safety" and "management system" aspects and is based on prevention. However, we will never be able to completely prevent and measure food safety performance, so there is a need to have effective food safety system, which includes integration of various elements within food supply chain whereas communication within circle is crucial (Scott and Chen 2010).

The occurrence of intense globalization and food trade is having a major impact on food systems worldwide. Food systems are changing and are consequently resulting in consistent quality, enhanced safety, greater availability, and diversity of broad assortments throughout the year. Food quality and food safety have become a hot topic in mass media. Consumers have become increasingly concerned and demanding about the quality and safety of food they are eating. The increased demand for safer food has resulted in the development and introduction of quality management systems, which are used to control the quality and safety of products like standards and good practices (Raspor *et al.* 2013).

QMS refers to all activities that organizations use to direct, control, and coordinate quality, including formulating a quality policy, setting quality objectives, quality

planning, control, assurance, and improvement (ISO, (2005). Both aspects contribute to the overall performance of an FSMS (Raspor 2008).

Kirezieva *et al.* (2013) clearly elucidate FSMS which is the result of the implementation of available and relevant quality assurance guidelines and standards (like Codex Alimentarius, hygiene legislation, guidelines on good practices, BRC, IFS, etc.). At primary production, these FSMSs are a result of implementing good agricultural and hygienic practices, while, at processing and trade, the FSMS includes good manufacturing and hygienic practices and HACCP-based principles.

1.6.1.1. Quality assurance:-

Quality assurance is a modern term for describing the control, evaluation, and audit of a food processing system. It consists of the integration of all functions and processes within an organization in order to achieve continuous improvement of the quality of goods and services (Vasconcellos 2004).

Quality assurance' refers to all the planned and systematic activities implemented within the quality system and demonstrated as needed to provide adequate confidence that an entity will fulfill requirements for quality while 'Quality system' refers to the organizational structure, procedures, processes, and resources needed to implement quality assurance (FAO/WHO, 2005[2]).

Quality and safety control in abattoirs should aim to minimize the introduction of contaminants during slaughter, processing, and distribution. This can be achieved by implementation of sanitization practices, proper personal hygiene of meat handlers and use of antimicrobial interventions for inhibition of pathogen growth (Buncic *et al*., 2014).

Each quality assurance system is focused on particular one. For example, GMP and HACCP are especially developed to assure food safety (Hoogland *et al*., 1998)

Quality assurance systems like Hazard Analysis Critical Control Point System helps to ensure that meat produced from the abattoirs is of good quality and safe for human consumption. However, the effect of HACCP involves many hygiene programs to properly evaluate its effectiveness. (Milios *et al.,* 2014).

Main prerequisites for the correct implementation of quality control systems and HACCP include commitment, financial support and they should be built on a solid foundation of pre-existing safety programs (Milios *et al*., 2012).

1.6.1.2. Hazard Analysis Critical Control Point (HACCP):-

Safety control in abattoirs is very important since it is a highly labor intensive working environment and many workers are involved, handling carcasses at different stages. Due to increased incidences of food-borne outbreaks around the world, many countries have established quality inspection systems and regulations to be used in meat industries (Sofos, 2008).

The HACCP system is science-based and systematically identifies, evaluates and controls hazards that are significant for food safety. Food hazards can be microbiological, chemical or physical and these should be controlled throughout from processing to the end product (Buncic, 2006).

HACCP was jointly developed in the USA by the Pillsbury Corporation and the United States Army Laboratories as a system that would provide a degree of certainty that food was free from pathogens and toxins (Crossland, 1997).

HACCP system is based on seven principles: conduct a hazard analysis; identify the Critical Control Points (CCP); establish the critical limits; establish monitoring systems; establish corrective action; establish documentation concerning all procedures and records appropriate to these principles and their application; and establish verification procedures (CAC, 1997).

HACCP is a preventative control system where hazards are identified, critical control points (CCPs) are determined and the methods for control and compliance are clearly specified (Kinsella *et al*., 2006).

International standard (ISO) 22000 and most other HACCP guides specify that there are other prerequisites necessary before HACCP plans should be developed, including appropriate sanitation and hygienic practices and assembly of a multidisciplinary HACCP team, identification of products, process flow diagram, and controls already practiced. The decision tree technique should be used to identify CCPs followed by the prescription of corrective measures that should be implemented to control biological hazards. Misidentification of CCPs in a HACCP plan may render the prescribed standard operating procedures ineffective, resulting in a HACCP system that may give variable and inadequate control over microbiological conditions of raw meat (Bryant *et al*. (2003).

Some of the programs which work hand in hand with HACCP include the Hygiene Management System (HMS), Good Manufacturing Programs (GMP), Hygiene

Assessment Systems (HAS) and Quality Management Systems (QMS) (DAFF, 2010).

According to Milios *et al*. (2012), the implementation of HACCP in the food industry is difficult since this system is based on scientific facts and not human perceptions. Its success requires inputs from different fields such as food engineering, food technology, microbiology and health (Milios *et al*. 2012).

The implementation of HACCP systems at abattoirs has to be preceded by the establishment of microbiological data specific to the abattoir for the objective assessment of risks (Wagude, 1999).

Reports from Zweifel *et al*., (2014) and Adams (2014) states that proper implementation of the HACCP systems should be based on measurable parameters like microbiological data gathered from different food industries during validation of the system.

The microbiological results should be evaluated over a certain period and compared with standards set by the legislation (Buncic *et al.,*2014). Microbiological parameters which have been used as indicators of poor hygiene in abattoirs include *Salmonella*, *Enterobacteriaceae, E. coli* and fecal *streptococci* and Total Viable Count (TVC) (Kramer, 2000). However, most common meat pathogens associated with food-borne illnesses are *E. coli* 0157: H7, non 0157 STEC *E. coli, Staphylococcus aureus* and *Salmonella* (Lasok and Tenhagen, 2013).

1.6.2. Food Safety Legislations and Standards:-

Whenever possible and practical, competent authorities formulate food safety objectives (FSOs) and related standards according to risk based-approach so as to objectively express the level of hazard control that is required to meet public health goals. Thus, competent authorities should have the legal power to set and enforce regulatory meat hygiene requirements, and have the final responsibility for verifying that regulatory meat hygiene requirements are met both for local consumption and export purposes (FAO, 2004).

Acts and regulations associated with safe, wholesome meat production give a clear guideline to producers and all those in the meat production chain on expected quality of meat and meat products by different government institutions involved (DAFF, 2012).

The legal frame for food safety in Sudan started with the Public Health Act (1939) which deals with food hygiene issues. The Act delegated the responsibility of food inspection to the MOH (Directorate of Environmental Health and Food control), in 1973 the Food Control Act (1973) was passed by the National Assembly and in accordance with this Act the MOH issued the necessary regulations such as General Health Requirements of Food Processing Establishments (1977). Food-borne disease surveillance is also carried out by the MOH (Department of Epidemiology). (Mustafa and Hamad, 2016).

Food standards first emerged and proliferated in rich countries but are spreading rapidly in developing countries (Swinnen, 2005). Standards make things work, because besides ensuring quality, safety, and efficiency they give global specifications for products, services, and systems with the aim of facilitating international trade. Standards take the form of technical specifications, terms and definitions, and principles through which goods are categorized or included in products' grouping (Jones and Hill 1994).

The Sudanese Standards and Metrology Organization (SSMO) were established in the year 1992 and since then it has taken over the full responsibility of issuing all commodity standards including food. SSMO also enforced the 2008 Act, which gives the organization the power to inspect all food commodities produced locally, as well as imported or exported foods. Certification audits for management systems, products, and food safety are provided on demand by SSMO.

Inspection for the safety of inputs and food safety establishments is undertaken by MOH, SSMO, MOI, and MOAR. (Mustafa and Hamad, 2016).

1.6.2.1. Sudanese standards for red meat by (SSMO):-

a)Public needs:-

The animal's carcasses (the source of fresh or chilled meat) should:

1. be free from epidemic and infectious diseases and from radiation according to the international standards applicable in this regard.
2. Prove that they are never treated with hormones for growth.
3. It is absolutely free of antibiotics and drugs when slaughtered.
4. Be slaughtered according to Islamic law according to the Sudanese standards.
5. Be slaughtered in the places (slaughterhouse) specified by the official bodies under the supervision of a veterinary inspector.

6. Be processed immediately after the slaughter, and the processing is intended to remove the skin, head, viscera and limbs, then washing and cooling.
7. The carcasses should be stamped for human consumption and should therefore be used as permissible, non-counterfeit and dyes that are not harmful to health.
8. The carcass should be cut and packed (if necessary) quickly, keeping in mind the sanitary rules.
9. In case of carcass parts (quarters / halves), chilled or frozen, the membrane and lymph nodes should be retained and no part removed may be inhibited for veterinary re-examination.
10. In case of chilled meat, it is required to be cooled immediately after slaughter to reach the temperature of the central range from (-1 to less than 5^0C).
11. In case of frozen meat, it must be frozen at a temperature not exceeding (-18 ^{0}C) and be frozen within three days at most from the date of slaughter.

b) Special requirements

1. Meat must be preserved in all their distinctive qualities and free from any strange odors.
2. Meat should be free from viscosity or any fungal growth or any signs of spoilage
3. No separate intracellular liquid is allowed in chilled or frozen meat packages.
4. Nitrogenated substances should not exceed 20 mg / 100 g of nitrogen sample.
5. Fatty acids in fat (estimated as Oleic acid) should not exceed 1.5% by weight.
6. Hydrogen ion concentration (PH) should be in chilled and frozen meat in the range of (5.6-5.7).
7. Thioparbituric acid should not exceed 0.9 mg / kg of mononaldehyde.
8. Meat must be free of parasites and its excretions.
9. Meat should be free from *Salmonella* and *Shigella* at 2.5 g.
10. The bacterial total number should not exceed one million (10 ^{6} CFU / g) per colony
11. It should be free of *Closteridium perpergens* and *Listeria monocytogenes*
12. Meat must be free of *Staphylococcus aureus* and its toxins.
13. Remnants of chemicals, drugs, natural organic hormones and remnants of fungal toxins should be found within the limits permitted by the Food Codex Allimentares.

c) Packing:

When packing the following must be considered:-

1. Packing and packaging materials must be stored in a healthy manner to prevent contamination and in refrigerated rooms at temperatures of less than 5^0C.
2. Packaging materials should not leave any toxic or harmful residue on the meat or cause contamination with any unwanted material.
3. The carcass or its parts must be covered with a clean cloth dampened with water or with any packaging materials allowed to be used.
4. In case of frozen meat or chilled in the form of small pieces it should be packed in polyethylene or any other material allowed to be used and then put in secondary packaging of wax-lined carton.
5. Packing or packaging shall be sufficient to achieve full protection of the meat products from pollution, transport or storage.

d) Supply and trading

The supply and handling shall be according to the standard Sudanese Standard No. 3909/2007 concerning the transfer and handling of meat.

f) Storage: -

Must be taken into account when storing carcasses and chilled and frozen meat
1. Do not exceed the storage capacity of refrigerators when storing chilled or frozen meat.
2. The carcasses (whole / half) shall be suspended when refrigerated storage.
3. Ventilation should be adequate during storage.
4. The temperature of the refrigerator must be regular.

g)Validity period

1. Carcasses and chilled meats must be stored at temperatures between 0 to - 4 ^{0}C and refrigerated at -1 to less than 5^0C in a period not exceeding 4 days of slaughter.
2. The carcasses and frozen meat should be stored at temperatures of no more than -18 ^{0}C and should be marketed within a period not exceeding 6 months from the date of freezing and 9 months at a temperature of not more than -24 ^{0}C and 12 months at a temperature of -30 ^{0}C.

h)Data:

The preamble should include the following data:
1. Type of meat animal.

2. Date of slaughter and expiry date (day / month / year), carcasses and parts Date of production and expiration of different parts (day / month / year)
3. Conservation and trading requirements.
4. Net weight when packing.
5. Sudan production term-country of origin
6. The terms slaughtered in accordance with Islamic law or (halal) (SSMO, 2008).

1.6.2.2. Quality requirements of importing countries:-

Several countries in the Middle East, the main destination of Sudanese export sheep and sheep meat, are upgrading their SPS standards for import of live animals and animal products to international standards. Saudi Arabia has preference for Sudanese sheep and sheep meat because the products meet specific quality and safety characteristics. Enforcement of quality regulations is the responsibility of the Saudi Ministry of Agriculture and Water. Quality requirements of Egypt although not major importer, is also discussed as this country is potential export destinations for Sudan. Mariner (2007) gave a more detailed account of the dynamics of demand for meat and live animals and SPS requirements in selected importing countries in the Middle East.

1.6.2.2.1 .Saudi Arabia:-

Importers of meat in Saudi Arabia require the following documents:

• Health certificate from the federal veterinary authorities indicating the results of ante and post-mortem examinations and certifying the meat to as originating from disease free animals and fit for human consumption.
• Certificate of origin authorized by the Sudan Chamber of Commerce and countersigned by the Saudi Embassy in Khartoum.
• Commercial invoice giving details of the shipment.
• Bill of lading
• Carcass label that indicates: names and addresses of the exporting and importing companies; date of slaughter; types of meat and carcass temperature.
• Certificate ratified by the Saudi Consulate or its authorized representative, or issued by a recognized Islamic centre or organization declaring that the animals were slaughtered in a licensed abattoir in accordance with Islamic procedures; each carcass must bear a stamp indicating that it was slaughtered under the supervision of the centre or organization.

The veterinary health certificate, certificate of origin and commercial invoice are countersigned by the Saudi Embassy in Khartoum. Table 5 summarizes the regulations governing the maximum allowable interval between slaughter of the animals and arrival of the meat products in Saudi Arabia, the recommended storage temperatures and the shelf life of the chilled and frozen meat products.

Table (1.3) Regulations governing the duration between slaughter and import, storage temperatures and shelf life for meat exported to Saudi Arabia:-

Product	**Type**	**Maximum allowable interval between slaughter and arrival**	**Shelf life**	**Storage Temperature(^{0}C)**
Chilled meat	Carcasses	10 days	4 weeks	-2 to 0
	Vacuum packed	40 days	10 weeks	-2 to 0
Frozen meat		4 months	10 months	Below -18

Source: Ibrahim (2004).

1.6.2.2.2 .Egypt:-

The Egyptian market stipulates the following regulations and requirements for imports chilled bone-in-beef from Sudan.

Requirements for import of chilled bone-in-beef

• Animals intended for slaughter should be quarantined for 21 days and tested for contagious diseases from the 16th day.

• Animals testing negative should be slaughtered in approved facilities.

• Only the fore and hind quarters shall be exported; the quarters shall be packaged in labeled cartons and stored at 0–2°C.

• Chilled bone-in-beef shall be deboned immediately upon arrival at the Cairo airport in one of the government deboning halls under supervision of veterinarians from the Public Corporation for Veterinary Services.

• A certificate of origin and copy of pro-forma invoice shall accompany the shipment.

Chapter Two

2. Materials and Methods

2.1. Study Area:-

Cross sectional study was conducted during September 2018 to January 2019 in an export slaughterhouse in Khartoum State and at Khartoum airport.

2.2. Bacteriology:-

2.2.1. Samples Collections:-

A total of 250 swab samples were collected, 130 samples from slaughterhouse and 120 from Khartoum airport.

Sheep and goats carcasses (n=80) were sampled at four sites (neck, forelimb, flank and hind limb) at different operational control points during the slaughter process (skinning, evisceration, washing and chilling) and at Khartoum air port (n=80) . Also, samples were taken from contact surfaces (50) included 10 from slaughterhouse water and samples from hands of the workers (n=40) in both slaughterhouse and at airport.

The swab was initially rubbed vertically for at least 5 seconds, then horizontally and finally diagonally in an area of 10 cm^2 for no less than 20 seconds, sufficient pressure has been applied. All samples from the rubbed sites and worker hands were placed separately in a cold box that had ice below 4° C but did not freeze.

Samples obtained with swabs were transported to the laboratory of the microbiology in the University of Sudan, College of Veterinary Medicine for microbial analysis within 24-48 hours of sampling.

2.2.2. Sample preparations:-

This was done according to Adzitey *et al.* (2014).The swabs were placed in 10 ml of sterile peptone water and shaken completely to obtain the pure product (10^{-1}). One (1) ml of pure liquid was transferred to 9 ml of sterile peptone water until a dilution of 10^{-6} was obtained. Serial dilutions (10^{-5} to 10^{-6}) were spread plated onto nutrient agar plates.

2.2.3. Determination of Total Viable Count (TVC): -

One ml of each dilution was added to a sterile Petri dish and the Agar plate count (maintained at 45°C in a water bath) was added and mixed carefully. The preparation

was then allowed to gel and finally incubated at 37°C for 24 hours and several colonies were counted and recorded, the number of colonies between 30 and 300 colonies was counted. The average counts obtained were multiplied by the dilution factor and expressed as the Colony Forming Unit per gram or cm^2 (C.F.U / cm^2) (Fawole and Oso, 2001).

2.2.4. Isolation and Identification of the Bacteria:-

The isolation and identification of *E.coli, Salmonella* and *S. aureus* was achieved by using selective media for each bacteria followed by Gram staining of presumptive colonies and standard biochemical tests (Cruikshank *et al*., 1975).

The isolation and identification of the bacteria were done as described by Barrow and Feltham (2003). The swab samples were cultured using prepared Nutrient Agar, Nutrient Broth, Deoxycholate Citrate Agar (DCA), Eosin methylene blue agar (EMB Agar) and Mannitol Salt Agar (MSA). The broth tubes and agar plates were incubated at 37^oC for 24 hours. Afterwards, the morphology of colonies on agar media were examined microscopically, smears were then made from clean slides fixed with heat and subjected to Gram stain and examined under oil immersion lens and the biochemical tests for species identification were conducted.

2.2.5. Subcultures:

The subcultures for all samples were made using Petri plate's nutrient agar when streaking with a wire loop. The plates were incubated at 37°C for 24 hours, and then the isolated colonies were subjected to different biochemical tests to determine the genus and species.

2.2.6. Gram staining:-

Gram staining was used to study morphology, form, and gram color reaction of each isolate.

A sterile handle was used to prepare the emulsion from a single colony in a clean slide. The smear was done and allowed to air dry and then fixed by passing the slide on the flame. The slide was placed on a shelf and Flooded with a crystal violet stain for two minutes, then washed with water and covered with Lugols
iodine for a minute, rinsed with water.

The stain has been decolorized with acetone or 70% alcohol, the slide was counterstained with carbol fuchsine diluted for one minute, rinse with water and allow to dry in air or dry with a filter paper. The slide was examined under a

microscope with a magnification (100x) using an immersion lens in oil. The bacteria considered Gram-positive took the violet color, while those considered Gram-negative have taken on the red color Barrow and Feltham (2003).

2.2.7. Biochemical tests:-

The purified isolates were identified by applying biochemical tests as described by Barrows and Feltham (2003).

2.2.7.1. Catalase test:-

A drop of 3% aqueous solution of hydrogen peroxide was placed on a clean slide. A test of culture colony, on nutrient agar, was placed on hydrogen peroxide. The test was considered positive when gas bubbles appear on the surface of the culture.

2.2.7.2. Oxidase test:-

Pieces of filter paper were soaked in freshly prepared 1% a solution of tetramethyl-p-phenylenediamine dihydrochloride. After draining for 30 seconds, the papers were dried in the oven and stored in dark screw-capped bottles.

The test was performed by placing the impregnated dry filter paper strip in a clean Petri dish and then moisten with DW.A small amount of fresh test culture was spread on the dampened strip. When the dark purple color developed in 5-10 seconds, the reaction was considered positive.

2.2.7.3. Sugar fermentation test:-

The peptone water sugar was prepared as described above and it has been inoculated with the test culture; the tube was incubated. The reddish color indicated the production of acid, while the production of gas was
indicated by the development of an empty space in the Durham tube.

2.2.7.4. indole test:

The Peptone water medium was inoculated with test culture and incubated at 37
° C for 48 h. One ml of the Kovac reagent was administered by the side of the tube. When a pink ring appeared in the reagent layer within a minute, the test was considered positive.

2.2.7.5. Voges Test -Proskauer (v.p):

The glucose phosphate medium, prepared as described above, was inoculated with the organism under test and incubated at 37 °C for 48 h, and then 1 ml of 5% alcoholic solution of alpha-naphthol and 0.2 ml of 40% potassium hydroxide (KOH)

was added. The mixture was shaken, placed in an inclined position, examined after 15 minutes and an hour.

A positive reaction was indicated by a bright pink color as the result of the production of acetyl methyl carbinol (acetone).

2.2.7.6. Methyl red test:

Ten ml of glucose phosphate broth were inoculated with a pure culture of the organism in question. The inoculated broth was incubated at 37 ° C for 48 hours or at 30 ° C for 72 h. Some drops of 0.04% of methyl red solution was then added. When the red color appeared, the reaction was considered positive and when the yellow color appeared, the reaction was considered negative.

2.2.7. 7. Hydrogen sulfide production:

The testing culture was inoculated in an aqueous medium of peptone and filter paper impregnated with a 10% lead acetate solution was placed in the the neck of the tube and is incubated at 37 ° C and examined every day for 7 days. The blackening of the paper indicated a positive reaction.

2.2.7. 8. Urease Test:

The test organism was streaked on the base slope of the prepared urea agar as described above and incubated at 37 ° C for two days. A positive reaction was indicated by a change in color to pink.

2.2.7. 9. Citrate utilization test:

The Simmon citrate medium, was used either as slopes in test tubes or as a plate medium in Petri-dishes. In both cases, the surface of the medium is slightly inoculated by streaking and when slopes were used, the butt of the medium was inoculated by Stab. The inoculated medium was incubated for 48 hours at 37 ° C.

Positive growth produced an alkaline reaction and changed the colors of the medium from bright green to blue which indicated the use of citrate, while in a negative test, the color of the media remains unchanged which indicates that citrate has not been used.

2.2.7. 10. Kligler iron agar (KIA)

The medium of different organisms, prepared from dehydrated powder ready for use. The medium was used at a concentration of 5.5 g per 100 ml of distilled water and the bubbles in the middle indicated the production of gas by glucose fermentation. The gas was the production of fermentation of lactose and glucose

(dextrose) and the hydrogen sulfide production. Organisms that can ferment glucose produce a red slant.

2.2.7. 11. Motility test:

The testing culture was inoculated with a straight loop at a depth of 5ml in the central of the motility Craigie tube containing semi-solid agar and incubated at 37 °C for 24 hours. The organism is considered mobile if there was turbidity in the middle inside and outside Craigie's tube, while the the growth of non-mobile organisms has been confined within the Craigie tube (Barrow and Feltham, 2003).

2.2.8. Isolation of bacterial pathogens:

This was done by applying streaking on selective media for the most common bacterial pathogens of meat. These include *Salmonella spp., s E. coli*, and *Staphylococcus aureus*.

2.2. 8.1. Detection of *Salmonella spp*:-

Table (2.1): Biochemical reactions of *Salmonella spp*.:-

Test/substrate	**Results**		***Salmonella spp.* reaction**
	Positive	**Negative**	
Urease	No color change	Change to pink	-
Indole	color change	No color change	-
Hydrogen sulfide	Blackening	No blackening	+
Citrate	Change color and turbid medium	No change color and turbid medium	+
Kliger iron agar (KIA)	color change	No color change	F
Catalase	Release of oxygen bubbles	No release of oxygen bubbles	+
Oxidation-fermentation	Fermentative (F)	Oxidative (O)	F
Motility	Turbidity	No turbidity	+
Oxidase	Color on reagent paper	No color on the reagent paper	-
Voges –proskauer (v.p) test			-
Methyl red test			+

KEY: + Positive

- Negative

2.2. 8.2. Detection of *Staphylococcus spp*:-

Table (2.2): Biochemical reactions of *Staphylococcus aureus*: -

Substrate	**Test Results**
Gram stain	Positive
Catalase	Positive
Coagulase	Positive
Mannitol sugar	Positive

2.2. 8.3. Detection of *Escherichia coli*:-

Table (2.3): Biochemical reactions of *Escherichia coli* carcasses samples:-

Test/substrate	**Results**		***Escherichia coli.* reaction**
	Positive	**Negative**	
Urease	No color change	Change to pink	-
Indole	color change	No color change	+
Hydrogen sulfide	Blackening	No blackening	-
Citrate	Change color and turbid medium	No change color and turbid medium	-
Kliger iron agar (KIA)	color change	No color change	+
Catalase	Release of oxygen bubbles	No release of oxygen bubbles	+
Oxidation-fermentation	Fermentative (F)	Oxidative (O)	F
Motility	Turbidity	No turbidity	+
Oxidase	Color on reagent paper	No color on the reagent paper	-
Voges –proskauer (v.p) test			-
Methyl red test			+

KEY: + Positive

- Negative

2.3. Knowledge, attitudes and practices questionnaire (KAP):

A Knowledge attitude and practice (KAP) survey is a representative study of a specific population to collect information on what is known, believed and done in relation to a particular topic (WHO, 2008). A KAP survey is a quantitative type method by interviewing through the use of a structured, standardized questionnaires and statistical method for collected information. It serves as an educational diagnosis of the community. A KAP survey is widely used to gather information through various types of cross-sectional surveys that planning public health programs (Launiala, 2009).Various KAP surveys related to food safety among food handlers were carried out worldwide (Haileselassie *et al*., 2013; Jianu and Goleţ, 2014).

The target population of this study was the 40 workers selected randomly in an export slaughterhouse in Khartoum state.

The purpose is to evaluate to knowledge, attitude and practice with regard to hygiene among slaughterhouse workers. Knowledge, attitude, and practice were determined by the use of structured interview and through direct observations of the hygienic status and practices by slaughterhouse workers.

Individual verbal consent was obtained from the respondents prior to data collection and permission for data collection was taken from Ministry of Animal Resources. The study was approved by Sudan University of Science and Technology.

2.3.1. Data Collection:-

The questionnaire consists of four parts; the first part of the collection were information about the socio demographic characteristics of the respondents such as; sex, age, educational level, years of working experience, and occupation.

The second part consisted of questions covering the aspects of knowledge that involved; training, frequency of the training and the knowledge about food safety and contamination.

The third part covered the aspects of attitude of the respondents toward hygiene, the last part consisted of practices which include health certificate, wearing of protective cloth, cleaning of protective cloth, eating, drinking smoking or snuffing during work.

The questionnaire was designed in Arabic. About 20 minutes were spent to interview each respondent.

2.4. Data analyses

2.4.1. TVCs analysis

The data were analyzed using the software Statistical Package for the Social Sciences version 23.0 (SSPS Inc. and Chicago, IL, USA). All bacterial counts were converted to $\log^{10}$ cfu/cm^2 for analysis. Analysis of Variance (ANOVA) was performed to evaluate the differences in the levels of TVCs between the different operational points/critical control points. Moreover, the statistical significance was set at a p-value of ≤ 0.05.

2.4.2. KAP analysis:-

Regarding KAP survey a comparative analytical method is used to demonstrate the differences in food safety knowledge, attitude, and practice among workers in slaughterhouse. Chi-square test is used to study the association between practices of respondents ($P<0.05$) according to educational level, working experience, and professional training.

Chapter Three

3. Results

3.1. Bacteriology:-

3. 1.1. Bacterial Viable Count:-

Table 3.1 showed that, the highest mean of TVCs log values in the anatomical parts were on samples from flank regions which recorded 8.54±0.06 log^{10} cfu/cm^2 at skinning, 8.54±0.04log^{10} cfu/cm^2 at evisceration and 8.52±0.06 at washing.

Table (3.1).Mean ± Sd of Total viable counts (Iog^{10}cfu cm^2) on parts of the sheep and goats carcasses (n= 80) in an export slaughterhouse in Khartoum state:-

Site	Operation Points			
	Skinning	Evisceration	Washing	Chilling
Neck	8.43±0.53	8.45±0.09	8.42±0.05	8.47±0.08
Fore Limb	8.46±0.08	8.39±0.49	8.47±0.05	8.49±0.05*
Flank	8.54±0.06	8.54±0.04	8.52±0.06	8.49±0.06
Hind Limb	8.39±0.12	8.42±0.09	8.46±0.08	8.39±0.10

*= (Sig.) significant at level (P<0.05).

Table 3.2 showed that, the mean log values of the loader worker hands (8.44±0.06 Iog^{10}cfu cm^2) were higher than the slaughter house butcher hands (8.43±0.11 Iog10cfu cm^2).The highest mean log values on some contact surfaces sites of the slaughterhouse and some utensils were on samples from knives (8.51±0.02 Iog^{10}cfu cm^2) followed by the slaughterhouse floor (8.46±0.05 Iog^{10} cfu cm^2).

Table (3.2) Mean ± Sd of Total viable counts (Iog^{10}cfu cm^2) on some sites of the slaughterhouse and some utensils in an export slaughterhouse in Khartoum state:-

Site	Number	Mean±St.Dev.	Significance
Slaughter House Butcher Hands	10	8.43±0.11	NS
Loader Worker Hands	10	8.44±0.06	*
Slaughterhouse Walls	5	8.45±0.05	*
Meat Scales	5	8.42±0.10	NS
Slaughterhouse Floor	5	8.46±0.05	*
Slaughtering Knives	5	8.51±0.02	*
Slaughterhouse Water	10	7.49±0.09	NS

*= (Sig.) significant at level (P<0.05), NS= Not significant.

Table 3.3 showed that The highest mean log values on some contact surfaces sites at Khartoum air port were on samples from worker hands (8.21 ±0.12 Iog^{10} cfu cm^2) followed by the carcasses (8.15±0.22 Iog^{10}cfu cm^2).

Table (3.3) Mean ± Sd of Total viable counts (Iog^{10}cfu cm^2) of worker hands, van of meat and carcasses in export airport in Khartoum state:-

Site	Number	Mean±St.Dev.	Significance
Airport Worker Hands	20	8.21 ±0.12	NS
Airport Van of Meat	20	8.13 ±0.11	NS
Airport Carcasses	80	8.15±0.22	NS

NS= Not significant.

3. 1.2. Pathogenic bacteria:-

The study revealed three types of bacteria namely *E. coli, Salmonella spp* and *Staphylococcus aureus* with their frequency and percentages of contamination of the carcasses as shown in Table 3.4.The highest relative frequency of isolates was *Staphylococcus Aureus,* 67(41.10%), followed by *E. coli* 65(39.88%) and *Salmonella spp* 31 (19.02%).

Table (3.4) Number and frequency of bacteria isolated from different sites associated with meat for export in the slaughterhouse:-

Site	*E. coli*	*Salmonella spp*	*Staph Aureus*	Total
Skining	11(6.75%)	5(3.07%)	11(6.75%)	27(16.56%)
Eviceration	11(6.75%)	2(1.23%)	15(9.20%)	28(17.17%)
Washing	14(8.59%)	6(3.68%)	10(6.13%)	30(18.40%)
Chilling	7 (4.29%)	5(3.07%)	13(7.98%)	25(15.34%)
B.hands	6(3.68%)	2(1.23%)	8(4.91%)	16(9.81%)
Up.hands	7(4.29%)	2(1.23%)	1(0.61%)	10(6.13%)
Walls	3(1.84%)	1(0.61%)	3 (1.84%)	7(4.29%)
Scales	2(1.23%)	2(1.23%)	3 (1.84%)	7(4.29%)
Floor	0(0%)	5(3.07%)	1 (0.61%)	6 (3.68%)
Knives	4(2.45%)	2(1.23%)	1 (0.61%)	7(4.29%)
Water	0(0%)	0(0%)	0(0%)	0(0%)
Totals	65(39.88%)	31(19.02%)	67(41.10%)	163(100%)

Table 3.5 showed that, the highest relative frequency of isolates at Khartoum airport was *Staphylococcus Aureus,* 86 (71.7), followed by *E. coli* 46 (38.0) and *Salmonella spp*11 (9.2).

Table (3.5) Number and frequency of bacteria isolated from different sites associated with meat for export in Khartoum airport:-

Sampling sites	**At Airport**		
	E.coli	***Salmonella spp***	***Staph Aureus***
Carcasses	32 (40.0)	7 (8.8)	58 (72.5)
Hands of worker	7 (35.0)	0 (00.0)	15 (75.0)
Contact surfaces	7 (35.0)	4 (20.0)	13 (65.0)
Total	46(38.0)	11(9.2)	86(71.7)

3. 2. KAP questionnaire:-

Table 3.6 showed that all of the slaughter men interviewed were males. The majority of them 60.0% were between the ages of 20 and 30 years. 40% of them were graduates, and 42.5% of the slaughter men have been working 1-5 years .In addition, 65% of the participants were workers.

Table (3.6): Demographic characteristics of respondents (n=40) in an export slaughterhouse in Khartoum state:-

Demographic characteristics		**Percentage %**
Age	20-30 years	24 (60.0)
	31-40 years	7 (17.5)
	41-50 years	7 (17.5)
	More than 50 years	2 (5.0)
	20-30 years	24 (60.0)
Educational level	Illiterate	2 (5.0)
	Primary school	11 (27.5)
	Secondary school	11 (27.5)
	Graduated	16 (40.0)
Working experience	Less than a year	8 (20.0)
	1-5 years	17 (42.5)
	More than 5 years	15 (37.5)
Occupation	Butcher	9 (22.5)
	Worker	26 (65.0)
	Technician	5 (12.5)

Figure (1) showed that a relatively smaller proportion 35.0% of workers from the slaughterhouse had received professional training on meat safety and hygiene before being employed.

Figure (3.1) Distribution of participants with respect to number of formal training received (n=40) in export slaughterhouse in Khartoum state:-

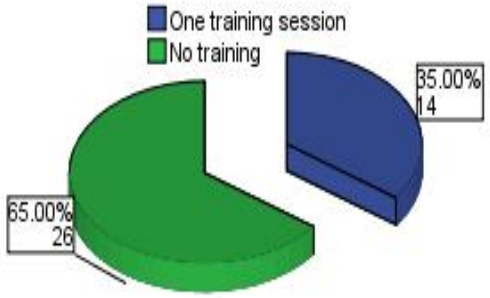

Figure2 Showed that the slaughter men who attended the training , most had received only one training session, the last session was more than 1-2 years ago, no refresher or updating courses were offered.

Figure (3.2): Distribution of participants with respect to last formal training received (n=40) in export slaughterhouse in Khartoum state:-

Table 3.7 revealed that the majority of the respondents had acceptable level of knowledge about their personal hygiene responsibilities to reduce the risk of the contamination by wearing protective clothes 95%, Washing hands regularly 100%, and proper cleaning and handling of instruments 100%.

The study showed that 90% of the respondents said that food contaminated by poisoning bacteria can be identified by taste or smell. About 77.50% thought that everyone to be at equal risk of food poisoning. 65% of the participants known that diarrhea is unacceptable health problem in work.

Table (3.7): Distribution of participants with respect to food safety knowledge (n=40) in export slaughterhouse in Khartoum state:-

Questions regarding food safety knowledge	Answers of participants		
	True	False	I don't know
Wearing protective clothes (a cap, apron, mask, gloves, and boots) is part of your personal hygiene responsibilities.	38 (95%)	1 (2.50%)	1(2.50%)
Wearing protective clothes (a cap, apron, mask, gloves, and boots) reduces the risk of contamination.	38(95. %)	1(2.50%)	1(2.50%)
Washing hands regularly is part of your personal hygiene responsibilities and can reduce the risk of contamination.	40(100 %)	0(0%)	0(0%)
Proper cleaning and handling of instruments reduces the risk of contamination.	40(100%)	0(0%)	0(0%)
Food contaminated by food poisoning bacteria can be identified by taste or smell.	36(90%)	2(5%)	2(5%)
Diarrhea does not affect the job and it is not necessary to take leave from work.	12(30%)	26(65%)	2(5%)
Everyone is at equal risk of food poisoning.	31(77.50%)	7(17.50%)	2(5%)

Table 3.8 showed that all participants 100.00% were agreed that safe meat handling is an important part of their job responsibility, training for workers was important to reduce contamination, knowledge will benefit their personal life and were agreed that they will change their meat handling behavior when know it is incorrect.

The majority of the respondents agreed that good personal hygiene could prevent food borne illness 97.50%, health status of the workers should be evaluated before employment 97.50% and knives can transfer diseases 92.50%.

Most of the respondents 72.50% thought that washing hands and knives with water was clean enough to get rid of the bacteria

About 90.00% of respondents agreed that It is necessary to check the temperature of the refrigerator to reduce risk of contamination, and 95.00% agreed that food borne diseases have harmful effects on both health and economic of the society.

Regarding health certificate the study showed that 67.5% of the participants had a valid health certificate, 35% of the participants renewed their health certificate every 6 months, while 32.5% of them renewed it annually.

Table (3.8): Distribution of participants with respect to food safety attitude (n=40) in an export slaughterhouse in Khartoum state:-

Questions regarding food safety attitude	Answers of participants		
	Agree	Disagree	I don't know
Safe meat handling is an important part of my job responsibility.	40(100.00%)	0(0.00%)	0(0.00%)
Food hygiene training for workers is an important issue in reducing the risk of food contamination.	40(100.00%)	0(0.00%)	0(0.00%)
I will change my meat handling behavior when I know it is incorrect.	40(100.00%)	0(0.00%)	0(0.00%)
Food safety knowledge will benefit my personal life and the consumer.	40(100.00%)	0(0.00%)	0(0.00%)
Good personal hygiene can prevent food borne illness.	39(97.50%)	1(2.50%)	0(0.00%)
Health status of the workers should be evaluated before employment.	39(97.50%)	1(2.50%)	0(0.00%)
Knife can transfer diseases.	37(92.50%)	3(7.50%)	0(0.00%)
Washing hands and knives with water is clean enough to get rid of the bacteria.	29(72.50%)	10(25.00%)	1(2.50%)
It is necessary to check the temperature of the refrigerator to reduce risk of contamination.	36(90.00%)	4(10.00%)	0(0.00%)
Food borne diseases have harmful effects on both health and economic of the society.	38(95.00%)	1(2.50%)	1(2.50%)

In table 3.9 most of the respondents were wearing caps 52.50 %, apron 60.00%, gumboot 77.50% and dress clean clothes 92.5% during the work .Whereas, all of them were not eating, drinking, smoking or snuffing in the workplace.

Table (3.9): Distribution of participants with respect to food safety practice (n=40) in export slaughterhouse in Khartoum state:-

Questions regarding food safety practice	Answers of participants		
	Always	Sometimes	Never
How often do you use a cap at work?	21(52.50%)	15(37.50%)	4(10.00%)
How often do you use a mask at work?	12(30.00%)	19(47.50%)	9(22.50%)
How often do you use an apron at work?	24(60.00%0	7(17.50%)	9(22.50%)
How often do you use gloves at work?	14(35.00%)	15(37.50%)	11(27.50%)
How often do you use Gumboots at work?	31(77.50%)	8(20.00%)	1(2.50%)
How often do you clean working clothes?	37(92.50%)	0(0.00%)	3(7.50%)
How often do you eat or drink at your workplace?	0(0.00%)	0(0.00%)	40(100.00%)
How often do you smoke or use snuff during work?	0(0.00%)	0(0.00%)	40(100.00%)

Chapter Four

4. Discussions:-

To prevent the occurrence of food borne illnesses and possible meat spoilage, it is important to ensure that foods are safe and in good hygienic conditions. The microbiological testing for different indicators such as *Salmonella*, coliforms and *E. coli* can be performed at different sites of the carcass surface (Buncic *et al*., 2014). Recommended parts including the rump, brisket, thigh, flank, and shoulders. Sampling should be performed at different stages during the slaughter process that is; after pelt removal, skinning, evisceration and pluck removal, washing, chilling and on the final product ready for redistribution to retailers (Lasok and Tenhagen, 2013).According to (Capita *et al*., 2004; Zwivel *et al.,* 2005), for practical and economic reasons, the swab technique is the most used method for sampling the carcass surface.

Total plate count was used to measure the general bacteria load on meat and is a useful tool in monitoring food safety. The results may reflect the hygienic level of food handling and retail storage. According to Sudanese standards for red meat the bacterial total number should not exceed one million (10^6 CFU / g) per colony (SSMO, 2008), and According to FAO (2007), Total viable plate count numbers exceeding 100 000/g (5.0 $\log^{10}$) on fresh meat are not acceptable and alarm signals, and meat hygiene along the slaughter and meat handling chain must be urgently improved. These standards from Sudanese and FAO were lower compared to the results found of the present study and hence these counts put the consumers at risk.

The bacterial counts of the carcasses in the present study ranged from 8.39±0.10 $\log^{10}$ cfu/cm^2 and 8.58±0.06 ($\log^{10}$ cfu/cm^2) were generally high above 10^7 where spoilage of meat occurs (Warriss, 2001), and above the International Commission on Microbiological Specification of Food (ICMSF, 1988) (<$1.0x10^6$cfu/g).

The higher counts could be due to the unhygienic practices followed during the meat handling and processing. In the present study, the highest mean log values in the anatomical site were on samples from flank region which recorded (8.54±0.06 $\log^{10}$ cfu/cm^2) at skinning, 8.54±0.04$\log^{10}$ cfu/cm^2 at evisceration and 8.52±0.06 at washing. Similar to this study Zweifel and Stephan (2003) noted that the neck and flank had the most increased contamination levels. This also agreed with Bekker

(1998) who indicated that washing of the carcasses with cold water does not significantly influence the microbiological load on beef carcasses. The high TVCs obtained from environmental contamination in abattoir is from slaughtering knives (8.51 ± 0.02 $\log^{10}$ cfu/cm^2) followed by slaughterhouse floor (8.46 ± 0.05 $\log^{10}$ cfu/cm^2) and this is an indication of ineffective and inadequate cleaning of floor before commencement of work and at the close of work, this is similar to Bhandare *et al*. (2009) who found higher levels of environmental contamination on abattoir floor.

Regarding the pathogenic bacteria, the microbiological profile in meat products is the key criteria for determining quality and safety of fresh produce. Ideally, meat should be considered as wholesome when pathogens of concern are absent or if present should be at low number depending on their toxin or metabolites produced (Biswas *et al*., 2011).

Bacteria including *Staphylococcus aureus, E. coli* and *Salmonella spp* are the causes of 60% of food borne illness requiring hospitalization in the United States and about 2.1 million children in developing countries die of diarrheal- related illnesses annually (WHO, 2009).In this study, the microbiological examination of carcasses revealed the presence of *Salmonella* spp*, E.coli* and *Staphylococcus aureus* in all stages of processing (skinning, evisceration, washing, chilling and at the airport).At the slaughterhouse the highest relative frequency of isolates was *Staphylococcus Aureus,* 67(41.10%), followed by *E. coli* 65(39.88%) and *Salmonella* spp 31 (19.02%).The highest recorded levels with *E.coli* 6.75% were at washing and evisceration, the highest level with *Salmonella* 3.68% recorded at washing and that of *Staph Aureus* 9.20% at evisceration.

The occurrence of *Salmonella* was higher than National Advisory Committee on Microbiological Criteria for Foods (NACMCF,(1993) who reported that incidence rates of *Salmonella* on raw beef are generally low (about 5%). Similar results in which little or no isolation of *Salmonella* in carcasses have been recorded in other studies. For instance, Sofos *et al*. (1999) detected 3% *Salmonella* from 30 carcasses in the United States.

The incidence of *E.coli* and *Salmonella* could be attributed to the poor cleaning and sanitary conditions in the abattoirs puncture of the viscera resulting in spread of infection and an increase in contamination of carcasses by fecal matter and to the poor handling by butchers, storage and environmental conditions.

Staphylococcus spp. was isolated from the majority of the samples and this agreed with studies done by other researchers who also found a high prevalence of *Staphylococcus aureus* in raw meats (Soyiri *et al*., 2008; Ahmad *et al.,* 2013).
The high prevalence of *Staphylococcus spp*. is an indication of contamination from meat handlers.
For providing hygienic meat and meat products, maintaining high standard of hygiene in the abattoir is a matter of paramount importance. This maintained by continuous monitoring to establish a hygiene base and to ensure the quality of the products (Sofos, 1994), besides imposing the hazard analysis critical control points system (HACCP) is a matter of great importance.
Regarding K.A.P questionnaire the results revealed that all of the slaughter men interviewed were males. The majority of them 60.0% were between the ages of 20 and 30 years, 40% of them were graduates, and 42.5% of the slaughter men have been working 1-5 years .In addition, 65% of participants were workers.
Information regarding the training of the interviewed workers showed that a relatively smaller proportion 35.0% of workers from the slaughterhouse had received professional training on meat safety and hygiene before being employed, those who attended the training most of them had received only one session, the last session was more than 1-2 years ago, no refresher or updating courses were offered.
Morrone and Rathbun (2003) indicated that risks along the food chain can be minimized through educate consumers and workers on food safety. Without the knowledge of food safety practices and food handling procedures, food borne illnesses cannot be reduced. Redmond and Griffith (2003) reported that to ensure this, there should be some form of introductory training with regular updating and refresher courses for food handling. Meat handlers must also understand the risks associated with food contamination by microbiological agents, and should be able to prevent meat contamination (Adams and Moss, 1997). Educational levels and training of meat handlers regarding basic concepts of meat safety and personal hygiene plays a vital role in ensuring that the consumers are provided with safe and wholesome products (Jianu and Golet , 2014). In addition to this regular updating and refresher courses should be carried on more frequently. This will help the meat handlers to have a better understanding of risks associated with contamination of food with microbiological pathogens and sanitation practices (McIntyre *et al*., 2013).

In the present study the majority of the respondents (Table 3.7) have acceptable level of knowledge about their personal hygiene responsibilities to reduce the risk of the contamination .However; there is a gap of Knowledge concerning poisoning bacteria, diarrhea as unacceptable health conditions and vulnerable groups at risk, The majority of the participants 90% believed that they could determine if food was contaminated with food poisoning bacteria by taste, smell and olfactory checks, they were unaware that food which looked, smelt and tasted normal could cause food poisoning. Similarly, 60% of food handlers assumed the same in studies by Walker *et al.* (2003), 51% by Gomes-Neves *et al* .(2011) and 50% by Jevsnik *et al.* (2008b). Misconceptions, therefore, exist regarding the terms food spoilage and food poisoning. Food spoilage organisms are not necessarily pathogenic, but damage the quality of food, reduce shelf life and in some cases can cause illness. Gram *et al.* (2002) stated that microbial food spoilage manifested itself as visible growth and food textural changes. Spoilage bacteria cause food to rot, deteriorate, perish or decompose and therefore can affect the smell, look and taste of food, rendering it unfit to eat.

About 65.00% of the participants knew that diarrhea was unacceptable health conditions in the work; diarrhea is the most frequent symptom of food poisoning. Meat handlers are encouraged to report illnesses such as diarrhea, sore throat, fever, cold or open lesions to the supervisor or management so that appropriate measurements are taken. This is reinforced by a study carried out by Bryan (1988) who found that infected food handlers were associated with a majority of food poisoning outbreaks.

Knowledge of vulnerable groups was poor as the majority of respondents 77.50% thought that everyone to be at equal risk of food poisoning. Although anyone can be affected by food poisoning; others are more at risk.

Apart from the knowledge, attitude is also a crucial factor that may influence food safety behavior and practice, thus decrease the occurrence of food borne diseases (Sani and Siow, 2014).

From the survey conducted, All participants 100% reported positive attitudes and agree that safe meat handling is an important part of their job responsibility, food hygiene training for workers is an important issue in reducing the risk of food contamination and they will change their meat handling behaviors when they know it

is incorrect, as well as food safety knowledge benefit their personal life and the consumer.

The majority of the respondents agreed that good personal hygiene can prevent food borne illness 97.50% health status of the workers should be evaluated before employment 97.50% and knives can transfer diseases 92.50%.

About 72.50% of participants knowledge of how to keep work surfaces hygienically clean was not good, they believed that washing hands and knives with water is clean enough to get rid of the bacteria; respondents have to know that disinfectant was the best product for killing bacteria on work surfaces. It requires application at a specific concentration for a specific amount of time. Hafez (1999) highlighted the importance of cleaning and disinfecting plant equipment to reduce contamination during processing. Detergent is a cleansing substance made from chemical compounds and used for general cleaning. Liquid detergent is more effective than common soaps, as they dissolve easily in water while absorbing dirt, which is eventually washed off. The soap powder can also be dissolved in water and used. Knives must also be sterilized or boiled in water (FAO, 1985).

The majority of respondents 90.00% agreed that It is necessary to check the temperature of the refrigerator to reduce risk of contamination, and about 95.00% agreed that Food borne diseases have harmful effects on both health and economic of the society.

Study regarding personal and hygienic practices in the slaughterhouse revealed that 67.5% of the participants have a valid health certificate, in contradiction to this study, Haileselassie *et al*. (2013) and Abd-Elaleem *et al.* (2014) noted that upon inspection most workers did not have valid health certificates. The study showed that 35% of the participants renew their health certificate every 6 months, 32.5% of them renew it annually.

Personal hygiene practices investigated in this study include wearing of protective clothing, the cleaning, and disinfection of working clothes, smoking, eating and drinking at the workplace. These practices are considered as mandatory preventative measures which have to be implemented during the slaughter process to reduce chances of cross contamination (Nel *et al.,* 2004).Wearing of protective clothing is one of the major measures implemented in the food industry. It helps to prevent cross

contamination. Protective clothing helps to protect both the food product and the meat handler from cross contamination (Muinde and Kuria, 2005).

The study showed that the respondents always use a cap and apron (Table 3.9) this results are in agreement with the results of Van Zyl (1995) who proposed that overalls, hair nets (beard nets, if any), hard hats, rubber boots, and aprons should always be worn by the meat handlers.

According to Abd-Elaleem *et al.* (2014) hairnets and beard-nets specifically help to prevent loose hairs and also dandruff from falling into the food since hair is reported to be a source of *Staphylococcus aureus*, on the other hand, handling of foods with bare hands may also result in cross contamination; hence introduce microbes on safe food. In this study, however, most respondents 92.50%always clean their working clothing.

All the respondents (100%) claimed that they never eat , drink, smoke or use snuff at the work Similar findings were also recorded by Nel *et al*. (2004); Jianu and Golet (2014) and Abdul-Mutalib *et al*. (2012), who have indicated that respondents reported that they neither smoke nor eat inside processing areas. Smoking may cause coughing thus, transferring aerosols containing microorganisms to the food (Gordon-Davis, 1998).

However, these personal hygiene practices are only claims from the respondents and due to the lack of evidence, there is no guarantee they carry out what they stated in the questionnaires ,shortcomings observed in the implementation of personal hygiene practices can be addressed by proper training, educating and monitoring of the workers.

Chi-square test results revealed that practices of respondents were not significantly different ($P<0.05$) according to educational level, working experience, and professional training.

Conclusion

The study showed that the levels of contamination on the exported sheep and goats' carcasses were higher than the acceptable values set by the Sudanese and international standards. Slaughter house, the workers, the vehicle used for the transport of the meat from the slaughter house to air port can act as the external sources for the contamination of the meat. The microbiological examination of carcasses revealed the presence of pathogenic organisms *Salmonella spp, E.coli* and *Staphylococcus aureus* in all stages of processing (skinning, evisceration, washing, chilling and at the airport). The questionnaire among slaughter worker revealed that the respondents had acceptable levels of knowledge, excellent attitudes and good practices toward food hygiene measure. Training, monitoring and educating slaughterhouse worker will help to ensure that the consumers and the imported countries to be provided with good quality wholesome meat all the times and establishing a hygienic program for exported meat is required in order to enable the Sudan facing the international trade parameters maintaining regionally acceptable meat quality standards required by meat export trade.

Recommendations

The following recommendations are suggested based on the findings obtained in this study:

1. Proper training of personnel or technical staff and instructing them with elements of sanitation and hygiene are needed to reduce the contamination.
2. Good Hygienic Practices (G.H.P) must be strictly applied in slaughterhouses to reduce the risk of carcass contamination at those specific stages.
3. Appling the (HACCP) principles at any point of the meat production line in the slaughterhouse is necessary
4. Cleaning and sanitizing transport vehicles between loads.
5. Finally, it is recommended that for a more comprehensive picture on the microbial load of carcasses exported, further studies can be conducted to include other microorganisms such *as Listeria-monocytogenes, Clostridium perfringens, Yersinia enterocolitica,and Campylobacter spp* .

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Appendices.

Questionnaire:-

بسم الله الرحمن الرحيم

Sudan University of Science and Technology
College of Graduate Studies

The Questionnaire

Knowledge, attitudes and practices questionnaire (KAP):

Part 1 Demographic characteristics:-

1. Name……

2. Ages…….years:-

a)(<20) b) (21-30) c) (31-40) d) (41-50) f) (>50).

3 Educational level:-

a)Non-education b)Basic certificate c)High school d) Graduated

4. For how long have you been working in the slaughterhouse?

a)<1year b) 2-5years..... c) >5 years

Part II KNOWLEDGE:-

1-Did you receive formal training in environmental sanitation, meat safety and hygine before or during your work?

a)Yes b) No

2- How many times have you received training?

a) One training session. b) 2-5 training sessions c) 6 and more training sessions d) Never.

3- When was your last training session?

a) Less than 6 months ago. b) 1-2 years ago. c).more than 2 years ago.

d) Never.

4- Do you know that wearing a cap is part of your personal hygiene responsibilities?

a)Yes b)No c)I don't know.

5- Do you know that wearing a mask is part of your personal hygiene responsibilities?

a)Yes b)No c) I don't know

6- Do you know that wearing a prone is part of your personal hygiene responsibilities?

a)Yes b)No c) I don't know.

7- Do you know that wearing boot is part of your personal hygiene responsibilities?

a)Yes b)No c) I don't know

8- Do you know that washing hands regularly is part of your personal hygiene responsibilities?

a)Yes b)No c) I don't know

9- Food contaminated by food poisoning bacteria can be identified by taste or smell?

a)Yes b)No c) I don't know

10-Do you think that everyone is at equal risk of food poisoning"?

a)Yes b)No c) I don't know

Part III ATTITUDE

1-Safe meat handling is an important part of my job responsibility.

a) Agree on, b) disagree. C)I don't know

2- Food hygiene training for workers is an important issue in reducing the risk of food contamination.

a) Agree on, b) disagree. C)I don't know

3- I will change my meat handling behavior when Iknow it is incorrect.

a) Agree on, b) disagree. C)I don't know

4- I believe food safety knowledge will benefit my personal life and the consumer.

a) Agree on, b) disagree. C)I don't know

5- I believe good personal hygiene can prevent foodborne illness.

a) Agree on, b) disagree. C)I don't know

6- Health status of the workers should be evaluated before employment.

a) Agree on, b) disagree. C)I don't know.

7- Knife can transfer diseases

a) Agree on, b) disagree. C)I don't know.

8. Washing hands and knives with water is clean enough to get rid of the bacteria

a) Agree on, b) disagree. C) I don't know.

Part IV. PRACTICE

1-Do you have a valid health certificate?

a) Yes b) No

2-How often do you renew your health certificate?

a) Every month. b) After 6 months. c) Annually. c)No need.

3- How often do you use a cap at work ?.

a) Always b) Sometimes c) Never

4- How often do you use a mask at work ?.

a) Always b) Sometimes c) Never

5- How often do you use an apron at work ?.

a) Always b) Sometimes c) Never

6- How often do you use gloves at work ?.

a) Always b) Sometimes c) Never

7- How often do you use Gumboots at work?.

a) Always b) Sometimes c) Never

8- How often do you clean and disinfect working clothes ?

a) Always b) Sometimes c) Never

9- How often do you eat or drink at your workplace?

a) Always b) Sometimes c) Never

10- How often do you smoke or use snuff during work?

a) Always b) Sometimes c) Never

Questionnaire in Arabic

بسم الله الرحمن الرحيم

كليه الدراسات العليا

استبيان

الجزء الأول

1- الأسم .....

2-الجنس:-

أ) ذكر ب) انثى

3- العمر .....

.(أ)أقل من20 سنه ب) (21-30) ج) (31-40) د) (41-50) و) أكثر من 50 سنه

4 :المستوى التعليمي :-

أ) أمى (غير متعلم) ب) الشهادة الأساسية ج) المدرسة الثانوية د) خريج جامعى

5- منذ متى وأنت تعمل في المسلخ ؟

أ) أقل من سنة ب) 2-5 سنوات ج) أكثر 5 سنوات

6- المهنه:-

أ) جزار ب) عامل ج) فنى

الجزء الثانى المعرفه

1- هل تلقيت تدريباً رسمياً في مجال صحه وسلامة البيئة وسلامة اللحوم قبل او اثناء العمل؟

أ) نعم ب) لا

2- كم عدد الدورات التدريبيه التي تلقيت فيها التدريب؟

أ) جلسة تدريبية واحدة ب) 2-5 دورات تدريبية ج) اكثر من 6 دورات د) لم اتلق اى دوره تدريبيه.

3 - متى كانت آخر دورة تدريبية لك؟

أ) أقل من 6 أشهر مضت. ب) من عام الى عامين ج) قبل أكثر من عامين.

اجب على الاسئله التاليه بأستخدام العبارات الاتيه:-

أ) صحيح ب) خطأ ج) لا أعرف

4 – ارتداء الملابس الواقيه مثل(الكاب (طاقيه الرأس) والماسك (كمامه الانف) والمريله والبووت والجونتات) هو جزء من مسئوليه النظافه الشخصية اثناء العمل

أ) صحيح ب) خطأ ج) لا أعرف

5 – ارتداء الملابس الواقيه مثل(الكاب (طاقيه الرأس) والماسك (كمامه الانف) والمريله والبووت والجونتات) تقلل من مخاطر التلوث اثناء العمل.

أ) صحيح ب) خطأ ج) لا أعرف

6 - غسل اليدين بانتظام هو جزء من مسئوليه النظافه الشخصية ويقلل من مخاطر التلوث اثناء العمل ؟

أ) صحيح ب) خطأ ج) لا أعرف

7 – **النظافه والتعامل الجيد مع ادوات العمل فى المسلخ مثل السكين تقلل من مخاطر التلوث اثناء العمل؟**

أ) صحيح ب) خطأ ج) لا أعرف

8 - **يمكن معرفه الأغذية الملوثة ببكتيريا التسمم الغذائي عن طريق الحواس مثل الشكل و الطعم والرائحه**

أ) صحيح ب) خطأ ج) لا أعرف

9 – الاسهال من الامراض البسيطه التى لاتؤثر على العمل ولاتستدعى اخذ اجازه مرضيه ؟

أ) صحيح ب) خطأ ج) لا أعرف

10- جميع الناس متساويين في خطر التسمم الغذائي "؟

أ) صحيح ب) خطأ ج) لا أعرف

<u>الجزء الثالث</u>

<u>اجب على الاسئله التاليه بأستخدام العبارات الاتيه:-</u>

1 - يعتبر التعامل الآمن الصحى(النظيف) مع اللحوم جزءًا مهمًا من مسئوليتي الوظيفية.

أ) أوافق ب) غير موافق. ج) لا أعرف

2 - التدريب على النظافة الغذائية للعمال هو مسألة مهمة في الحد من مخاطر تلوث الطعام.

أ) أوافق ب) غير موافق. ج) لا أعرف

3 - سأغير سلوك التعامل مع اللحوم عندما أعلم أنه غير صحيح.

أ) أوافق ب) غير موافق. ج) لا أعرف

4- **المعرفة بسلامة الغذاء ستفيد حياتي الشخصية وتفيد المستهلك.**

أ) أوافق ب) غير موافق. ج) لا أعرف

5- النظافة الشخصية الجيدة يمكن أن تمنع الأمراض التي تنتقل عن طريق الأغذية.

أ) أوافق ب) غير موافق. ج) لا أعرف

6- يجب تقييم الوضع الصحي للعمال قبل التوظيف.

أ) أوافق ب) غير موافق. ج) لا أعرف

7 - السكين والادوات المستعمله بالمسلخ يمكن أن تنقل الأمراض.

أ) أوافق ب) غير موافق. ج) لا أعرف

8- يكفى غسل اليدين والسكين بالماء للنظافه والتخلص من الجراثيم.

أ) أوافق ب) غير موافق. ج) لا أعرف

9- من الضرورى فحص درجه حراره الثلاجات لتقليل مخاطر التلوث؟

أ) أوافق ب) غير موافق. ج) لا أعرف

10- الامراض المنقوله بواسطه الغذاء لها تأثير ضار على صحه واقتصاد المجتمع؟

أ) أوافق ب) غير موافق. ج) لا أعرف

الجزء الرابع الممارسه

1 - هل لديك شهادة صحية صالحة (غير منتهيه تاريخ الصلاحيه)؟

أ) نعم ب) لا

2 - كم مرة تقوم بتجديد شهادتك الصحية؟

أ) كل شهر. ب) بعد 6 أشهر. ج) سنوياً. ج) لا حاجة لتجديدها.

اجب على الاسئله التاليه بأستخدام العبارات الاتيه:-

أ) دائما ب) في بعض الأحيان ج) أبد

3 - هل تستخدم الكاب (طاقيه العمل) اثناء العمل؟

أ) دائما ب) في بعض الأحيان ج) أبدا

4 - هل تستخدم الماسك (كمامه الانف) اثناء العمل؟

أ) دائما ب) في بعض الأحيان ج) أبدا

5- هل تستخدم المئزر(المريله) اثناء العمل؟

أ) دائما ب) في بعض الأحيان ج) أبدا

6- هل تستخدم القفازات (الجونتات) اثناء العمل؟

أ) دائما ب) في بعض الأحيان ج) أبدا

7-**هل تستخدم البووت(جزمه العمل) اثناء العمل؟**

أ) دائما ب) في بعض الأحيان ج) أبدا

8 - كم مرة تقوم بتنظيف وتطهير ملابس العمل ؟

أ) دائما ب) في بعض الأحيان ج) أبدا

9 – هل تأكل أو تشرب في اثناء العمل مكان عملك؟

أ) دائما ب) في بعض الأحيان ج) أبدا

10 - هل تدخن او تستخدم السعوط أثناء العمل؟

أ) دائما ب) في بعض الأحيان ج) أبدا