Assessment of Meat Hygiene Statues at Assabaloga Slaughterhouse in Khartoum State, Sudan

A thesis Submitted to the University of Khartoum in fulfillment of the requirements for Master Degree of Veterinary Science

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قال تعالى:

(أولم يروا أننا خلقنا لهم ممّا عملت أيدينا أنعاماً فهمّ لها ما نكلون (71) وذللناهَا لهم فمنهَا ركوبهم ومنهَا يأكلون (72) صدق الله العظيم

سورة يس
Dedication

To all my family

To all those who taught me
ACKNOWLEDGEMENT

Thanks to Allah who taught mankind things they ignored. Thanks to Allah for guiding me to complete this research.

May Allah’s peace and prayers be on Prophet Mohamed, the teacher of all man kind. May Allah grand him the best reward ever given to a Prophet for guiding his Ummah.

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Abstract

This study was an attempt to evaluate the status of meat hygiene in four slaughterhouses (Alkadaro, Ghanawa, Alhuda and Assabaloga) in Khartoum State. These slaughterhouses are working in the field of local and export oriented carcasses. The assessment was based on isolation and identification of bacteria from mutton intended for export (fresh, chilled and after unloading at airport). Assessment was also based on infrastructure of these slaughterhouses (availability and condition of a diagnostic laboratory, number and condition of refrigerators, condition of slaughter halls, number of veterinarians, technicians and laborers, application of hygienic measures to inspect and handle parts of slaughtered animals, and determination of reasons of condemnation of livers, lungs, hearts and heads, which may have impact on carcass contamination).

A total of 175 swab samples were made from four areas of the carcass at three stages: at the slaughter hall (75 swabs), from cold carcasses (50 swabs) and after unloading at Khartoum airport (50 swabs). Swabs were taken only from mutton of Assabaloga slaughterhouse because at that time the other slaughterhouses were not working for export. The swabs were subjected to aerobic culture using appropriate media and then identification of isolates. The isolates were identified according to their microscopic, cultural and biochemical properties. Staphylococcus epidermidis (16%), Micrococcus luteus (10.7%), Kurthia zopfil (8%), Micrococcus roseus (6.7%) and Micrococcus kristinae (2.7%) were isolated from fresh carcasses. Kurthia zopfil (16%), Aerococcus viridans (14%), Micrococcus varians (12%), Micrococcus kristinae (12%), Micrococcus luteus (10%) and Micrococcus roseus (6%) were isolated from chilled carcasses. Kurthia zopfil (22%), Micrococcus varians (14%), Micrococcus luteus (14%), Micrococcus kristinae (10%), Aerococcus viridans (10%) and Staphylococcus epidermidis (4%) were isolated from carcasses after unloading at the airport. The least contamination was in the fresh carcasses and the highest was in carcasses after unloading at the airport.

From a retrospective data of the year 2007 obtained from the four slaughterhouses, reasons for condemnation of major organs at post-mortem,
calculated from the total number of animals slaughtered in this year, were: abscess in heads (0.3% – 5.0%), fasciola in livers (0.0% - 2.0%), necrosis in livers (1.6% – 10%), pneumonia in lungs (0.6% – 5.0%), cysticerci in hearts (0.0% - 5.0%) and adhesion in hearts (0.1% – 0.2%). These reasons, as stated by the authorized veterinarians in these slaughterhouses, are almost the same as those prevailing during the period of sampling in this study (April, 2008 to May, 2009).

Each of the slaughterhouses had acceptable diagnostic laboratory, clean, spacious and well ventilated slaughter hall (s), reasonable number of refrigerators, which were of good condition, and reasonable number of veterinarians and assisting cadre. The temperature of the refrigerated vehicles was 3°C - 4°C and the carcasses temperature was 2°C - 3°C and all transporting vehicles were in good condition. There was no bad odor in the refrigerated carcasses and no separation of liquids.

This study concluded that meat hygiene status in these slaughterhouses was good and the isolated bacteria were either non-pathogenic or opportunistic pathogens, and it is unlikely that these bacteria were from infected organs at post mortem examination, but from pitfalls in application of hygienic measures during skinning and handling of organs and carcasses.
البحث

تتناول دراسة أربعة فصول في اللحم وسلامة صحة التقييم المحالة في السودان، ولختيم، والسودان، والغموض، والجهود والصادر المحلي.

ходит صادق من البكتيريا وتعرف على التقييم اعتماداً (257) وفِي ومبرد الأرجل (85).

وحكمة العدد وحالته، والتشخيص معلم ووجود العمال وتقنيات البيطرية البينات، (75%)

المعالجة، وتعمل كسائلية والأنسجة، (175 مرحلة ثلثة في جسم صاحب) وفِي (0.3–5%)

الرئتي (85%)

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INTRODUCTION

In the Sudan, most of the animals are raised on natural pastures by nomadic tribes. So, Sudanese animals are almost free from feed additives, hormonal and chemical residues, a fact which gives special preference to the Sudanese animal products. According to Gracey (1981) the contamination by live bacteria or their toxins was most important and frequent type of food poisoning. Meat is defined as those animal tissues which are suitable for use as food. The majority of meat consumed is derived from domesticated mammals and birds like cattle, sheep, camels, buffaloes, goats and chickens. Live sheep and mutton represent an important component of the Sudanese exports.

Establishing a hygienic program for exported mutton is of utmost importance in order to enable the Sudan to cope with the international trade parameters. This entails a vital need to improve the slaughter houses and to impose strict hygienic measures to provide healthy and wholesome meat to fulfill the international requirements.

(Brownlie, 1966) reported that keeping quality of meat and meat products depends on the numbers and types of the contamination bacteria and their metabolism and rate of growth it also depends on the physical or chemical environment.

Objectives of the study:

1- To evaluate the hygienic status of the major slaughter houses in Khartoum State, Sudan.

2- To determine the bacterial contamination of export mutton.
CHAPTER ONE
LITRATURE REVIEW

1.1 Meat hygiene and inspection

Meat inspection practice is one of the important activities of the veterinary services. Its aim is to insure that meat is free from diseases, wholesome and fit for human consumption (Mitchell, 1980). Alonge (1991) defined meat hygiene as a system of principles designed to ensure meat and meat products are safe, wholesome and processed in a hygienic manner and are fit for human consumption. According to Thornton (1968), the efficient meat hygiene practices begin in the farm and maintained throughout the chain i.e. in the animal collection centers, markets, during transportation of animals for slaughter, in abattoirs, during transport of meat to butcheries and even at the consumer home. Meat hygiene is essentially a public health function, the primary role of which is to safeguard against infectious diseases by preventing their transmission to humans thereby providing safe wholesome meat and meat products for human consumption (Ibrahim and Salih, 1970). To insure that meat quality standards are maintained, slaughter of animals for human consumption should be done in an abattoir. An abattoir has been defined as a premise approved and registered by the controlling authority for hygienic slaughtering and inspection of animals. Processing and effective preservation and storage of meat products for human consumption is also practiced in abattoirs (Alonge, 1991). Meat hygiene programmers should have as their primary goal the protection of public health. This should be based on a scientific evaluation of meat-borne risks to human health and also take into account all relevant food safety hazards, as identified by research, monitoring and other relevant activities (FAO/WHO, 2005). In developed countries, the role of the veterinary profession in addressing needs of urban communities has long been focused on public health and hygiene (Bellani et al., 1978) and (WHO, 1981). The main objective of meat hygiene and inspection is to prevent food-borne infections and meat spoilage. The meat hygiene, inspection
and control practices are based on the transmissibility of diseases through either consumption or handling of meat (Ibrahim, 1990). The standards of meat hygiene in a particular country are greatly influenced by the economic situation and the level of public education (Kaplan, 1957). The effective operation of meat hygiene services is multidisciplinary. It involves the veterinary medicine and engineering professions. The veterinarian is the one who is trained to deal with diseases transmitted through meat (WHO, 1957). Veterinary involvement in food safety activities throughout the food chain may encompass food safety, zoonoses and animal health. Risk management activities in these areas will contribute in various ways to reduce food-borne risks to human health by preventing eliminating or controlling hazards transmitted by food (OIE, 2002). Meat veterinary involvement is currently focused on meat hygiene (defined by Codex Committee on Meat Hygiene as all conditions and measures necessary to ensure the safety and suitability of meat at all stage of the food chain (Codex, 2005). It is clear that in the case of meat hygiene, a major component of suitability is related to detection and removed of abnormalities in meat that are of public health significance. Other aspects of suitability relating to consumer expectation include certification requirements such as the Codex General Guidelines for Use of the Term 'Halal' (CAC, 1997).

According to (FAO/WHO, 2003) official or officially-recognized programmers for specified zoonotic agents should include measures to:

- control and eradicate their presence in animal populations, or subsets of populations,
- prevent the introduction of new zoonotic agents;
- provide monitoring and surveillance systems that establish baseline data and guide a risk-based approach to control of such hazards in meat;
- Control movement of animals between primary production units, and to abattoirs, where trade animal populations are under quarantine restrictions.

Salih (1996) proposed that in order to improve the standard of meat hygiene, laws related to animal studies should be revised and included in meat hygiene
regulations. He noted that there is lack of proper training or the various staff members working in the meat inspection services. He suggested that programmers should be formulated to improve their academic and technical abilities. He further suggested the establishment of a meat research center where data pertaining to meat hygiene (Number of slaughtered animals, condemnation and reasons for condemnation throughout the country) could be collected and analyzed. Examples from developed countries, such as New Zealand, indicate that regulatory authorities are facing increasing challenges with respect to public health risks associated with meat products. Thus, meat inspection resources should be allocated according to their maximum ability to reduce food-borne hazards, rather than according to the classical rules of meat inspection. Scientific evaluation of routine post-mortem inspection procedures for each class of livestock, and effective management of production, processing and inspection data are central to this process. The meat inspection system that has evolved in New Zealand reflects a response to non-scientific forces such as market requirements and industrial practices rather than scientific discipline (Hathaway and McKenzie, 1991).

1.2 Sources of meat contamination

There were several genera of bacteria specially associated with the hands and nasal cavities and mouth, the important of which are Micrococcus and Staphylococcus, (Bryan, 1978; Jay, 1986). The most important genera of bacteria known to occur in foods were given by Jay (1986). They were 29 in numbers and included Acetobacter, Acinetobacter, Aeromonas, Alcaligenes, Altramanus, Bacillus, Brochothrix, Campylobacter, Citrobacter, Clostridium, Corynebacterium, Lactobacillus, Leuconostoc, Proteus, Micrococcus, Moraxella, Pediococcus, Pseudomonas, Salmonella, Serratia, Shigella, Staphylococcus, Streptococcus, Vibrio, and Yersinia.

Their primary sources were: soil, water, plants and plant products, food utensils, intestinal tract of man and animals, food handler’s feet, animal hides, air and dust.
Bryan (1978) and Jay (1986) considered food handlers to be the important source of contamination. The microflora on their hands and outer garments generally reflect the environment and the habits of individuals. This flora consisted of genera found on any object handled by the individuals in addition to those from water, dust and soil. Haines (1933) and Empey and Scott (1939) found that the sources of bacterial contamination of meat are hides, hooves, soil adhering to the hide, intestinal contents, air, water supply, knives, cleaves, saws, hooks, floors and workers. Gracey (1985) reported that bacteria associated with meat depend on bacteriology of the soil on which the animals were kept prior to slaughter. The bacteria were transferred to the hides and then to the exposed meat. Frazier (1978) showed that any bacteria on the knife would soon be found on meat in various parts of Carcase as it was carried by the blood. The contamination of carcases come from different sources including environment and equipments with which meat comes in contact during slaughtering and processing, but hides remain as an important source of contamination. Hussein (1971) isolated bacterial contaminants of fresh meat from the gastro-intestinal tract and hides of the slaughtered animals and from the water, halls and air deposits. Jespen (1967) noticed that bacteria are carried to the abattoir on skin, hoofs and body cavities of meat animals. Lawrie (1979) reported that if a contaminated knife was used or organisms were in advertently introduced from the skin where the main blood vessels were severed bleeding could lead to contamination of the tissues. Gracey (1980) reported that there are different sources of meat contamination for example, invasion of blood vessels by bacteria from the intestines of weaken or ill animals just prior slaughter. The animal's digestive tract was claimed to carry dangerous loads of bacteria. The hide, legs and hooves contain varying amounts of soil bacteria. Actual contagion with dirty hands, clothing's and equipment are important factors in the presence of bacteria in meat. Frazier and Westhof (1988) emphasized the importance of contamination from external sources during bleeding, skinning and cutting. The intestinal contents, knives, air, hands and clothes of the workers are important external sources. They also reported that during handling, contamination came from carts, boxes and other contaminated
meat in chilling storage. During processing contamination came from special equipment (grinders, sausage stuffers, fillers spices and casings. From their microbiological survey Schuler and Badenhop (1972) found that the packing materials might also present an important source of contamination. In slaughter processing plants the bacterial count of these materials ranged from 11-376 bacterial cells per centimeter square.

1.3 Animal welfare

1.3.1 Prior to slaughtering rest

Meat hygiene and inspection legislations of Khartoum state (1999) recommended that the animals should have enough rest. Diseased animals or animals at pregnancy are not accepted for slaughter. Prior to slaughter, rest of slaughter animals is needed to optimize physiological functions and to help in detecting evidence of any disease which may be recognized during this period (FAO/WHO, 1993). Lapworth (2004) reported that a survey of deaths among railed cattle from Australia showed that fewer animals died on transit when they were rested for more than 12 hours between herding and loading at the property yards. He recommended 6 to 12 hours of rest before transport and said that the length of the rest-be fore-transport period depends on the time taken to herd and handles the cattle, distance to be traveled and the current weather conditions.

1.4 Presentation of animals for slaughter

Only healthy, clean and appropriately identified animals should be presented for slaughter. Ante-mortem examination is an important preslaughter activity, and all relevant information on animals presented for slaughter should be utilized in meat hygiene systems (FAO/WHO, 2003). Meat inspection procedures consist or inspection of livestock before they are slaughtered (ante-mortem), followed by post-mortem inspection of carcasses and offal's. Inspectors also ensure that the livestock are slaughtered humanely, that proper arrangements are made to handle and ship the products, that the construction, facilities and equipments at the plant are up to standard, and that sanitary requirements are
met (Jyue, 2002). Mitchell (1980) suggested that with very few exceptions most countries of the world appreciate that ante-mortem inspection is an essential part of meat inspection and closely related to ante-mortem and post-mortem inspections is the strict supervision of hygiene in the abattoir and places where meat is processed for human consumption. The health status of the farm of origin and the husbandry of slaughter animals has a significant effect on the safety and wholesomeness of meat. In this respect, all efforts should be made to collect and evaluate information that might have influence on ante-mortem and post-mortem inspection (FAO/WHO, 1993).

1.4.1 Ante-mortem examination

Ante-mortem inspection, without which no adequate inspection of the carcases is possible (Houthuis, 1957), is more important than post-mortem examination. In fact, the importance of ante-mortem inspection cannot be over-emphasized. It should be carried out if possible on the unloading ramp on arrival and thereafter daily until slaughter (Mitchell, 1980). Thornton (1957) stated that the inspector should be present at the actual time of slaughter to detect abnormalities which may be overlooked if the post-mortem examination is conducted some hours later. FAO/WHO (1962) stated that meat hygiene starts from the animal being on the farm through its journey till it reaches the consumer as fresh, wholesome, sound and safe meat. In the abattoir, ante-mortem inspection detains diseased or suspected animals for further detailed examination by the meat inspector. All animals presented for slaughter should be subjected to ante-mortem inspection, by a competent person whether on an individual or a lot basis. Ante-mortem inspection should support post-mortem inspection by application of a specific range of procedures and/or tests that consider the behavior and appearance, as well as signs of disease in the live animal (FAO/WHO, 2005). Ante-mortem examination is of great value in detection of animals suffering from infectious diseases particularly notifiable diseases and emergency cases. It insures that load animals released for slaughter are in good state of nutrition, cleanliness and free from diseases (Ibrahim, 1989). According to
Gracey, (1985), ante-mortem examination was found to be valuable in the prevention of food poisoning. In this respect the rejection of food animals showing symptoms of shivering and diarrhea proved to be effective in limiting Salmonella contamination in Australia. Ante-mortem examination at the abattoir should occur as soon, as is practicable after delivery of slaughter animals. Only animals that are judged to be sufficiently rested should proceed to slaughter, but should not be withheld from slaughter any longer than necessary. Where there is an undue delay before slaughter, e.g., more than 24 hours, ante-mortem examination should be repeated (FAO/WHO, 2003). Herenda et al. (2000) suggested that some of the major objectives of ante mortem inspection include the following:

- Screening of all animals destined for slaughter.
- Ensuring that animals are properly rested and that proper clinical information, which will assist in the disease diagnosis and judgment, is obtained.
- Reduction of contamination on the killing floor by separating the dirty animals and condemning the diseased animals if required by regulation.
- Ensuring that injured animals or those with pain and suffering receive emergency slaughter and that animals are treated humanely.
- Identifying reportable animal diseases to prevent killing floor contamination.
- Identifying sick animals and those treated with antibiotics, chemotherapeutic agents, insecticides and pesticides.
- Both sides of an animal should be examined at rest and motion.

An effective reporting system should operate from the ante-mortem area giving details of normal stock released for slaughter, animals affected with a localized condition and those with conditions not advanced enough to render them unfit for slaughter (Gracey, 1986).
1.4.2 Post-mortem examination

Post-mortem inspection procedures and tests should be established by the competent authority according to a science- and risk-based approach. In the absence of a risk-based system, procedures will have to be based on current scientific knowledge and practice. Post-mortem inspection procedures based on current knowledge and practice vary considerably in different countries (OIE Terrestrial Animal Health Standards, 2004). Post-mortem inspection should provide necessary information for the scientific evaluation of pathological lesions affecting the wholesomeness of meat. Professional and technical knowledge must be fully utilized by coordinating all the components of ante mortem and post-mortem findings to make a final diagnosis (Herenda et al., 2000).

In post-mortem, the routine meat inspection procedure is to divide the slaughtered animals into four parts i.e. the carcases, the plug (lung, heart, liver and spleen), the viscera and the head. Post-mortem inspection involves visual examination, palpation of organs and tissues, incision where necessary, use of the inspector’s sense of smell, and laboratory tests, if indicated (Gracey, 1986).

Routine post-mortem examination of a carcass should be carried out as soon as possible after the completion of dressing. The reason is to detect any abnormalities so that products only fit for human consumption are passed as good. All organs and carcass portions should be kept together and correlated for inspection before they are removed from the slaughter chain (Herenda et al., 2000).

1.4.3 The judgment at post-mortem examination

Meat for human consumption should be prepared from animals that were healthy and have been well bled. Animals having infectious, toxic, or physical agents that may be hazardous to human health should not be used for food fitness that can be determined by a comprehensive evaluation that may include organoleptic, microbiologic, and chemical examinations.
Meat should be examined under a light of adequate intensity. Texture, color, and odor should be noted. Meat should be firm, and cut surfaces should be glossy. Gray or green discoloration may indicate bacterial action. Dark-red meat may result from postmortem retention of blood in animals that were not properly bled. Areas of bruising hemorrhage, or inflammation should be readily recognized. Odors from contaminating chemicals, urine or other sources are unacceptable. (Cynthia et al., 2005).

1.5 The Hazard Analysis Critical Control Point (HACCP) system and its role in the detection of contamination of meat in the slaughter house

Hazard Analysis Critical Control Point is a food safety management system, which concentrate prevention strategies on known hazards and the risks of them occurring at specific points in the food chain (Shmoury, 2000). On the other side also he reported that (HACCP) comes from two key phrases, "Hazard Analysis" and "Critical Control Points". Hazard Analysis involves investigation intended to disclose (through examination), identify, estimate and calculate the risks of all factors associated with the processing and marketing of a given product. In simple terms, it is necessary to assess all possible hazards and the likelihood of their occurrence (by analysis). Control Points are steps, operations or stages in the manufacturing or marketing processes that needs to be controlled and monitored as they have a great effect on the quality of the product.

Thornton (1966) reported that 40% of contamination of meat occurred on the slaughter floor and 33% during flaying. According to Scarafoni (1967) the dirt and skins of animals contribute to 33% of the pollution, the abattoir atmosphere to 5%, the visceral content 3%, transport and storage elements 50%, halving, quartering and packing of carcases, 3%. Jay (1986) explained that the (HACCP) was a preventive system of control that included a careful analysis of ingredients, products and process in an effort to determine those components or areas that must be maintained under very strict control to assure that the end product meet the microbiological specifications that had been developed.
For evaluation of the safety of food products, it is important to focus on the total number of microorganisms per gram or per ml and the types of organisms represented in this number (Jay, 1986). According to Mackey and Roberts (1993) it is necessary to conduct monitoring exercises under the (HACCP) system, using automated methods to measure microbial loads, because traditional inspection procedures had failed to improve the microbiological condition of carcass meat. Biss and Hathaway (1998), suggested that critical points include pre slaughter status, inverted dressing, handling and chilling and that the use of visible faecal contamination for monitoring hygiene may give erroneous results. It is concluded that (HACCP) approach to slaughter can reduce microbiological contamination of sheep carcasses Guyon et al. (2001) showed that pre evisceration, defatting and associated worker’s materials are critical points for carcase. The new slaughter inspection system which rely on (HACCP) principles with Food Safety and Inspection Service (FSIS) over sight and verification services can maintain or even improve food safety and other consumer protection conditions relative to traditional inspection methods (Cates et al., 2001) Jericho et al. (2000) concluded that the control of aerosols in the hide removal floor should be treated as a critical control point in HACCP plan.

1.6 Transport of slaughter animals

Meat consumers are increasingly demanding that animals be reared, handled, transported and slaughtered using humane practices (Appleby and Hughes, 1997). Transport of slaughter animals should be carried out in a manner that does not have an adverse impact on the safety and suitability of meat. Slaughter animals require transport facilities which ensure that hazards are not introduced during transportation to the abattoir and ensure as well, that animal identification as to the place of origin is maintained; and consideration is given to avoiding undue stress. Overstocking during transportation may also subject the animal to suffocation and other body injuries, such as bruises, wounds, fractures, etc (Thornton, 1973; Blood et al, 1979).
Von Borell (2001) reported that transportation is considered a major stressor for farm animals and might have deleterious effects on health, well-being, performance, and, ultimately, product quality. Feeding of animals during transportation is quite advantageous and helps to reduce losses in body weight. It was found that body weight of transported cattle could be reduced by 3-6% during 24-72 hours journey. However, to minimize the losses resulting from transportation, animals should be rested and fed before slaughter to regain physiological normality (Houthuis, 1957; Willsow and Payne, 1978).

1.7 Meat surfaces contamination and bacterial isolates

Banwart (1981) reported that normal sheep have microflora that was established in their early life. Besides this microflora; they tend to harbour different types of organisms found in their environment, since they are contaminated by soil, air and feed excreta. Dressed sheep carcases are sterile. Nevertheless, before they were contaminated by bacterial deposit in their hides, personnel and the environment (ICMSF, 1980). Number and distribution of microorganisms on the surface of fresh meat vary with the method of dressing and cleanliness of the environment (ICMSF, 1999). Frazier and Westhoff (1999) reported that important contamination, however, come from external sources during bleeding, handling and processing. In the post-mortem contamination bacteria usually originate from exogenous sources. Large numbers of bacteria of mar kinds were naturally found on the skin, hoofs and cavities. Bacteria found in the surfaces of the carcases after slaughter, were identical with that found in the animal hide. During the slaughtering process and handling the environment become grossly contaminated (Thornton, 1957). During dressing and evisceration the outer surfaces were mainly contaminated from the hide or skin, tools, equipments, water … etc. Sources of superficial contamination of carcases were quantitatively estimated by Serafor (1967) as follows:

1. Direct on the skin of animals, approximately 33%.
2. Pollution in abattoir atmosphere, approximately 5%.
3. The visceral content in normal condition, approximately 3%.
4. Transport and storage, approximately 50% or more.
5. Halving, quartering and packing of carcases, approximately 2%.
6. Miscellaneous, utensils, personnel ... etc, approximately 3%.

Thornton (1968) investigated 40% of the carcases contamination occurred in the slaughter floor. Empey and Scott (1939) observed that transfer of microorganism from the hide to the underlying tissue begin with the first stage of skinning. Bacterial counts were ranging between $10^4$ to $10^5$ viable cells per square centimeter of the superficial tissue of the carcase. Cross contamination may be acquired through water used in the slaughter process. Washing of carcases immediately after slaughter is the standard of industrial practice, however, washed carcases usually were not sanitized (ICMSF, 1980). A considerable reduction in the bacterial count associated with the use of chlorinated water (Patternson, 1972). Ayres et al. (1955) reported that bacterial contamination in water collected from the utensil used for washing of slaughtering tools. If water was reused continuously the microbial content increases rapidly. Dirty hands, clothes of workers and equipments can serve as intermediate sources contamination found on meat (Frazier and Westhoff, 1955). Frazier and Westhoff (1955) said that handling of the meat induces contamination from carts, boxes and other containers. They isolated many kinds of meat contaminant include human pathogens. Especially intestinal type. A source of bacteria in the carcases is the lymph nodes, which filter out bacteria from the lymph. Microbial count of $10^5$/gm from the lymph nodes were found (Banwart, 1981). Accidental puncture of the intestine or the stomach was found to be a source of contamination, besides the equipments used in slaughtering and dressing tools. Knives, saws, cleavers, hooks, wiping cloth and brushes made significant contribution to the over all contamination. Bacterial counts were ranging between $10^4$ to $10^5$ per square centimeter of the superficial tissues of the carcases. Gross contamination may be due to water use during the slaughtering process. Washing of carcases is to be done immediately after slaughter (ICMSE, 1980). The most frequent coli form bacteria present in meat were *Escherichia coli*, *klebsiella spp.*, *Citrobacter spp.*, *Enterobacter cloacae* and *Arizona spp.* (Fatima, 1985). Thornton (1952) found that the types of bacteria in the slaughter house were *Staphylococcus, Micrococcus, Bacillus, Pseudomans, Achramobacterium Aerobacter and Coliform*.

In processed meat subjected to qualitative analysis in the Sudan the
following results were obtained. The percentage of pathogenic bacteria such as *Salmonella* spp. was 8.6%, *Clostridium perfringes* was 4.6%, *Staphylococcus aureus* was 30.4% and *Escherichio co* was 16.2% (Ibrahim, M.E. 2006).

Hussein (1987) reported that the aerobic organisms isolated from fresh meat were *Bacillus* spp., *Staphylococcus* spp., *Diphtheroides* spp., *Micrococcus* spp., *Streptococcus* spp. and *Lactobacillus* spp., while gram-negative isolates were dominated by *Escherichia coli*, *Citrobacter freundii*, *Proteus morgani*, *Alcaliger* spp., *Aerommonus* spp.

John and Anthony (1974) stated that *lactobacteriaceae* may be the eventual cause of meat spoilages, under some condition in meat handling, where it inters the product through contamination from plant equipment or workers handler of the product. Lawarie (1991) found that the organisms derived from infected personnel or health carriers include *Salmonella* spp., *Shigella* spp., *Escherichia coli*, *Bacillus*, *Proteus*, *Staphylococcus albus* and *Staphylococcus aurues*, *Clostridium welchii*, *Bacillus cerues* and fecal streptococci; According to Gracy et al. (1999), describing a study in North Ireland that showed a wide range of organisms isolated from all areas of the abattoir, included *Pseudomonus*, *Klebsiella*, and *Citro-bacter*. Intisar (1998) recognized different types of aerobic bacteria present in Omdurman slaughterhouse and Khartoum north retail market, the bacterial isolates were gram positive genera especially *Micrococcus* and *Enterobacteria*. Salih (1971) reported heavy contamination of fresh meat in Khartoum State with spoilage bacteria of genera – *Micrococi*, *Streptococci*, *Bacillies*, and *Pseudomonas*. 
CHAPTER TWO
MATERIALS AND METHODS

2.1. The study area and samples

The study was carried out at four slaughterhouses in Khartoum State namely, Elkadaro, Ghanawa, Alhuda and Alsablooga. These are the major slaughterhouses in Sudan. More than ten visits were made to the four slaughterhouses from April 2008 to May 2009. We collected informative retrospective data about these slaughterhouses. A total at 175 swab samples were taken from Alsablooga slaughterhouse. Seventy five samples were taken from the fresh carcases and fifty samples from the chilled carcases and fifty samples were taken after unloading the carcases from the refrigerated vehicle at the air port.

2.1.1 Elkadaro slaughter house

Elkadaro slaughter house was established in 1974 for meat export and local consumption (cattle, sheep and camel). This slaughter house is composed of two slaughter halls one for slaughtering sheep & other for cattle. It is equipped with a diagnostic laboratory under supervision of veterinarians, and has thirteen refrigerators for cooling meat

2.1.2 Ghanawa slaughter house

The slaughter house was established in November 1999 for meat export and local consumption cattle /Camel /Sheep/ and goat Ghanawa slaughter house is composed of two halls, the upper hall for slaughtering sheep and goats and the lower one far cattle and Camels. The slaughter house has a diagnostic lab. Under the supervision of veterinarian, and it have six refrigerators, for cooling meat (4°C)
Table (1): manpower in the four slaughterhouses

<table>
<thead>
<tr>
<th>Slaughterhouse</th>
<th>Manpower</th>
<th>Vet.</th>
<th>Tech.</th>
<th>Laborers</th>
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<td>12</td>
</tr>
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<td>5</td>
<td>2</td>
<td>23</td>
</tr>
<tr>
<td>Alsabalooga</td>
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</tr>
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</tr>
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Tables (2) Number of animals slaughtered for export in Elkadaro slaughterhouse during 2007

<table>
<thead>
<tr>
<th>Month</th>
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<th>Number of camel</th>
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Table (3) Number of animals slaughtered at Elkadaro slaughterhouse for local consumption during 2007

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<thead>
<tr>
<th>Species</th>
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<th>Average no./month</th>
<th>Average no./year</th>
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Table (4) Number of animals slaughtered for export in Ghanawa slaughterhouse during 2007

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<thead>
<tr>
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<th>Number of Goat</th>
<th>Number of Camel</th>
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Table (5) Number of animals slaughtered in Ghanawa slaughterhouse for local consumption during 2007

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<th>Number of cattle</th>
<th>Number of sheep</th>
<th>Number of Camel</th>
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</tr>
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Table (6) Number. of animals slaughtered at Alsabalooga slaughterhouse for export during 2007

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<td>May</td>
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Table (7) Number of animals slaughtered at Ghanawa slaughterhouse for local consumption during 2007

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<td>Total</td>
<td>16.882</td>
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Table (8) Number of animals slaughtered at Alhuda slaughterhouse for local consumption during 2007

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<td>August</td>
<td>1509</td>
<td>1327</td>
<td>2.836</td>
</tr>
<tr>
<td>September</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>October</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>November</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>December</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>21.234</td>
<td>10.672</td>
<td>31.906</td>
</tr>
</tbody>
</table>
Table (9) Percentage of animals slaughtered for export and local consumption in the four slaughterhouses during 2007

<table>
<thead>
<tr>
<th>Species</th>
<th>Percentage %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Elkadaro</td>
</tr>
<tr>
<td>Sheep</td>
<td>66.24*</td>
</tr>
<tr>
<td>Cattle</td>
<td>11.24°</td>
</tr>
<tr>
<td>Goat</td>
<td>51.47•</td>
</tr>
<tr>
<td>Camel</td>
<td>58.49∞</td>
</tr>
</tbody>
</table>
2.1.3 Alsablooga Slaughter House

The slaughter house was established in 1997 for meat export and local consumption (cattle, sheep and camels). It is composed of tow slaughter halls and has diagnostic laboratory under supervision of veterinarian. Also have fifteen refrigerators for cooling meat.

2.1.4 Alhuda slaughter house

The slaughter house was established in 1997 for local consumption (sheep, cattle). Alhuda slaughter house is composed of one slaughter hall for slaughtering cattle and sheep.

2.2. Sampling method

Sampling was done according to systemic random sampling methods as described by Thrusfield, (1995). Sampling sites from which swabs were taken are:

- Thigh muscles,
- external abdominal muscles,
- hip muscles and from the vertebral area.

Then swabs were transferred as soon as possible to the Preventive Medicine Research Laboratory, Faculty of Veterinary Medicine, University of Khartoum.

Swabs were stored in deep freezer at -20°C before processing took place.

The samples were examined for isolation and identification of aerobic bacterial contaminants of mutton intended for export.

2.3 Cultural media

2.3.1 Solid culture media

2.3.1.1. Blood agar

As prescribed by Oxoid Laboratory Products, London (Oxoid Lab.), 40 grams of the base powder were added to one liter of distilled water. The mixture was then boiled until the powder dissolved completely. The Solutia is autoclaved at 121°C and 15 pound per square inch for 15 minutes. It was then cooled to 45-
50°C. 7% of sterile blood was added with gentle rotation and then poured into Petri dishes as 15-20 ml amount and left to solidify. The poured Petri-dishes were kept in the refrigerator (about 4°C) until it is used within one day.

2.3.1.2. **Nutrient agar**

The medium was prepared as described by (Oxoid Lab.), 25 grams of powder were added to one liter of distilled water and brought to boil to dissolve the powder completely. It is sterilized by autoclaving for 15 minutes at 121°C and 15 pounds per square inch. Then poured aseptically as 18-20 ml potions in Petri-dishes.

2.3.2 Semi - solid media

2.3.2.1. **Motility medium**

The medium was described by Cruickshank *et al.* (1975). New Zealand agar 0.2% was dissolved in nutrient broth and distributed in sterile test tubes containing Craigie tubes, and then the media was autoclaved at 121°C and 15 pounds per square inch.

2.3.2.2 **Hugh and Liefson’s (O/F) medium**

Hugh and Liefson’s (O/F) medium (Cowan and Steel,1974) contained peptone (2g), NaCL (5g), KHPO4 (0.3g), agar (3g), distilled water (1000 ml), and bromocrysol purple, 0.2%. aqueous solution (15 ml). The solids were dissolved by heating in the water. The pH was adjusted to 7.1, the medium was filtered. The indicator was added. Sterilization was done by autoclaving for 15 minutes and pressure of about 15 lb per square inch. Sterile glucose solution (1%) was added to the medium, mixed and distributed aseptically in ten ml volumes into sterile test tubes with cotton plugs of not more than 16 mm diameter.
2.3.3 Liquid cultural media

2.3.3.1. Peptone water

Peptone water was prepared according to (Cruikshank et al., 1975). Ten grams peptone and 5 grams NaCl were dissolved by heating in 1000 ml distilled water. The pH was adjusted to 7.2 and the medium was distributed in five amounts in test tubes and sterilized by autoclaving at 115°C for 15 minutes under pressure at 15 lb per square inch. The stock was preserved in the refrigerator.

2.3.3.2. Nutrient broth

Nutrient broth (Oxoid Lab.) contained; lab-lemco powder (1 g), yeast extract (2 g), peptone (5 g) and sodium chloride (5 g). PH was adjusted to 7.4, approximately. An amount of 13 grams of the dehydrated medium was added to one liter of distilled water, the reconstituted medium was mixed well then distributed in 5 ml amounts and sterilized by autoclaving at 121°C for 15 minutes under pressure of 15 lb per square inch.

2.3.3.3 MR-VP medium

MR-VP medium (Oxoid Lab.) contained; peptone (5 g), dextrose (5 g) and phosphate buffer (5 g). The PH was adjusted to 7 after reconstitution approximately. To reconstitute the dehydrated medium, 15 grams were added to one liter of distilled water and mixed well. Then distributed in test tubes with cotton plugs and sterilized by autoclaving at 121°C for 15 minutes under pressure of 15 lb per square inch.

2.3.3.4. Nitrate broth

Nitrate broth (Cowan and Steel, 1985) contained KNO (1 g) And 13 grams of nutrient in 1000 ml distilled water. Then the medium was distributed in sterile test tubes with cotton plugs and then sterilized by autoclaving at 121°C for 15 minutes under pressure 15 lb per square inch.
2.3.3.5. Carbohydrates liquid medium

Carbohydrates liquid medium was prepared as described by (Cruickshank et al., 1975). The sugars used are glucose, maltose, sucrose, lactose and manitol. All sugars were used at one percent concentration in peptone water containing one percent Andrade’s indicator. The medium was distributed in 5 ml amounts in test tubes with cotton plugs and autoclaved under 10 lb pressure per square inch for 5 minutes.

2.4. Sterilization

2.4.1. Hot air oven: This method was used for sterilization of clean glass containers which were wrapped in paper or put in stainless steel cans, and the temperature was 160°C for one hour (Stainer et al., 1986).

2.4.2. Sterilization by red heat

The method was used for sterilizing wire loops, straight wires and tissue forceps. It was done by holding the object over flame as near and vertical as possible until it becomes red hot (Cruickshank et al., 1975).

2.4.3. Sterilization by autoclaving

This method was used for sterilizing of culture media and for materials that could not withstand the dry heat. The temperature was 115-121°C under 10-15 pounds pressure for 15-20 minutes (Barrow and Feltham, 1993).

2.5. Chemical Reagents

2.5.1. Oxidase test reagent

Tetra methyl-pheynlene-diamine dihydro chloride was prepared as 1% aqueous solution. Filter paper of 50 x 50 millimeter size were impregnated in reagent before and dried at 50°C (Barrow and Feltham, 1993).
2.5.2. Hydrogen peroxide

30% Hydrogen peroxide produced by B.D.H. (British Drug House) was diluted to 3% aqueous solution for catalase test.

2.5.3. Kovac’s reagent

This reagent was prepared as described by Barrow and Feltham (1993.) Five grams of p-dimethylamino benzaldehyde were dissolved in 75 ml of amyl alcohol by warming in water bath. After the mixture was cooled, 25 ml of concentrated hydrochloric acid were added. It is used for indole test.

2.5.4. Potassium hydroxide and Alphanaphthol

According to Cowan and Steel (1974), the reagent prepared as 40% potassium hydroxide and 5% alphanaphthol for use in Voges-Proskauer V.P. test.

2.5.5. Nitrate test reagent

According to (Bio Merieux) it consists of two separate solutions. The first of them, the sulfanilic acid reagent, was prepared by dissolving 0.4 gram of sulfanilic acid in 100 ml acetic acid. The other solution, alpha-naphthylamine, was prepared by dissolving 0.6 gram of N.N-dimethyl-1-naphylamine in 100 ml acetic acid.

2.5.6. Bromocrysol purple and phenol red indicators

Bromocrysol purple and phenol red indicators were obtained from British Drug House. Methyl red was a product of Hopkins and William’s. It was prepared as 5% solution for use in methyl red test. It was Composed of acid fuchsin (5 g), distilled water 1000 ml and N-NaOH (150-180) ml. The acid fuchsin was dissolved in distilled water and 150 ml of alkaline solution were added. It was used in sugars test as one per cent volume indicator was prepared according to Cowan and Steel (1974).
2.5.7. Acid alcohol

Acid alcohol prepared as described by Cowan and Steel (1974). It contained concentrated HCl (3 g), ethanol (95-97%) ml.

2.5.8. Ammonium oxalate and crystal violet solution

Ammonium oxalate and crystal violet solution were prepared according to Cowan and Steel (1974) as follows:

**Solution 1:** Crystal violet (10 g) and ethanol (95%) 100ml. They were mixed together till dissolved.

**Solution 2:** Ammonium oxalates one per cent aqueous solution. Then 20 ml of solution 1 and 80 ml of solution 2 were mixed.

2.5.9. Strong carbol fuchsin

Strong carbol fuchsin included the following ingredients as described by Cowan and Steel (1974).

**Solution 1:** Basic fuchsin ten grams and ethanol (95%) (100 ml) were mixed and dissolved in stoppered bottle and kept at 37° over night.

**Solution 2:** Phenol (5 g) and distilled water (100 ml) were mixed and dissolved. For use ten, ml of solution 1 were poured into 100 ml of solution 2.

2.5.10. Weak carbol fuchsin

Weak carbol fuchsin was prepared by diluting one volume of strong carbol fuchsin with 10-20 volumes of distilled water (Cowan and Steel, 1974).

2.5.11. Lugol's iodine

Lugol's iodine contained the ingredients shown as described by Cowan and Steel (1974). Iodine (5 g), potassium iodide (10 g) and distilled water (100ml).
The potassium iodide was dissolved with the iodine in ten ml of the water and adjusted to volume with distilled water.

2.6. Culture methods

Swabs were transferred to peptone water and streaked on blood agar plates and were incubated aerobically for 18-24 hours at 37°C. Solid media were examined visually for growth and colonies appearance and liquid media were similarly examined for turbidity. Different selected colonies were picked with a sterile loop and streaked onto a fresh nutrient agar plates. The cultures were purified by sub culturing. Isolates were preserved in cooked meat or nutrient agar plates in the refrigerator for further investigation.

2.7. Microscopy and Identification of bacteria

2.7.1 Gram stain

Using a sterile wire loop a part of isolates colonies four primary plots and pure were taken and spread on microscopes slides to make thin smears. They were fixed with heat and placed on staining rack. They were covered by crystal violet for two minutes and washed off by tap water, then covered with no iodine for one minute and washed off by tap water, then decolonized with acetone for few seconds and washed off by tap water, then covered with carbol fuchsin for thirty seconds. Finally the stained smears were washed and air dried. Then they were examined under oil immersion lens (100 x). The Gram positive and negative organisms, shape and arrangement of organisms were identified according to Barrow and Feltham (1993).

2.7.2. Bacteriological test for properties and chemical reactions

2.7.2.1. Oxidase test

A sterile platinum loop was used to spread the isolated colony on Oxidase paper. Color change (violet) indicated a positive reaction according to Barrow and Felltham (1993).
2.7.2.2. Catalase test

Using sterile glass rod a part of a isolated colony was emulsified in one drop of hydrogen peroxide on a clean slide. Gas bubbles indicated positive reaction (Barrow and Feltham, 1993).

2.7.2.3. Motility test

The isolates were studied for motility by Craigie technique (Cruickshank et al., 1975), in which the bacteria was inoculated into a central tube containing semi solid agar placed in test tube using straight wire. After incubation at 37°C for 24 hours, the tubes were examined for migration of the bacteria out side the Craigie tube.

2.7.2.4. Hugh and Leifson’s test

Hugh and Leifson’s Test or oxidation fermentation test (O/F) was done as shown by Cruickshank et al., (1975). Duplicate tubes of freshly prepared medium were inoculated by stabbing with a straight wire. One of the inoculated media was immediately covered with a layer of sterile liquid paraffin to a depth of one ml and examined daily for up to 14 days. A colour change from green to yellow in both tubes indicated a fermentative organism but change in the uncovered tube only indicated that the organism was oxidative.

2.7.3 Voges-proskauer test

Voges-Proskauer test was carried out as described by Cruickshank et al., (1975). A test tube contains MR-VP medium was inoculated with 24ml peptone water culture and incubated for 48 hours. One ml of 40% KOH solution and three ml of 5% alpha-naphthol solution were added. A positive reaction indicated by the development of a pink colour in two to five minutes. The colour became crimson after 30 minutes.
2.7.4 Nitrate reduction test

Nitrate reduction test was carried out as described by Cowan and Steel (1985). Nitrate broth was inoculated and incubated for up to five days. One ml nitrite solution 1 was added followed by one ml of solution 2. A red colour indicated a positive reaction. The tubes not showing red colouration within five minutes, powdered zink was added and allowed to stand. Development of red colour indicated that nitrate was present. Absence of red colouration in this case indicated absence of nitrate.

2.7.5 Carbohydrates fermentation tests

Carbohydrates fermentation tests were carried out as described by Cruickshank et.al. (1975). 5 carbohydrates media; glucose, lactose, manitol, sucrose and maltose, were inoculated with peptone water culture by a sterile loop. A fermentation reaction was indicated by change of colour of the medium to pink.
CHAPTER THREE

RESULTS

3.1 Reasons of condemnation in four slaughter houses in Khartoum State

The main reasons of livers condemnation recoded in Elkadro, Alhuda and Alsablooga slaughter houses were Necrosis, which Elkadro has highest percentage (10%), the reasons in Ghanawa slaughter house were Facsiola (2%) (table 10). The data in table (11) showed that the main reasons of lungs condemnation in the four slaughter houses were Pneumonia, Elkadro slaughter house has highest percentage (5%). The data in table (12) showed that main reasons of hearts condemnation in Elkadro slaughter house were Cysticercus (5%) and main reason in three slaughter houses were Adhesion (0.1%-0.2). In table (13) the main reasons of heads condemnation in four slaughter houses were Abscess, Elkadro slaughter house has highest percentage (5%).

3.2. Isolation and identification of bacterial species obtained from mutton intended for export at Alsabalooga Slaughter house

3.2.1 Samples taken from the fresh carcasses

The isolates of fresh samples were classified according to Gram, Stain reaction to Gram positive cocci and Gram positive bacilli. Gram positive cocci included Aerococcus, Staphylococcus and Micrococcus, which were the most frequently isolated bacteria. The Gram-positive bacilli isolated were Kurthia, All Gram positive cocci were identified by their biochemical properties as Micrococcus Luteus, Micrococcus varians, Staph epidermidis and Aerococcus viridans, (Table 14).

3.2.2 Samples taken from chilled carcasses

Isolates from chilled carcasses were classified according to Gram stain reaction to Gram – positive cocci and bacilli. Micrococcus sp was the most frequently isolated bacteria, Other genera observed were Staphylococcus sp, Kurthia and Aerococcus spp.

According to the biochemical tests, isolates of Gram-positive genera were
identified as *Micrococcus luteus*, *Micrococcus roseus*, *Micrococcus kristinae*, *Staph epidermidis* and *Aerococcus viridan* (Table 14).

### 3.3.3 Samples taken after unloading the carcasses from refrigerated vehicle at the airport

Several species of bacteria were isolated from refrigerated carcasses and were classified according to Gram stain into Gram-positive cocci and Gram-positive bacilli. The Gram-positive cocci included *Micrococcus* spp and *Staphylococcus* spp and Gram-positive bacilli. Isolated were *Kurthia zopfil*.

According to biochemical tests, the bacteria isolated were identified as *Micrococcus luteus*, *Micrococcus kristinae*, *Micrococcus roseus*, *Micrococcus varians*, *Staph epidermidis* and *Kurthia zopfil* (Table 14).
**Table(10): Reasons of livers condemnation.**

<table>
<thead>
<tr>
<th>Slaughter houses</th>
<th>Organs</th>
<th>Reasons of condemnation</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elkadro</td>
<td>Livers</td>
<td>Necrosis</td>
<td>10%</td>
</tr>
<tr>
<td>Ghanawa</td>
<td>Livers</td>
<td>Facsiola</td>
<td>2%</td>
</tr>
<tr>
<td>AlHuda</td>
<td>Livers</td>
<td>Necrosis</td>
<td>1.7%</td>
</tr>
<tr>
<td>Alsablooga</td>
<td>Livers</td>
<td>Necrosis</td>
<td>1.6%</td>
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</table>
Table (11) Reasons of lunges condemnation

<table>
<thead>
<tr>
<th>Slaughter houses</th>
<th>Organs</th>
<th>Reasons of condemnation</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elkadro</td>
<td>Lunes</td>
<td>Pneumonia</td>
<td>5%</td>
</tr>
<tr>
<td>Alsablooga</td>
<td>Lunes</td>
<td>Pneumonia</td>
<td>3.7%</td>
</tr>
<tr>
<td>Ghanawa</td>
<td>Lunes</td>
<td>Pneumonia</td>
<td>2.3%</td>
</tr>
<tr>
<td>Alhuda</td>
<td>Lunes</td>
<td>Pneumonia</td>
<td>0.6%</td>
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</tbody>
</table>
### Table (12) Reasons of hearts condemnation

<table>
<thead>
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<th>Organs</th>
<th>Reasons of condemnation</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elkadro</td>
<td>Hearts</td>
<td>Cysticercus</td>
<td>5%</td>
</tr>
<tr>
<td>Ghanawa</td>
<td>Hearts</td>
<td>Adhesion</td>
<td>0.2%</td>
</tr>
<tr>
<td>Alsablooga</td>
<td>Hearts</td>
<td>Adhesion</td>
<td>0.2%</td>
</tr>
<tr>
<td>Alhuda</td>
<td>Hearts</td>
<td>Adhesion</td>
<td>0.1%</td>
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</table>
Table(13) Reasons of heads condemnation

<table>
<thead>
<tr>
<th>Slaughter houses</th>
<th>Organs</th>
<th>Reasons of condemnation</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elkadro</td>
<td>Heads</td>
<td>Abscess</td>
<td>5%</td>
</tr>
<tr>
<td>Alhuda</td>
<td>Heads</td>
<td>Abscess</td>
<td>0.7%</td>
</tr>
<tr>
<td>Ghanawa</td>
<td>Heads</td>
<td>Abscess</td>
<td>0.6%</td>
</tr>
<tr>
<td>Alsablooga</td>
<td>Heads</td>
<td>Abscess</td>
<td>0.3%</td>
</tr>
</tbody>
</table>
Table (14) Gram–positive bacteria isolated from fresh carcases, chilled carcases and after unloading carcases from refrigerated vehicle at the air port:

<table>
<thead>
<tr>
<th>Gram- positive species</th>
<th>Fresh carcases</th>
<th>Chilled carcases</th>
<th>After unloading carcases from refrigerated vehicle at the air port</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Staph epidermidis</em></td>
<td>12 (16%)</td>
<td>-</td>
<td>2 (4%)</td>
</tr>
<tr>
<td><em>Micrococcus luteus</em></td>
<td>8 (10.7%)</td>
<td>5 (10%)</td>
<td>7 (14%)</td>
</tr>
<tr>
<td><em>Kurthia zopfi</em></td>
<td>6 (8%)</td>
<td>8 (16%)</td>
<td>11 (22%)</td>
</tr>
<tr>
<td><em>Micrococcus roseus</em></td>
<td>5 (6.7%)</td>
<td>3 (6%)</td>
<td>-</td>
</tr>
<tr>
<td><em>Micrococcus Kristinae</em></td>
<td>2 (2.7%)</td>
<td>6 (12%)</td>
<td>5 (10%)</td>
</tr>
<tr>
<td><em>Aerococcus viridians</em></td>
<td>-</td>
<td>7 (14%)</td>
<td>5 (10%)</td>
</tr>
<tr>
<td><em>Micrococcus varians</em></td>
<td>-</td>
<td>6 (12%)</td>
<td>7 (14%)</td>
</tr>
</tbody>
</table>

* As percentage of total samples examined from fresh carcases (75 samples), chilled carcases (50 samples) and after unloading carcases from refrigerated vehicle at the air port (50 samples).

All samples taken from Alsablooga slaughter house show growth like these,
from the fresh carcases there was 35 samples showed bacterial growth out of 75 samples. From the chilled carcases there was growth in 35 samples out of 50 samples. From the after unloading carcases from refrigerated vehicle at the airport there was growth in 40 samples out of 50 samples.
Sudanese mutton is famous for its high quality. This is attributed to its freedom of chemical and hormonal residues as well as its low fat contents. These properties made it on the top of the Sudan exports to many countries all over the world including gulf countries, Egypt and Jordan. Exportation of slaughtered animals, meat (beef, mutton) constitutes a great contribution to the Sudanese national economy (Ministry of Foreign Trade, 2003). Therefore, maintaining high standards of hygiene in the abattoirs is a matter of a paramount importance. Generally, maintained good hygienic levels are by continuous monitoring to establish a hygiene base and to ensure the quality of the products (Sofas, 1994). Poor meat hygiene practices in slaughterhouses before and after slaughter would lead to meat contamination and its products. FAO/WHO (1962) and Thornton (1968) emphasized that meat hygiene should be observed at all stages of meat productions till it reaches the consumer as fresh/sound, whole some and safe meat (from farm to table). Most of the meat contaminations caused by aerobes. These organisms may gain access to the meat from the systems of the living animal or as a result of slaughter contamination (Lawrie, 1979). This study was designed and conducted to highlight the hygiene situation in four major slaughterhouses in Sudan. A retrospective data pertaining to the facilities and manpower of these slaughterhouses were collected. It was obvious that these slaughterhouses were well equipped with good logistic facilities as premises, numbers of halls, laboratories, refrigerators …etc. The manpower, namely the veterinarians, technical staff and labors seem adequate and fairly trained to perform the job of slaughtering in a moderately hygienic status. Also data concerning the reasons of condemnation of meat following slaughtering were collected during 2007. In the year 2007, the major causes of condemnation of organs (liver, lung, head, heart ) were recorded as follows: Livers (Faciolasis and necrosis), Lungs (pneumonia, aspiration pneumonia), Hearts (Cysticercus, adhesion) and Heads (abscess). They can also be of low significance as organs like liver, lung, heart, tongue and head are
not usually prepared for slaughtering. Similar findings were reported by many research workers who are concerned with quality and hygiene Sudan e.g. Darien (2008).

Alsabalooga slaughterhouse was also selected for collection of swab samples to examine carcasses for bacterial contamination at different stages in this study.

Aerobic bacterial species isolation was tried. Out of the 175 swab samples, 110 (62.9%) samples showed bacterial contamination where as 65 (37.1%) showed no bacterial contamination. We believe that this is not serious as all the bacterial organisms isolated were not known to be pathogenic for humans.

Bacterial isolated from meat carcasses intended for export include Staphylococcus, Micrococcus, Kurthia, and Aerococcus.

In our findings, Micrococcus has the highest rate of isolation and this organism is widely distributed in humans, animals, soil, water and food (Omer, 1990).

Results obtained regarding the contamination rate showed that bacteria isolated from samples taken from the slaughter hall, slaughterhouse chills and car refrigerators are 46.6%, 70% and 80%, respectively. This indicates that the meat contamination is acquired after animals slaughterhouse and increase when meat is sent for export. Again, this is not of great value to the consumer as those organisms are not pathogenic.

As conclusion, the four slaughterhouses used for meat export are fairly good in the hygiene. That is justified by the facts that these slaughterhouses are well equipped with materialistic and human facilities. Good laboratory equipments are available there. In addition, no major pathogenic bacteria were isolated from the swab samples tested during this study.
Recommendations

1. More advanced training program for meat inspectors and meat handlers is required.
2. Provision of advanced technical equipments.
3. Regular sterilization of tools used in slaughtering, dressing is very important.
4. Use of hygiene program and HACCP in slaughterhouse lead to improve quality of our export meat.
REFERENCES


APPENDICES
Figure 1: Antemortem inspection
Figure 2: routine meat inspection
Figure 3: sheep carcases in the refrigerated vehicle
Table (15) Biochemical properties of Gram-positive bacteria isolated from fresh carcasses, chilled carcasses and after unloading carcasses from refrigerated vehicle at the air port

<table>
<thead>
<tr>
<th>Bacteria species</th>
<th>Biochemical Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Oxidase</td>
</tr>
<tr>
<td>Staph epidermidis</td>
<td>-</td>
</tr>
<tr>
<td>Micrococcus luteus</td>
<td>+</td>
</tr>
<tr>
<td>Kurthia zopfil</td>
<td>-</td>
</tr>
<tr>
<td>Micrococcus roseus</td>
<td>+</td>
</tr>
<tr>
<td>Micrococcus kristinae</td>
<td>+</td>
</tr>
<tr>
<td>Aero Coccus viridians</td>
<td>-</td>
</tr>
<tr>
<td>Micrococcus varians</td>
<td>+</td>
</tr>
</tbody>
</table>

O.F = Oxidation fermentation
V.P. = Voges – proskauer reaction
W = Weak
O = Oxidation
F = Fermentation
+ = Positive
- = Negative
Table (13) Biochemical Properties of Gram-Positive Bacteria isolated from fresh carcases, chilled Carcases and after unloading Carcases from
## Refrigerated Vehicle at the Air Port

<table>
<thead>
<tr>
<th>Gram-positive species</th>
<th>Biochemical Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Oxidase</td>
</tr>
<tr>
<td>Staph epidermidis</td>
<td>-</td>
</tr>
<tr>
<td>Micrococcus Luteus</td>
<td>+</td>
</tr>
<tr>
<td>Kurthia zopfil</td>
<td>-</td>
</tr>
<tr>
<td>Micrococcus roseus</td>
<td>+</td>
</tr>
<tr>
<td>Micrococcus Kristinae</td>
<td>+</td>
</tr>
<tr>
<td>Aero Coccus viridians</td>
<td>-</td>
</tr>
<tr>
<td>Micrococcus varians</td>
<td>+</td>
</tr>
</tbody>
</table>

O.F = Oxidation fermentation  
V.P. = Voges – proskauer reaction  
W = Weak  
O = Oxidation  
F = Fermentation  
+ = Positive  
- = Negative