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Application of Some Food Safety Measures

(ISO22000/HACCP) in Food establishment in Khartoum state

تطبيق بعض معايير سلامة الغذاء 22000 ISO **و** HACCP **في المنشآت الغذائية**

بولاية الخرطوم

BY

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DEDICATION

In the name of God, most merciful.

This work is dedicated with mercy to the soul of my late parents.

To my lovely family

&

To my brothers and sisters

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All thanks are to God for giving me courage to complete this work.

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ABSTRACT

Meat handling facilities are under increased consumer and regulatory pressures to improve the microbiological safety of perishable raw meat.

The aim of this study was to assess the effect of personal hygiene on microbial contamination of sheep carcasses before and after treatment at slaughterhouse in Khartoum state. A total of 600 swab samples were collected from different operational points namely; skinning, evisceration and washing especially from the site of neck, shoulder, brisket and rump. For these samples, the Total Viable Count (TVC) was recorded before and after treatment by putting on protective clothes (aprons, gloves, masks, boots and hair covers). In addition 80 swabs samples were also taken from hands of workers and their knives before and after washing by water and liquid soap after each step in the slaughtering operation. The results revealed that there was reduction in the bacterial counts according to the anatomical site of sampling at operational points with range of 2.39± 1.03 log10 cfu/cm^2, 2.30±1.11 log10 cfu/cm^2 and 2.35±0.98 log10 cfu/cm^2 in the neck after treatment ($p \leq 0.05$). The viable counts of the workers hands reduced to 2.23±0.99 log10 cfu/cm^2, 2.12±1.33 log10 cfu/cm^2, 2.12 ±1.01 log10 cfu/cm^2 at different operational points. The presence of bacteria in the meat in the slaughterhouse indicated unhygienic handling. The reduction of total viable count after treatment indicates the value of implementation of personal and general hygiene.

This study revealed only two species of bacteria which were *E.coli* and *Salmonella* spp. *E.coli* and *salmonella* were isolated in all operational (post skinning, evisceration and washing).

This cross-sectional study was conducted to evaluate the knowledge, attitudes and practices of food workers in Khartoum state. A questionnaire was designed for random selection. Results indicated that the respondents had acceptable level of knowledge, excellent attitudes and poor practices toward food hygiene measures. Almost all of the participants (90-93.3%) agreed with various statements in the attitude part of the questionnaire. Good hygienic practices of food

workers revealed that 93.3% wearing aprons, but 90% were agreed of using masks. The management of the slaughterhouse facilities should be used because they responsible for maintenance of hygienic standards. Food will be safe and a number of food borne diseases will be eradicated.

ملخص الاطروحة

هذه الدراسة أجريت في احد مسالخ القطاع الخاص بولاية الخرطوم التى تعمل في مجال صادرات لحوم الضأن وذلك لتحديد أثر تطبيق مواصفة سلامة الغذاء بالتحديد اساسيات النظافة الشخصية للعاملين في خط الانتاج على العد البكتيرى في جسم الذبيحة . تم أخذ حوالى 600 عينة بواسطة مسحات من مناطق مختلفة من جسم الذبيحة (العنق, الكتف, الصدروالردف) فى . (ثلاثة من مراحل تجهيز الذبيحة (بعد السلخ ,بعد تفريغ الاحشاء وبعد الغسيل

لهذه العينات قبل وبعد المعالجة بلبس الملابس الواقية (TVC)) تم تسجيل العد البكتيرى (بالطوطى,قفازات, كمامات, أحذية واقية وأغطية رأس) كما أخذت 80 عينة أخرى من أيدى

العاملين والسكاكين المستخدمة فى العمليات الانتاجية المختلفة قبل وبعد كل عملية بغسلها بالماء والصابون السائل وأوضحت النتائج أن هناك إنخفاضاً فى أعداد البكتريا وفقاً للمنطقة التشريحية والعملية الانتاجية, ففى العنق بعد المعالجة كانت :

(2.39±1.03 log10 cfu/cm^2, 2.30±1.11 log10 cfu/cm^{2,} 2.35±0.98 log10 cfu/cm^2) ((p≤ 0.05.

وفى أيدى العاملين انخفضت الى:

2.23±0.99 log10 cfu/cm^2, 2.12±1.33 log10 cfu/cm^2, 2.12 ±1.01 log10 cfu/cm^2))

دققت هذه الدراسة في وجود نوعين من البكتيريا ,الايكولاى والسالمونيلا وقد تم عزلها في كل مراحل تجهيز الذبيحة (بعد السلخ, بعد تفريغ الاحشاء وبعد الغسيل).

اجريت هذه الدراسة ايضاً لتقييم معرفة ومواقف وممارسات عمال المسلخ وفق اختيار عشوائى. اشارت النتائج بأن المشاركين أظهروا مستوى مقبول من المعرفة, مواقف ممتازة وممارسات سيئة نحو اجراءات سلامة الغذاء. إتفق جميع المشاركين تقريباً (90- 93%) مع مختلف البيانات فى الجزء الخاص بالمواقف وكشفت الممارسات الصحية الجيدة للعمال أن 93% يرتدون البالطو و 90% إتفقوا فى لبس الأقنعة.

إدارة المسلخ هى المسئولة عن الحفاظ على المعايير الصحية والحصول على غذاء آمن والقضاء على الأمراض المنقولة بالغذاء.

CONTENTS

CHAPTER TWO

List of tables

Introduction

Contaminated food is one of the most widespread public health problems of the contemporary world and it causes considerable morbidity and mortality. Globally, millions of people are affected by food-borne disease. Rooney and Wall 2003).

During the 1980s, some of the government production agencies asked NAS/NRC (National Academy of Science/ National Research Council) to form a committee that would generate some general principles for the application of microbial criteria in foods. At this committee proposed the implementation of HACCP in food protection programs.

The National Codex Committee participates internationally in setting food safety standards, which could eventually lead to international standardization of meat safety standards (Sierra Leone Standards Bureau, 2005). HACCP was jointly developed in the USA by the Pillsbury Corporation and the United State Army Laboratories as a system that would provide a degree of certainty that food was free from pathogens and toxins (Crosland, 1997). The HACCP system principles make up the Codex standard which has become the reference for international food safety and identified as the baseline for consumer protection under the agreement of Sanitary and phytosanitary measures agreed at the General on Tariffs and Trade (GATT) negotiations in Effective food 1995 (Slatter,2003).

HACCP has a proven track record for identifying and preventing contamination and combines common sense with science to ensure safer food production. It is very complementary to Total Quality Management (TQM) and quality assurance (Herrera, 2004).

As an increasing amount of food products are traded internationally, standards such as ISO 22000 become crucial for giving consumers confidence that the food they come in contact with is safe. The goal of ISO 22ooo is to provide one internationally recognized standard for a food safety management system that can be applied to any organization in the food chain. The first step to developing a Food Safety Management System in slaughterhouse is to implement pre-requisite programmes, i.e. Good Manufacturing Practices (GMP) and Good Hygienic practices (GHP). (Huss, 2003) ISO 22000 has been aligned with ISO 9001 in order to enhance the compatibility of the two standards.

The Food Safety Management System should cover organizational and technical issues address the needs of the consumer and are based on the concept of continuous assessment and participation of all employees working in the slaughterhouse (Jouve, 2000). The standards of inspection must be established by the government while the control of quality is in the hands of the processer (Pyke, 1971).The hygienic status of dressed carcasses is largely dependent upon the general slaughterhouse hygiene and the skills of the workers. Training, knowledge of food safety issues and communication skills of slaughterhouse workers were evaluated to identify their role in the contamination of carcasses (Ann et al., 2006).Traditional and conventional methods of meat hygiene do not match the international standards. Extrinsic or environmental parameters are known factors to have direct effect on microbial quality of food (Jay, 2005. Hobbs and Roberts, 1993).Bacteria causing diseases or spoilage of meat may be carried and transmitted to surfaces and food by workers handling the food product. Dirty hands, workers clothes and slaughterhouse equipment may act as intermediate source of meat contamination. Accordingly, washing and sanitizing agents are effective in reducing bacterial population and the presence of pathogenic bacteria on carcasses (Thornton and Gracey, 1976; Gill, 2004., Abdelsadig, 2006., Ali, 2007., Abdalla *et al.*, 2009b). Proper training of workers and inspectors is a pre-requisite for an efficient food control system. There is a continuing need for training and upgrading the knowledge and skills of workers and inspectors. Careful frequent hand-washing will do much to reduce contamination. Therefore hand-washing facilities must be sufficient and water supply must be adequate. In general, most of meat processing plants in Sudan were operating in poor condition which was negatively affected the safety and quality of food (Ali, 2007).

Objectives:

To evaluate the food safety management system implemented in representative red meat slaughterhouse in Khartoum state.

To provide insight into the actual microbiological results achieved with implementation of personal hygiene in slaughterhouse.

To protect the consumers from diseases transmitted through red meat.

Chapter one

Literature Review

1.1 General Quality Management

Total quality management (TQM) consists of three qualities: Quality of return to satisfy the needs of the shareholders, quality of products and services to satisfy some specific of the consumer (end consumer) and quality of life at work and outside work to satisfy the needs of the people in the organization. http//servicedesk unimelb.edu.au

Powell (1995) who made the points of total quality management can be traced to 1949, when the Union of Japanese scientists and engineers formed a committee of scholars, engineers, and government officials devoted to improving

Japanese productivity, and enhancing their post-war quality of life” and “American firms began to take serious notice of TQM around 1980.”

Bemowsky (1992) stated that the term TQM was initially coined in 1985 by the Naval Air Systems Command to describe its Japanese-style management approach to quality improvement. Perhaps, the main reason for the origin of the term TQM could be a substitution in the previously used term of Total Quality Control (TQC), the word “control” by “management” with the reasoning that quality is not just a matter of control, it has to be managed.

Feigenbaum (1956) defined TQC as “an effective system for integrating the quality-development, quality maintenance, and quality-improvement efforts of the various groups in an organization so as to enable production and service at the most economical levels which allow for full customer satisfaction”. Definition of TQC or Company Wide Quality Control (CWQC) is: “Quality control consists of developing, designing, producing, marketing, and servicing products and services with optimum cost-effectiveness and usefulness, which customers will purchase with satisfaction. To achieve these aims, all the separate parts of a company must work together” (Ishikawa, 1990)

Deming (1986) stressed the importance of management’s role, both at the individual and company level, in the delivery of quality. About 80-90% of quality problems were under management’s control, emphasizing organization-wide cultural change and worker/management cooperation as the path to achieving high quality. Juran (1951) noted that the majority of quality problems are the fault of poor management, not poor shop- floor workers, and that long term training to improve quality should start at the top with senior management.

Crosby (1980) defined cost of quality as the price of conformance and non-conformance, where the price of conformance is that which is needed to ensure things turn out right, and the price of non-conformance is the expense incurred in doing things wrong. This concept is more readily understood by the manufacturing sector because of the need to comply with specifications and standards set by the company or customers. In large companies the cost of quality is important to justify the considerable investment incurred in a process of continuous quality improvement (Dale *et al.*, 1990).

Main (1994) emphasized that TQM is not a management tool but an overall way of managing. Ishikawa (1985) referred to it as the "thought revolution" of management. Wilkinson *et al., (*1998*)* referred to TQM as the "innovation in management practice" of the late 1980s and 1990s. Indeed, TQM is a management system to continually improve quality in every aspect of the organization involving everyone in the organization to satisfy internal and external customers.

Dale and Boaden (1994) reported that the process of quality improvement cannot be successful without the efforts of people, either individuals or teams. The absence of company-wide employee commitment accounts for 80% of TQM failures. The standards of inspection must be established by the government while the control of quality is in the hands of the operators (Pyke, 1971). Oakland (1989b) described employee participation as the involvement of every single person in the company regardless of position or location. Conducting the Employee Motivation Survey prior to the implementation of TQM is important because it accurately identifies the company's position in relation to the requirements of TQM and the changes needed to secure TQM success through employee motivation (Kondo, 1991). Employees must be motivated to ensure quality in their own work. This, coupled with management's commitment to make resources available to help employees improve their work processes and quality, will lead to a definite and permanent decrease in the cost of quality.

Wilkinson (1994) identified TQM as having two sides -a "hard" and "soft" side. Whilst the "hard" side emphasizes TQM tools and techniques, the "soft" side emphasizes employee involvement and commitment. The human factor is responsible for the culture change required for successful TQM implementation. Hill (1991) defined the TQM culture as that which nurtures trust and respect for individuals, building a shared belonging to the company and drive for continuous improvement for the benefit of the company and individual. Total quality consists of three qualities: Quality of return to satisfy the needs of the shareholders, Quality of products and services to satisfy some specific needs of the consumer (end consumer) and Quality of life – at work and outside work to satisfy the needs of the people in the organization.

Gardial (1993) defined customer satisfaction as the positive or negative feeling about the value received through the use of an organization's product or services. This reaction applies to both immediate use situations and to overall reactions from a series of use situations.

TQM has led companies becoming highly competitive both locally and internationally through the production of quality products that meet customer requirements at the lowest cost, significantly increasing their market share and profitability (Phaik, 2000).

1.1.1TQM Model

A TQM model is proposed by the authors who were based on the concepts of TQM Oakland (1989b), Flood (1993) Dale *et al* (1990), and the quality gurus. The concepts are classified into the following five areas:

1) Management leadership and employee participation in the new philosophy (Deming, 1986). Make quality the concern of everyone in the company (Crosby, 1980; Crosby, 1984; Feigenbaum, 1991).
2) Emphasis on meeting the requirements of both the internal (Crosby, 1980; Feigenbaum, 1991) and external customer (Ishikawa, 1985).
3) Eliminate non-conformance. Ensure conformance to standards, specifications and requirements. Have zero defect standard of performance. Reduce the costs of appraisal, prevention and failure (Crosby, 1984; Feigenbaum, 1991).
4) Use statistical and quantitative control methods. Problem solving using Quality Control Circles, the Shewart / PDCA cycle, Quality Assurance. (Ishikawa, 1985; Deming, 1986)
5) Search continually to improve processes and products (Deming, 1986). Quality is a continuous program (Crosby, 1980; Feigenbaum, 1991).

A definition of TQM using the 5 Pillars is: A system of quality management consisting of the 5 Pillars of management commitment, customer focus, quality costs, quality systems and continuous improvement to ensure that a company meets customer requirements at the lowest cost and continually improves its processes, products and services via the use of creative techniques and innovation (Phaik, 2000).

A warning was given by Oakland (1989a) who said that "management's commitment to TQM must be real and obsessional, not lip service. It is possible to detect real Commitment; it shows on the shop floor, in the offices, at the point of operation". MacDonald (1992) suggested that lack of management commitment was the most common reason for the failure of TQM.

A central principle of total quality management is that mistakes may be made by people, but most of them are caused, or at least permitted, by faulty systems and processes. This means that the root cause of such mistakes can be identified and eliminated, and repetition can be prevented by changing the process (Gilbert, 1992).

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 that 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. Total quality consists of three qualities: Quality of return to satisfy the needs of the shareholders, quality of products and services to satisfy some specific needs of the consumer (end consumer) and quality of life – at work and outside work to satisfy the needs of the people in the organization.

The main goal of applying HACCP plans in abattoirs is to ensure that animals are slaughtered and dressed under conditions that mean the meat will carry minimal public health risk. (FAO, 2004).

The HACCP is a food management system, but HACCP systems are also recognized for assessing and managing food-borne diseases where the approach to control is prevention (Brashear's, *et al.,* 2001).According to Mackey and Roberts (1993) it was 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 the carcass meat.

Food Safety and Inspection Service (U.S.D.A.,1997) emphasized that, processing operations were presently required to have sanitation standard operation procedures (SSOP) and functional hazard analysis critical control points(HACCP) system , to improve food safety through purchase requirement.

According to Stringer (2005) it is extremely difficult for any government body or international agency to quantify the level of risk that a society is willing to tolerate or accept or even to specify who has the ultimate responsibility and legitimacy to make such a decision. As soon as such an appropriate Level of Protection (ALOP) (WTO 1995) is found in a society it can be used to derive acceptable amounts of hazards to be present at the consumer level. These called food safety objectives (FSO) (CAC 2005) and formulated per product and hazard and can be regarded as a functional link between the overall goal formulated as ALOP and practical instruments in HACCP (Swarte and de Donker 2005). Food Safety Inspection Services defined a hazard as biological, chemical or physical property that might cause food to be unsafe for human consumption (U .S.D.A., 1997).

The ISO standards applicable to the abattoir industry include ISO 9001-2000, HACCP, and ISO 22000: 2005 (Holt and Henson, 2000). Especially in low-processed products such as fresh meat, there is almost no site at which microbial hazards can be eliminated. Thus, only hygiene concepts using the basic HACCP methodology can be developed (Upmann and Jacob, 2004). HACCP principles with food safety and inspection services (FSIS) can maintain or even improve food safety and other consumer protection conditions relative to traditional inspection methods (Cates *et al.,* 2001*).*

ISO 22000 was expected to be available as an International Standard in 2005 (Faergemand and Jespersen, 2004). ISO circulated the final draft of the standard to the national standard bodies that make up its membership for a 2-month voting period, ending on 5 July 2005. The standard can be applied on its own, or in combination with other management system standards such as ISO 9001:2000, with or without independent (third party) certification of conformity (Frost, 2005). The working group that developed ISO 22000 has representatives from14 countries and input from 13 others representing all continents. In the working group, there are also representatives from organizations such as the Codex Alimentarius, the global food safety initiative (GFSI) and the confederation of food and drink industries of the European Union (CIAA).

The food safety management system should cover organizational and technical issues address the needs of the customer and are based on the concept of continuous assessment and participation of all employees working in the slaughterhouse (Jouve, 2ooo). Pre-operational and operational sanitation standard operating procedures (SSOPs) should minimize direct and indirect contamination of meat to the greatest extent possible and practicable. A properly implemented SSOP system should ensure that facilities and equipment are clean and sanitizes prior to start of operations, and appropriate hygiene is maintained during operations. SSOP guidelines may be provided by the competent authority, which may include minimum regulatory requirements for general sanitation. In September 2005, the international organization for standardization (ISO) had published the ISO 22000:2005standard-food safety management systems-requirements that is applicable to any organization in the food chain". This standard integrates the requirements defined by ISO 9001 and the methodology used by HACCP (Sofia, 2011).

The ISO 9001:2000 standard is a quality management standard complied with in order to demonstrate quality assurance of products produced in an organization (SABS, 2001). The ISO recently merged the ISO 9001:2000 and HACCP standards to form the ISO 22000:2005 standard: Food safety management systems – Requirements (SABS, 2005*)*. It is a food safety management system designed to allow all types of organizations within the food chain, including abattoirs to implement. (SABS, 2005*)*. Benson and Saraph (1991) proposed a system-structure model of quality management that related to organization context, actual quality management, ideal quality management, and conformance quality. Their results suggested that organizational context influences manager's perceptions of both ideal and actual quality management. Important contextual variables are corporate support for quality, past conformance quality, managerial knowledge, and the extent of external quality demands (Adam and Moss 1997).

1.2 Food Safety

Food safety remains a critical issue with outbreaks of food borne illness resulting in substantial costs to individuals, the food industry and the economy (Kaferstein, Motarjemi, & Bettcher, 1997).

Each year, unsafe food makes at least 2 billion people ill worldwide, or about one third of global population (NIAID, 2007). 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). A variety of methods has been developed to reduce the level of contaminating bacteria on carcasses, although most of the current methods focus on washing and sanitizing procedures (Dickson and Anderson, 1992).

In Sudan the problems of slaughterhouses are due to poor waste disposal systems and environmental sanitation, lack of workers training and understanding of the importance of sanitation (Ibrahim, 1989).

Buzby and Roberts (1999) found that food safety behaviors and perception of risk vary greatly among people from different countries because of differences in available technology, food production practices, cultural differences, and geographic differences. Insufficient food safety practices are major contributors to the transmission of food borne illness (Mitchel *et al.*, 2007)

Food safety is inseparably linked to food quality and food safety and recognized as the main criterion and the main driving force of food quality efforts (Knura *et al.* 2006; Luning *et al.* 2006). The importance of food safety knowledge has increased with the increase in food borne illness and the emergence of new pathogens (Tonova, 2001; Haapala and Probart, 2004). Thus, knowledge and awareness are essential in reducing food borne outbreaks and illnesses that continue to occur among all consumers (Kendall *et al.*, 2003).

Everyone in the food system, from producers to consumers, must recognize the need for vigilance in controlling microbiological hazards to reduce the risk of food borne illness (Knabel, 1995).

Public awareness of food safety issues has increased dramatically worldwide (Shareen, 2004). Recently in developing countries the pressure of growing human populations, the globalization of the food trade, combined with increased food contamination sources, renders individual attempts in assuring food safety ineffective (UN,WHO 2005)

There are many countries round the world adapted laws for hygienic practice in slaughterhouse (Hess and Lott 1970; Dickson and Anderson, 1991; Schutz, 1991). According to Gracey (1985) the public health role is to safeguard the community against hazards from meat and to provide these products in good quality. Public awareness of food safety issues has increased dramatically worldwide (Shareen, 2004), and more recently in developing countries (UN, 2005). Consumers now demand higher quality food that is assured through production in facilities adhering to strict food safety system (UN, WHO2001).

Contaminated food is one of the most widespread public health problems of the contemporary world and it causes considerable morbidity and mortality. Food poisoning can be very serious in vulnerable groups such as the elderly, infants, young children, pregnant women and immune – compromised individuals (Rooney and Wall, 2003). A variety of methods has been developed to reduce the levels of contaminating bacteria on carcasses, although most of the current methods focus on washing and sanitizing procedures (Dickson and Andreson.1992).

Food Safety quality is best assured by an integrated, multidisciplinary approach, considering the whole of the food chain (OIE, 2011). Food quality should no longer be associated with the product alone but should be extended to the production process itself (Noordhuizen and Metz, 2005).The food safety programs have to be integrated into Quality Management Systems (Knura *et al,* 2006). Quality management systems and, as part of it, quality assurance systems and food safety management systems were set up to contribute to food safety along the food chain *(*Caswell *et al.,* 1998; Petersen, 2003; Luning *et al.,*2006).

Food safety is inseparably linked to food quality and food safety is recognized as the main criterion and the main driving force of food quality efforts *(*Knura. 2006*;* Luning *et al.* 2006). Food safety, synonymous with food hygiene, embraces anything in the processing, preparation or handling of food to ensure it is safe to eat. The food chain, like any other chain, is only as strong as its weakest link and the responsibility for food safety lies not only with producers processors of food, but also governments and consumers themselves (Griffith, 2000).

The socioeconomic impact of food borne illness includes loss of productivity, loss of income, loss of trade, loss of food as a result of condemnations (DHSA, 2000).

1.3Meat Hygiene

The abundance of nutrients in meat favours the growth of microorganisms, and so renders meat perishable (Subratty and Gurib, 2003). Meat has thus tradionally been a vehicle for a significant proportion of human food-borne diseases. Therefore the need to reduce the risk of food-borne diseases through formal control systems is no longer seen as optional but mandatory (CAC, 2003). The necessity for an efficient national food control system thus arises not only from public health considerations, but also from trade and economic implications (Hugas and Tsigarida, 2008). Traditional and conventional methods of meat hygiene do not match the international standards. Extrinsic or environmental parameters are known factors to have direct effect on microbial quality of food (Jay, 2005., Hobbs and Roberts, 1993). Only healthy, clean and appropriately identified animals should be presented for slaughter (CAC/RCP, 2005). The internal tissues of healthy slaughtered animals are free from bacteria at the time of slaughter (Jay, 2000). It is necessary to study and asses the influence of social traditions and religion in the community and also the economical and environmental conditions in a particular area for achieving the goals of meat hygiene programs (Kaplan, 1957). In response to the increasing number of food borne illnesses, governments all over the world are intensifying their efforts to improve food safety (Orriss and Whitehead, 2000; Anonymous, 2002).

The main objective of meat hygiene and inspection is to prevent meat spoilage and meat borne infections. The meat hygiene, inspection and control practices are based on the concept of transmissibility of diseases through either consumption or handling of meat (Ibrahim, 1990). Results of Arain *et al. (*2010) concluded that the fact of unhygienic and poor sanitary condition under which meat was handled and sold at local meat shops/stalls. The standards of inspection must be established by the government while the control of quality is in the hands of the processor (Pyke, 1971).

According to Thornton (1968) (FAO/WHO, 1954) the efficient meat hygiene practices begin in the farm. It should be maintained in the animal collection centers, markets, during transportation of animals for slaughter, in abattoirs, during transportation of animals to butcheries and even at the consumer home.

Salih (1969) proposed that in order to improve the standards of meat hygiene the laws should be revised in the study of animals resources in order to include meat hygiene and regulation. Microbial contamination of animal carcasses is a result of the necessary procedures required to process live animals into retail meat. The contamination can be minimized by good manufacturing processes, but the total elimination of food borne pathogenic microorganisms is difficult, if not impossible.

The slaughterhouse is the initial point at which micro-organisms translocate from the environment to the product also the point at which food-borne pathogens would be introduced into the carcasses (Gregory, 1996; Hechelmann, 1995; Kapsrowiak and Hechelmann, 1992; NACMCF, 1993).

As a general rule, slaughterhouses and meat establishments must fulfill the protection of products from external contamination and to follow hygienic standards (Havas, 1995). The hygiene in slaughterhouse should be improved in order to reduce further the number of microorganisms. Control of a simple time course should be maintained in every operation in order to record the seasonal effects (Sumner *et al.*, (2003).

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 (Sofos, 1994). It is possible for bacteria on the instruments used in slaughtering to contaminate some deep tissues through the blood stream (Mackey and Derrik, 1979).

1.4Slaughterhouse Processes

1.4.1Skinning

The hide and viscera of animals entering a slaughter facility are potential sources of contamination of carcasses with pathogenic bacteria (Grau 1987). Large populations of microorganisms are present on the hide and fleece and composed of normal resident skin flora eg. Micrococci, staphylococci and organisms including salmonella derived from the environment (soil, pasture, feaces). (Kloos, 1980). Cutting the skin around the anus and freeing the anal sphincter and rectal end of the intestine are major source of carcass contamination with *E.coli* and *salmonella* of the perianal and rectal channel than the hind leg or brisket (Grau, 1986). *Salmonella* can often be found on the hands and equipments of the workers (Smeltzer *et al,* 1980, Stolle, 1981). In one study in Germany, the highest contamination of carcasses with *salmonella* was associated with removal of hooves and freeing of the skin around the legs (Stolle, 1981). Levels of carcass contamination have been found to be associated with levels of physical contaminants such as mud or feces on the hide (Elder *et al.*, 2000).

Bacteria number is high on region of carcass where the initial manual removal of the skin takes place and lowest where skin is mechanically pulled away *(*Kelly *et al.,* 1980). Gill, (1998) demonstrated that incision through the hide and skinning operations are both critical in determining contamination levels of beef carcasses. Ali (2007) recorded high contamination level on flank site and lower contamination level on rump sites during skinning.

In both sheep and cattle it have been shown that dressed carcasses from animals with dirty hides were of no worse hygienic condition than those from animals with relatively clean hides (Biss and Hathaway, 1996*;* Van Donkorsgoed *et al* 1997*).* The skin and hair of livestock harbor many bacteria as well as the gastrointestinal tract and digesta (Korber *et al.,* 1997*).* The majority of bacteria occurring on carcasses are deposited on the surface during dressing operations, and that these bacteria originate largely from the hides of animals (Grau, 1986).

1.4.2Evisceration:

Incision of lymph nodes can contaminate the hands, knives of workers and *salmonellae* can then spread to edible tissues. *Salmonellae* are occasionally present inside livers, significant contamination of liver surface occurs during evisceration and separation from other viscera, and from the hands and knives of workers (Thomas and Mc Meckin, 1981).

Hussein (1971) isolated bacteria from fresh meat in gastro-intestinal tract and hides of the slaughtered animals and the water, halls and air deposits. Contamination of sheep carcasses by evisceration process reported by Gill (1998) and the microorganisms increased in the abattoirs compared by their post flaying level. The results of Amine *et al. (*2013) revealed that after evisceration the bacterial count is high due to fecal contamination and the neck is most contaminated site. The main sources of contamination during the slaughter are slaughtered animals, the environment and the labors (Sheriden, 1998). Wahib (2004). Found that the surface region of neck and hind limb had the highest rate of contamination compared to all parts of the carcass.

The microbiological contamination of carcasses occurs mainly during processing and manipulation, such as skinning, evisceration, storage and distribution at slaughterhouses and retail establishments (Gill, 1998; Abdalla *et al.,* 2009a*).*

1.4.3 Washing

Washing remove some bacteria and redistribute some organisms from one site to another. The effectiveness of washing varies with temperature, pressure and volume of water and the design of the system and time spent (Elrasheed, 2007). Washing with water at less than about 40-50c tends to give relatively small and variable reductions in bacterial contamination. Bacterial counts at more highly contaminated sites may be reduced, while counts are unchanged at sites with an initial low level of contamination *(*Kelly *et al.*, 1981).

Slaughterhouses and meat establishments must fulfill two requirements: The protection of products from external contamination and to follow high-hygienic standards and the facilitating of the slaughter and butchering of animals so as to economically and efficiently produce meat for the market (Havas, 1995). Microbial contamination of animal carcasses during slaughtering is an unavoidable problem in the conversion of live animals to meat for consumption (Dickson and Anderson 1991). The hygiene in slaughterhouses should be improved in order to reduce further the number of microorganisms. (Sumner *et al.,* 2003).

There has been some indication that bacteria become entrapped in muscle fibers, rendering them inaccessible to antimicrobial treatments (Pohlman *et al.,* 2002*)*. Decreasing the amount of pathogens in the live animal should decrease the occurrence of the pathogen in the food supply and reduce the risk of food-borne illness to consumer *(*Jordan *et al.,* 1999).

The bacterial load at the surface of sheep carcasses is essentially to evaluate that to cope with the international standards *(*Elhassan *et al.,* 2011). The word meat is defined as the parts of the hygienically slaughtered animal intended for human consumption. This definition insuring the importance of hygiene in the process of slaughtering of animals and emphasizing on the (importance) intention of the slaughter for human consumption (Lawrie, 1979).

Gill (2004) reported that wholesome meat which is hygienically produced, is pathogen free, retains its natural state and nutritive value, ensures to maintain a degree of microbial contamination control and is unconditionally acceptable to the consumer. The presence of various bacteria on meat is an indication of low standard levels of animals, the handling of meat from pre-slaughter to post-slaughter, abattoir facilities and sales of meat *(*Obeng *et al,* 2013).

One of the most common causes of food borne illness is cross contamination: the transfer of bacteria from food to food, hand to food, or equipment to food (Zain and Naing, 2002). Fecal matter was a major source of contamination and could reached carcasses through direct deposition, as well as by indirect contact through contaminated and clean carcasses, equipment, workers, installations and air (Borch and Arinder, 2002). Slaughter operations, such as bleeding, dressing, and evisceration, may expose sterile muscle to microbiological contaminants that are present on the skin, the digestive tract, and in the environment (Gill and Jones, 1997; Bacon *et al,* 2000*;* Abdalla *et al.*, 2009a*;* Abdalla *et al.*, 2009b).

Total counts are not a reliable indicator of hygienic performance with respect to safety (Gill and Baker, 1997). The types of microorganisms and extent of contamination present on the final product are influenced by sanitation procedures, hygienic practices, application of food safety interventions, type and extent of product handling and processing, and the conditions of storage and distribution (Sofos 2005).

1.5 Hygiene of slaughterhouse workers

Contamination of meat carcasses has pointed to many sources including abattoir workers (Wagude, 1999). The Food Safety Management System should cover organizational and technical issues address the needs of the consumer and are based on the concept of continuous assessment and participation of all employees working in the slaughterhouse (Jouve, 2000).

The high incidence of food borne illnesses has led to an increase in global concern about food safety. Several food borne-disease outbreaks have been reported and associated with poor personal hygiene of people handling foodstuffs *(*Altekruse *et al.,* 1998., Bryan, 1988; Shapiro *et al.*, 1999). Worker mishandling of food is one of the major causes of food borne disease outbreaks (WHO, 2000).

Food handlers have a major responsibility in the prevention of contamination associated with food spoilage and food poisoning during the production and distribution of food and, if personal hygiene is unsatisfactory, they may cross-contaminate raw and processed foodstuffs or a symptomatic carriers of pathogenic organisms may contribute to the spread of disease (Walker *et al.*, 2003).

According to Johns (1991) personal hygiene can be defined as follows: ‘‘as clean as is reasonably practical of hands, forearms, neck, hair and any clothing liable to come into contact with food. Personal hygiene is critical in preventing contamination of food and food borne illness, they must wash their hands properly to prevent contaminating other foods, and surfaces they touch. (Medeiros *et al.*, 2001). Koopmans and Duizer (2004) indicated that contamination of food could occur anywhere in the "farm-to-fork" continuum, but most of food borne illnesses can be traced back to infected persons who handle food improperly. Workers at food chain may transmit pathogens to food from a contaminated surface, from another food or from hands contaminated with organisms from their gastrointestinal tract.

For many years there have been requirements regarding the clothing and personal hygiene of workers, if properly enforced, these should control contamination from workers' bodies (Kasprowiak and Hechelmann, 1992; Restaino and Wind, 1990). 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 work stations; 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 waste water ducted to drains (Brendan *et al.,* 2006).

Slaughter and dressing of animals, and handling and inspection of meat, presents many opportunities for cross-contamination. Personal hygiene practices should prevent under general contamination, and prevent cross-contamination with human pathogens that may cause food-borne disease (CAC/RCP, 2005).

There is approved association between slaughter practice and hygienic practice of the workers (Gerats, 1990). The washing and disinfestations with hot water rarely take place, and both hygienic disposition and easy access to hygienic facilities were important for hygienic behavior in slaughterhouse (Gerats *et al.*, 1982; Stolle and Reuter 1989; Abdalla *et al*., 2009a; Abdalla *et al.,* 2009b).

Operator's knives are used to separate the skin from underlying hock and skin become heavily contaminated, as do their knives, steels and clothes.

Salmonellae can often be found on the hands and equipments (Smeltzer *et al*, 1980, Stolle, 1981).

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 (Sheena and Stiles, 1982; Ayliffe *et al*., 1987; Nicoletti *et al*., 1990)

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 (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. Contamination can occur from the preparation of various types of foods by persons with rotavirus-contaminated hands (Ansari *et al.*, 1991). Transmission to hands may take place through cross-contamination of foods and utensils when food workers process raw foods *(*Coates *et al*., 1987).

(Powell *et al*., 1997*)* emphasize the importance of training food handlers, but studies have shown that food-borne disease outbreaks still occur despite training given to food handlers Hands, arms and fingers of food employees may become contaminated with fecal microorganisms after using the toilet. These organisms include salmonellae, *E. coli*, *Staphylococcus aureus* (Snelling, 1991),

The FDA (2009) reported that food borne illness risk factors in selected institutional foodservice, restaurant, and retail food store facility. (Types*,* 2004) identified risk practices and behaviors that contributed to food borne illnesses: improper holding/time and temperature; poor personal hygiene; contaminated equipment /prevention of contamination. Many studies found that food safety training is positively associated with self-reported changes in food safety practices

(Clayton *et al*., 2002; McElroy and Cutter, 2004), and improved attitudes (Wie and Strohbehn, 1997).

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(Brendan *et al.*, 2006).

Food workers play a critical role in ensuring food safety, those who do not practice proper personal hygiene, including hand washing at the appropriate times and using appropriate methods, can contaminate food (Clayton *et al*., 2002; McElroy and Cutter, 2004).

Duration of hand washing is important for mechanical action as well as to allow sufficient contact time with antimicrobial products (Larson, 1995). 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).

In terms of food establishments, the main purpose of wearing gloves is to prevent pathogenic organisms from being transmitted to foods via hand contact from food workers. An intact vinyl or latex glove (i.e., one with no punctures, tears, or holes) will provide protection from transmission of contaminating microorganisms from hands (Paulson, 1996). The use of gloves alone does not provide a sufficient barrier against transmission of pathogenic microorganisms from food employees to consumers (Fendler *et al*., 1998). Hand washing was strongly encouraged prior to gloving (Snyder, 1997; Fendler *et al.*, 1998; Paulson, 1996) and after removal of gloves (Larson, 1995; Doebleling *et al*., 1988; Olson *et al.*, 1993).

According to Bardell (1995), it is not uncommon for gloves to be worn for long periods of time without being changed and it is not unusual for food employees to put gloved hands to their mouths or noses without changing their gloves.

There have been requirements regarding the clothing and personal hygiene of workers. If properly enforced, these should control contamination from workers' bodies (Kasprowiak and Hetchelmann, 1992; Restaino and Wind, 1990).

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).

The hygienic condition of the dressed carcass is largely determined by the skill with which workers remove the hide and gut. Dressing can be performed equally hygienically with the carcass supported on a cradle, as in past practice (Nottingham *et al*.1974; Hudson *et al.* 1983).

Upgrading dressing line facilities cannot be expected to improve dressing hygiene, unless there is a simultaneous improvement in working practices (Hudson *et al*. 1983). 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 (Thornton and Gracey, 1976; Gill, 2004). Jeffery *et al.*, (2003) noted that the workers hands and the equipment were the sources of meat contamination. There were significant increases in total bacterial counts at skinning points than that at washing operations; also, dirty workers hands, clothes and equipments of the slaughterhouse acted as intermediate sources of contamination of meat (Gill, 1998*;* Gilmour *et al*., 2004; Abdelsadig, 2006; Abdalla *et al*., 2009b).

Gerats (1990) approved the association between slaughter practice and hygiene practice of the workers. The washing of hands and disinfestations with hot water rarely take place, and both hygienic disposition and easy access to hygienic facilities were important for hygienic behavior in slaughterhouse *(*Gerats *et al.*, 1982; Stolle and Reuter 1989; Abdalla *et al*, 2009a; Abdalla *et al*, 2009b).

According to Gordon-Davis (1998) one of the a major risks of food contamination originates from the working practices of food handlers and disease-causing micro-organisms present in or on the food handler's body are subsequently transmitted from the food handler to the food during the handling process.

Mart *et al.,* (2000) highlight the education of food handlers as a crucial line of defense in the prevention of most types of food borne illnesses. To ensure that staff members conform to personal hygiene requirements two issues must be considered: the environment within which the staff operates and the ''quality'' of the staff members. From food hygiene point of view the quality of the working environment depends on the facilities or equipment provided, which include toilets and protective clothing. The quality of staff depends upon their health, their hygiene and their habits (Johns, 1991).

The increasing incidence of food borne diseases has been assigned too many different factors, including population growth, changes in food preparation habits, a rise in the number of food-service establishments, increased consumption of food outside the home and a lack of food safety training and education among consumers and food handlers (Motarjemi and Käferstein, 1999). Worker mishandling of food is one of the major causes of food borne disease outbreaks (WHO, 2000).

Because outbreaks often lead to severe economic losses, food handler training is an important business strategy for managing food safety risks. Moreover, food handler training is seen as one strategy by which food safety can be increased, offering long-term benefits for the food industry (Smith, 1994).

The human body is a reservoir for numerous microorganisms, with hands being the main agents for cross contamination within a food handling establishment (Gordon-Davis, 1998). Jay (1996) reported that the hands of food handlers generally reflect the environment and also the habits of an individual.

The final step in hand-washing is drying. All the respondents indicated that they used disposable paper towels for this purpose. The usage of disposable paper towels is recommended due to its single use followed by disposal, which eliminates the possibility of cross-contamination (Hobbs and Roberts, 1993).

Van Zyl (1995) proposed that the overalls, hairnets (beard nets if applicable), hardhats, gumboots and aprons should at all times be worn by meat handlers. Because the purpose of wearing overalls is to protect both the food product and the meat handler from cross contamination, because meat handlers are probable sources of contamination from micro-organisms, it is important that all possible measures be taken to reduce or eliminate such contamination (Mortimore and Wallace, 1994)

Hobbs and Roberts (1993) emphasized the importance and advantages of having on-site health services especially in large food handling establishments, with a large work force. According to Jacob (1989) routine medical examinations of food handlers are of little value because they merely reveal the health status of the worker at a specific point in time.

Small and Lues (2003) explained that food handlers must undergo medical examinations before employment to assess the general health of the food handler. However, Jacob (1989) suggested that routine medical examinations are regarded as not being cost-effective and, in fact, unreliable.

1.5 **Training of the meat handlers on personal hygiene practices**

The Manpower Services Commission (1981) defined training as ‘a planned process to modify attitude or skill behavior through learning experience to achieve effective performance in an activity or range of activities’.

Gracey (1986) suggested that effective sanitation programmes should be started by identifying the needs, then set up detailed cleaning instructions for all areas and equipment. Meanwhile all workers in the slaughterhouse must receive proper training in general, environmental and personal hygiene.

Workforce management has to be guided by the principles of: training, empowerment of workers and teamwork. Adequate plans of personnel recruitment and training have to be implemented and workers need the necessary skills to participate in the improvement p rocess. Ahire *et al.* (1996). Criteria that may be used for evaluating the effectiveness of a training programme include reaction to training, knowledge acquisition, changes in job-related behavior and performance and improvements in organizational-level results (Kirkpatrick, 1967).

Employees must be trained to use the seven quality tools, which are: process flow charts, tally charts, histograms, Pareto analysis, scatter diagrams and control charts.

When problem solving teams such as quality control circles, work improvement teams and cross-functional teams are formed, team members must be trained in the appropriate techniques and tools as well as team-building (Dale and Boaden, 1994).

Improper training could present a higher risk to food safety than no training at all (Mortlock *et al*., 2000). Proper training of food handlers is one of the cornerstones of the HACCP program and should be part and parcel of an operation's basic employee training (Norton, 2002).

Continuous Improvement is the continual search for excellence and customer satisfaction. Both of these escalate and evolve into ever higher standards and greater expectations so that any company wanting to rank among the market leaders must actively engage in this Pillar of TQM to improve growth and productivity. Employees need to actively participate in "weeding out the last bug from a produce and process" and management must give "workers the opportunity to use their brains and make a contribution to the improvement of their companies" (Lillrank and Kano, 1989).

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

Management should ensure that all staff are medically fit, adequately trained in both personal and food hygiene practices, and wearing clean, protective clothing when entering or working on the food premises (South African Bureau of Standards, 2001), Kitcher (1994) and Tebbutt (1992) identified correlations among management's attitude toward training, levels of hygiene knowledge, and standards of food-handling practice. Food hygiene training is therefore crucial in food safety and an essential part of the HACCP concept (Walker *et al.*, 2003).

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. The food business operators should ensure that food handlers are supervised and instructed and/or trained in food hygiene matters and have received adequate training in the application of HACCP principles (CAC, 2003).

Training and education of food handlers regarding the basic concepts and requirements of personal hygiene plays an integral part in ensuring a safe product to the consumer , Adams and Moss (1997), reported that To ensure this, there should be some form of induction training with regular updating and refresher courses for the food handlers.

Gould (1994) reported that all food handlers must have participated in a training programme in personal hygiene, good manufacturing practice, cleaning and disinfection procedures before starting to work in the plant.

Many studies pinpoint the need for training and education of food handlers in public hygiene measures due to their lack of knowledge on microbiological food hazards, temperature ranges of refrigerators, cross contamination and personal hygiene (Bas *et al.* 2004; Nel *et al.* 2004). When employees have a better understanding of surface-borne and carcass-borne pathogens, the incidences of recontamination and cross-contamination will be limited (Korber *et al.*, 1997).

Education on food safety should be given to all staff in food processing businesses so as to bring behavioral changes besides adoption of positive attitudes (Coleman and Roberts 2005; Powell *et al.* 1997). But in some previous studies no differences were detected between the staff who attended an educational course with those who did not (Angelillo *et al*. 2001; Askarian *et al.* 2004). This statement was supported by several studies *(*Howes *et al.* 1996; Powell *et al*. 1997) and indicates that although training may increase the knowledge of food safety; this does not always produce a positive change in food handling attitudes. Meanwhile, Ehiri and Morris (1996) pointed out that knowledge alone is not sufficient to promote positive attitudes and safe behaviors among food handlers.

It is impossible to ensure that food will be free from contamination in the food chain given that disease etiological agents have many opportunities to enter the food system. However, Morrone and Rathbun (2003) indicated that risks along the food chain can be minimized through educating consumers and employees on safe food handling. Without knowledge of food safety practices and proper food handling procedures, food borne illnesses cannot be reduced (Redmond & Griffith, 2003).

Meat handlers should furthermore understand the risks associated with contamination of food by microbiological agents, and should be trained to avoid the contamination of the meat. Ryser and Marth (1991) concluded that the training and education should be directed towards a thorough understanding of food hygiene, which includes aspects of sanitation.

In the slaughtering units, the carcasses' contamination with pathogens can occur mostly in the steps of skinning and eviscerating, respectively in the cases of meat manipulation by the operators in the cooling and delivering steps, if the good manufacturing practices (GMP) and good hygiene practices (GHP) are not strictly followed (Gill, 1986; Abdalla *et al.,* 2009b).

For many years there have been requirements regarding the clothing and personal hygiene of workers, if properly enforced, these should control contamination from workers' bodies (Kasprowiak and Hechelmann, 1992; Restino and Wind, 1990).

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).

The training of frontline management in supervisory and leadership was suggested as an important factor in changing the way supervisors treat workers, and in turn the way co-workers were likely to treat each other. Learning to communicate better with each other also had been particularly useful. (Kent and Mike, 2010).

Edwards *et al*. (1979) reported that the slaughter of animals in abattoirs of developing countries was carried out in unsuitable buildings by untrained slaughter men and butchers that were unaware of sanitary principles.

Medeiros *et al.,* (2004) found that improving food safety knowledge and belief through training had a positive effect on food handling practices.

Training helps to improve overall employee knowledge of food safety (Costello *et al*., 1997; Finch and Daniel, 2005; Howes *et al.*, 1996; Roberts *et al.*, 2008) although others have found that training is not consistently associated with improved knowledge (Luby *et al*., 1993). Chapman *et al.*, (2010) observed the influence of a food safety information sheet on practices within the foodservice environment.

Results showed that the information had a positive impact on food handler behaviors. Food workers play a critical role in ensuring food safety, those who do not practice proper personal hygiene, including hand washing at the appropriate times and using appropriate methods, can contaminate food. The FDA Report on the Occurrence of Food borne Illness Risk Factors in Selected Institutional Foodservice, Restaurant, and Retail Food Store Facility (Types, 2004). According to Taylor (1996) most food poisonings result from food handler error, which may be mitigated with food safety training. These factors may be directly controlled and influenced by food handlers. Therefore, Food Handler Certification courses are beneficial because they provide participants with the knowledge to identify and mitigate the risks that may contribute to food borne illness *(*Ministry of Health and Long Term Care, 1998*)*.

Salih (1969) noted that there is lack of proper training of the various staff members working in the meat inspection services. He suggested that programmes should be formulated to improve their academic and technical abilities, and also suggested the establishment of a meat research center where data pertaining to meat hygiene could be collected and analyzed.

Management must satisfy themselves that the staff-training programme is adequate to ensure that operatives have the appropriate level of knowledge, skills and ability to carry out their work in a hygienic manner (Brendan *et al.,* 2006*).*

The law's implementation recognizes education of food handlers as a crucial line of defense in the prevention of food borne illnesses (Sun and Ockerman, 2005; Legnani *et al.,* 2004*;* Worsfold, 2004; Mart-ínez-Tomé *et al*., 2000*).*

1.7 Ecoli and Salmonella at slaughtering process

Meat is a major reservoir for *E. coli* O157:H7, which is carried in the intestinal tract of healthy animals and excreted in faeces (Chapman *et al.* 1993).

Other organisms of concern to meat processors throughout the red meat supply chain include spoilage microorganisms and pathogens such as *Salmonella enterica*, *Listeria Monocytogenes and Clostridium perfringens*. All these may be found in the faeces and on the hides of cattle presented for slaughter (Reid *et al.* 2002; Nightingale *et al.* 2004; Fegan *et al.* 2005a; 2005b) and can be transferred to the carcass during harvest, particularly through hide removal and evisceration (Bell 1997). Omer (1990) noticed that the presence of *E.coli* in large numbers in food indicated faecal contamination.

Meat and its products were known to be potential source of food poisoning by *salmonella* (Hubbbert *et al,* 1975). The incidence of *salmonellae* on sheep carcasses varies widely. Sometimes they are rarely found while sometimes they can be found on close to half of the carcass and times on all carcasses (Grau and Smith 1974). At slaughter, *salmonellae* were detected more frequently in mesenteric and caecal lymph nodes from the younger animals (Wray, *et al.*, 1995).

When sheep awaiting slaughter were held for 7 days, the incidence of *salmonellae* on the fleece, in the rumen and in the feaces are increased with time of holding (Grau and Smith 1974). The hide and fleece can carry considerable numbers of salmonellae. Grau and Smith (1974) found 200 salmonellae/cm^2 on sheep fleece.

According to a study by Scott and Bloomfield (1990), if surfaces are contaminated with low numbers of organisms (120 organisms/cm^2) such as *E. coli, Salmonella, and S. aureus,* contact with fingers can transfer organisms in sufficient numbers to pose a potential infection hazard. Alaboudi (1989) reported that seven different bacteria: *E.coli, klebsiella; proteus; pseudomonas; salmonella; shigella* and *staphylococcus* were isolated from raw and cooked meat as well as from hands of food handlers and utensils.

Zahra *et al* (1985) found that *E.coli* was the most predominant bacterium in fresh meat. *Ecoli0157* has been found in the feaces of cattle and sheep (Dorn and Angrick, 1991). According to Ajit and Misra (1990) *salmonella* was isolated from lymph nodes of slaughtered sheep. The isolates from muscles included *Escherichia coli, proteus, pseudomonas, klebsiella* and *citrobacter.* Brahmbhalt and Anjaria (1993) isolated Escherichia coli from raw meat and Amanie (2000) isolated *E.coli* from meat at all stages of processing.

Dorsa *et al*., (1995) discussed how fecal contamination on carcasses protects the included bacteria by providing additional moisture which affects the collagen, lipids, and proteins on the carcass.

The selection of *Ecoli* is justified from its established position as an indicator of fecal contamination and on the assumption that the pathogens associated with meat are largely of fecal origin (USDA/ FSIS, 1996). The most pressing food safety issues in the food industry nowadays are due to the presence of *E. coli* O157:H7 and salmonellae in raw meat and poultry products and in produce (Sperber, 2005).

Following the reviews of the *E. coli* O157 outbreaks, a full investigation was conducted by an independent committee who made some excellent recommendations regarding the control of the hazard in slaughterhouses (Pennington, 1997, Bell and Kyriakides, 2000b).

Livestock are common carriers of Salmonella spp. and can easily transmit the pathogen to non-carrier animals through fecal shedding (Berends *et al.*, 1996). The ability of the Salmonella to survive in an environment with a low water activity increases with an increase in temperature (Tamblyn, 1995). Salmonella and *E. coli* O157:H7 are the main target organisms in contemporary fresh meat production. Studies have shown that most contamination of faecal origin occurs during hide/skin removal and evisceration processes (Newton *et al.* 1978; Bell 1997; Sofos. 1994), and is best removed immediately, before bacteria attach firmly to the meat surface.

The important role of good hygienic practices for controlling *Salmonella* throughout animal husbandry, slaughtering processes and the further processing of raw meat and raw meat products has long been well understood and was well addressed by a World Health Organization Expert Committee on *Salmonellosis* Control (WHO, 1988). The types of microorganisms and extent of contamination present on the final product are influenced by sanitation procedures, hygienic practices, application of food safety interventions, type and extent of product handling and processing, and the conditions of storage and distribution (Sofos, 2005).

Large numbers of *E.coli*, streptococci and aerobic spore forming bacteria on the hands of food handlers were identified (Minch and Horward, 1951). *E. coli* counts increased on hands that were not washed prior to gloving (Paulson, 1996). This occurred after glove changes at one-hour and three-hour intervals. No significant growth of contaminating microorganisms was found on hand surfaces after 3 hours of consecutive glove wearing when hands were effectively washed prior to gloving (Paulson, 1996). Hands themselves can also be contaminated with organisms found on the glove surface.

Enteric pathogens that are believed to be capable of being transmitted by food workers, but are not limited to: *E. coli*, hepatitis A virus, *Salmonella* spp., *Shigella* spp., and *Clostridium perfringens* (Paulson, 1994; Restino and Wind, 1990). The brisket is a site which is usually considered as a dirty site in terms of total bacterial contamination. Cutting the skin around the anus and freeing the anal sphincter and rectal end of the intestine are major source of carcass contamination with *E.coli* and *salmonellae* in the operation of releasing the anal sphincter and rectum of sheep, the operator may handle the anus and with his hand then handle the exposed tissue of the hind leg after the anal sphincter and the rectum are cut free, there can be about 100 fold increase in *E.coli* and a significant increase of salmonellae on sheep carcasses without any detectable increase in the total aerobic viable count(Grau, 1986).

Dicksone (1988) and Hennlick and Verny (1990) emphasized that hygienic measures promote the quality and safety of meat and increase its shelf life. Heuvelink *et al* (2001) noted that a greater awareness of the importance of good hygienic practices among slaughterhouse, personal hygiene and governmental meat inspection.

Only healthy, clean and appropriately identified animals should be presented for slaughter (CAC/RCP, 2005), and the internal tissues of healthy slaughtered animals are free from bacteria at the time of slaughter (Jay, 2000). Primary production is a significant source of hazards associated with meat. A number of hazards are present in animal populations intended for slaughter and their control during primary production, often presents considerable challenges, e.g. *E.coli 0157:H7*, *Salmonella spp. Campylobacter spp* and various chemical and physical hazards. A risk – based approach to meat hygiene includes consideration of risk management options that may have a significant impact on risk reduction when applied at the level of primary production. Many aspects of slaughter and dressing procedures have the potential to result in significant contamination of meat, e.g hide/feather removal, evisceration, carcass washing, post-mortem inspection, trimming and further handling in the cold chain. Effective process control requires design and implementation of appropriate systems. Industry has the primary responsibility for applying and supervising process control systems to ensure the safety and suitability of meat, and these should incorporate prerequisite GHP and HACCP plants as appropriate to the circumstances.CAC/RCP, (2005). Mead (1994) found that the two important stages that have the greatest impact on carcass contamination of red meat are the evisceration process involving the removal of the internal organs including the intestines and the flaying process involving the removal of the hide or fleece. Thorntone (1968) found that to produce meat of good keeping quality, all attempts should be made to dress and handle carcasses in a manner which reduce bacterial contamination to the minimum possible. The main objective of meat hygiene and inspection is to prevent meat spoilage and meat borne infection. The meat hygiene inspection and control practices are based on the concept of transmissibility of diseases through either consumption or handling of meat (Ibrahim, 1989).

Goetzsche (1958) reported on meat hygiene water supply was often a problem in the Sudan. The long journey travelled by meat animals and the dirt on their bodies affect their condition and health and create many problems of microbiological origin. Problems of slaughterhouses are due to poor waste disposal systems and environmental sanitation, lack of workers training and understanding of the importance of sanitation (Ibrahim, 1989).

In the meat industry, the microbiological quality of carcass meat depends mainly upon hygienic slaughter and dressing processes (Shale, 2006). The risk of carcass contamination is increases if animals are dirty when presented for slaughter (Hilton, 2002).

Haines (1933); Empey and Scott, (1939) found that the sources of the bacterial contamination of meat are hides , hooves , soil adhering to the hide , intestinal content , air , water supply , knives , sews , hooks , floors and workers. Fraizer and Westhof (1988) emphasized the importance of contamination from external source during bleeding, skinning and cutting; these include the knives, air, hands, and clothes of the workers.

Contaminating bacteria on the knife would soon be found on meat in various parts of the carcass as it carried by the blood. The contamination of carcasses 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 (Fraizer 1967). The major source of carcass contamination is contact with the skin during hide removal or contamination by spillage of stomach contents during evisceration (Humphrey and Jorgensen, 2000). As a follow up, the risk of carcass contamination can emade during the course of the skinning process but mostly during the evisceration process, in the case of improper manufacturing and hygiene practices (Davies, 2011).

Kregelj and Soban (2001) pointed out that the principles sources of bacterial contamination (anaerobic, proteolytic, spores, psychrophilic and parasites) at the abattoir were skin of animal, feaces, slaughterhouse overalls, hands and knives. Carcass dressing and evisceration processes constitute critical points in the microbial contamination of muscle for which corrective measures need to be implemented (Bacon *et al*, 2000; Abdalla *et al*; 2009a; Abdalla *et al*., 2009b).

Jericho *et al*., (2000) concluded that the control of aerosols in the hide removal floor should be treated as a critical control point. Pre-evisceration and associated work's materials are critical points for carcass (Guyon *et al*., 2001). Elder, (2000) suggested that the sanitary procedures within the processing plants were effective in reducing the prevalence of carcass contamination from pre-evisceration to post evisceration processing.

Contamination can occur by direct contact between the hide and the carcass or by transfer from workers' hands, clothes, tools or factory equipment, which have had previous contact with the hide (Bell 1997). Peel and Simmons (1978) showed that Salmonella were more prevalent and more numerous on the knives of workers working with the hide than on the knives of those involved in working with the carcass after the hide had been removed.

Chapter Two
Materials and Methods

2.1 Area of survey

This survey was conducted to assess the effect of personal hygiene on microbial contamination of sheep carcasses before and after treatment at slaughterhouse in Khartoum state from December 2012 to February2013 in one of the private slaughterhouses which is utilized for export of mutton in Khartoum State.

2.2 Sampling:-

A total of 600 swab samples were collected from neck, shoulder, brisket and rump of 20 selected sheep carcasses before and after following food safety measures (wearing of gloves, aprons, masks and caps) at skinning, evisceration and washing. Carcasses sites were sampled by the swab technique (10cm × 10 cm), for which sterile cotton swabs with 0.1% peptone water. Also 80 swab samples were taken from the workers ' hands and their knives before and after washing using soap and water.

2.3 Bacteriology:-

Processing of the samples was conducted in Microbiology Laboratory of the college of veterinary medicine, Sudan University of Science and Technology. Test tubes containing swabs were shaking on a vortex mixer for 30 seconds for uniform distribution of microorganisms. Tenfold serial dilution up to 10^{-6} all the sample were prepared using sterile normal saline solution and the samples were processed for total viable count.

2.3.1Total viable count

For evaluating total viable count (TVC), the standard pour plate technique was followed using 10^{-4} and 10^{-5} dilutions. Sets of plates in duplicate were prepared for each dilution and after solidification of agar the plates were incubated at 37ºC for 24 h and counts were expressed as log10 cfu/cm^2. (Harrigan, 1998).

Detection of presence or absence of *E.coli* and *Salmonella* were enumerated using varies selective media employing spread or pour plate technique with 0.1 ml inoculums from 10^{-2} and 10^{-3} dilutions.

2.4 Culture media:

2.4.1 Blood agar

All media was prepared according to the manufacturer instruction, 40 grams of the base powder were added to one liter of distilled water. The solution was then boiled until the powder dissolving completely. The mixture was autoclaved at 120C° 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 in to Petri dishes and left to solidify. The poured Petri dishes were kept in the refrigerator (about 4C°) until it is used within one day.

2.4.2 MacConkey agar

The medium was prepared by dissolving 59 grams of powder in one liter of distilled water. The solution was swirled for ten minutes until the powder was dissolved completely. It was then sterilized by autoclaving for 15 minutes at 120 C° and 15 pound per square inch. The MacCkongy agar was cooled at 47C°, mixed well, pour in Petri dishes and left to dry by the partial exposure to the air at 37C°.

2.4.3 Nutrient agar

25 grams of powder were added to one liter of distilled water and boiled to dissolve the powder completely. It is sterilized by autoclaving for 15 minutes at 120C° and 15 pound per square inch.

2.5 Sterilization

2.5.1 Hot air oven:

This method was used for sterilization of clear glass containers, which were wrapped in paper or put in stainless steel cans; at temperature must be 160 C° for one hour (Stainer *et al*, 1986).

2.5.2 Sterilization by red heat:

Wire loop was held over flame as near and vertical as possible until it becomes red hot (Cruickshank *et al*, 1975).

2.5.3 Sterilization by autoclaving:

This method was used for sterilization of culture media and for materials that could not with stand the dry heat. The temperature was 115-121C^o under 10-15 pound pressure for 15-20 minutes (Barrow and Feltham, 1993).

2.6 Reagents:

2.6.1 Nitrate test reagent:

According to Cowan and steel (1974) two separate solutions were used. First of them the sulfanilic acid in 100 ml Acetic acid and other solution a; pha-naphthylamine which was prepared by dissolving 0.6 gram of N.N-dimethyle-1-naphylamine in 100ml acetic acid.

2.6.2 Potassium hydroxide and Alphnaphthol:

According to Cowan and steel (1974) the reagent prepared as 40% potassium hydroxide and 5% Alphnaphthol for use in voges-proskauer test V.P.

2.7 Diluents:

2.7.1 Physiological saline: It was prepared by dissolving 8.5 grams sodium chloride in one liter distilled water them dissolved and sterilized by autoclaving at 121c for 15 minutes under 15 pounds per square inch pressure (Cruickshank *et al*, 1975).

2.8 Culturing, microscopy and identification of bacteria

2.8.1 Primary culturing and purification:

Blood agar, macConkey agar and nutrient agar were used and streaked by swab samples and then incubated at 37c^o for 24 hours. The primary culture was examined for differentiation of colonies according to hemolysis, size. color, surface and shape. Different types of colonies were sub cultured in nutrient agar for purification and incubated at 37c^o for 24 hours.

2.9 Staining

Smears were prepared by emulsifying part typical and well isolated colony in a drop of sterile normal saline or distilled water and spread in a clean slide. The smears were then allowed to dry by air then fixed by gentle flaming; all smears were examined by Gram stain.

2.9.1 Gram stain:

Smears were placed on staining rack. They were covered by crystal violet for 1-2 minutes and washed off by tap water, then covered with logul's iodine for one minute and washed off by tap water, then decolorization with acetone for few seconds and washed off by tap water, then covered with diluted carbol fuchsin for 1-2 seconds. Finally the stained smears were washed and air dryed. Then they were examined under oil immersion lens (100x).The Gram positive and negative organisms shape and arrangement of organisms were identified according to Barrow and Felltham (1993).

2.10 Biochemical tests:

2.10.1 Urease test: A slope of urea agar medium was inoculated with the tested organism and incubated at 37 c° for 24 hours. A change of color to red indicated a positive reaction. (Monica Cheesbrought 2000).

2.10.2 Citrate utilization:

Inoculate Simon's citrate agar from a light suspension of the organism in quarter strength Ringer solution. Incubate at the optimum temperature for the test organisms. Growth of a blue color on the Simon's agar indicates a positive result (Monica Cheesbrough 2000).

2.10.3 Indole test:

Tube of tryptophane broth was inoculated and incubated for 24 hours at 35c°, tested by adding (o.2-o.3) ml Kovacs' reagent. Appearance of distinct red color in the upper layer was considered a positive test (Monica Cheesbrough 2000).

2.10.4 Oxidase test:

A piece of filter paper was soaked with a few drops of oxidase reagent. A colony of the tested organism was then smeared on the filter paper. Positive test was deep purple (Monica Chessbrough 2000).

2.11.5 Kliger's Iron Agar (KIA)

This is a differential medium. It tested for organisms' abilities to ferment glucose and lactose to acid and acid plus gas end products. It also allows for identification of sulfur reducers. If gas is produced as a result of glucose or lactose fermentation, then fissures will appear in the agar or the agar will be lifted off the bottom of the tube. Organism that can ferment glucose but not lactose will produce a red slant and a yellow butt in a KIA tube

If an organism is capable of using neither glucose nor lactose, the slant of the tube will be red and the color of the butt will remain unchanged.

KIA tubes are also capable of detecting the production of H_2S. It is seen as a black precipitate. Sometimes the black precipitate obscures the butt of the tube. In such cases, the organisms should be considered positive for glucose fermentation (yellow butt). (Monica Chessbrough 2000).

Questionnaire:

Questionnaires were filled by 30 workers who directly involved in slaughtering process in the abattoir. Each questionnaire was comprised three distinct parts; food hygiene knowledge, attitudes and practices. In the knowledge part, there were close-ended questions emphasizing personal hygiene, cross contamination, microbiological food hazards and specific foodborne diseases. Each question was provided by three possible answers (true, false and do not know). Subsequent part of the questionnaire was dealing with the attitudes of the responders about various hygienic measures for food safety. The handlers were asked to indicate their level of agreement to the statements using a three-point rating scale (agree, disagree and no idea). Practices of food workers were assessed by their self-reported hygienic behaviors in the last part of the questionnaire. In this part questions were provided with five-point rating scale (never, rarely, sometimes, often and always). Two additional questions concerning how often they consume or recommend the products of their working plants were also included in this part. The questionnaire was pilot tested on 10 abattoir workers' and amended for clarity with the addition of some answer options. Although the questionnaire was intended to be self-administered, some illiterate workers needed help in filling it.

Statistical analysis:

Statistical analysis was conducted using SPSS software for windows, version 11.5. Descriptive statistics were provided and Spearman's correlation coefficient was used to test the association between knowledge, attitudes and practices scores. *P*-value less than 0.05 were considered as statistically significant.

Chapter Three

Result

The mean total numbers of viable bacteria before and after treatment at operational points were: In the neck was 4.90+_ 1.62, 5.03+_1.62, 4.56+_1.34(Tables 1,2,3) but after treatment TVC was reduced to 2.39+_1.03, 2.30+_1.11, 2.35+_0.98, with statistical significance difference at p-value of <_0.5(Tables 4,5,6) but In the shoulder was 4.74+_1.63, 4.88+_1.49, 4.64+_1.43(Tables1,2,3) and after treatment TVC was reduced to 2.55+_0.95, 2.31+_0.93,2.14+_0.91, with statistical significance difference at p-value of <_0.5(Tables 4,5,6). In the brisket TVC was 4.90+_1.69, 4.96+_1.66, 4.68+_1.54(Tables 1,2,3) before treatment but reduced after treatment to 2.50+_0.91, 2.01+_1.01, and 2.20+ _0.90 with statistical significance at p-value of <_0.5(Tables 4,5,6).whereas In the rump TVC was 4.80+_1.62, 5.16+_1.62, 4.41+_1.39(Tables 1,2,3) and reduced after treatment to 2.62+_1.01, 2.37+_0.90, 2.04+_0.84 with stastical significance at p-value of <_0.5(Tables 4,5,6).

The mean TVCs on knives were 4.85+_1.48, 4.75+_1.90 post skinning and post evisceration respectively but after treatment was reduced to 2.17+_1.06, 2.17+_1.14 with significance difference at P-value of <_0.5. The TVCs of the workers hands at post skinning, post evisceration and post washing are 4.91+_1.57, 5.14+_1.55, 4.59+_1.45 and after treatment are 2.23+_0.99, 2.12+_1.33, 2.12+_1.01 with significance difference at P-value of <_0.5 (Table 8).

This study checked only two species of bacteria which were *E.coli* and *Salmonella* spp. *E.coli* and *salmonella* were isolated in all operational(post skinning, post evisceration and post washing). *E.coli* and *Salmonella* are Gram negative, red colored bacilli. (Table 9).

Thirty slaughterhouse workers were participated in this study. Table 10, 11 and 12 summarize the results regarding knowledge, attitudes and practices of respondents. Considering food workers' knowledge, almost all of them were aware of the critical role of general sanitary measures in the work place such as washing hands, using gloves, caps and aprons and proper cleaning of the instruments (97.9% correct answers, Table 10). Diarrhea, bloody diarrhea, brucellosis and typhoid were answered with correct options by 86.6%, 77.3%, 64.9% and 51.5% of respondents, respectively. However, correct responses about jaundice and abortion were generally low, ranging between 18.6% and 26.8% (Table 10). The knowledge of the study population about microbiological food hazards was generally lower than their knowledge of diseases. Their correct responses for Salmonella, Hepatitis A virus, Hepatitis B virus, Staphylococcus and Clostridium were 39.2%, 21.6%, 35.1%, 33% and 33%, respectively. Two questions were about the knowledge of respondents for necessity to take leave during infectious diseases of eye and skin. Their correct responses were 64.9% and 87.6%, respectively (Table 10).

Table (1) Mean and standard deviation of Total viable count of bacteria on skinning operation before treatment

Significanc e	) CFU/cm^2) Mean Log_{10} and Standard Deviation	Site
*	4.90± 1.62	**Neck**
NS	4.74±1.63	**Shoulder**
NS	4.90±1.69	**Brisket**
*	4.80±1.62	**Rump**

*Significant difference at P value of<0.05. NS not significant (P value of > 0.05).

Table (2) Mean and standard deviation of total viable count of bacteria on evisceration operation before treatment

Significance	(CFU/cm^2) Mean Log_{10} and Standard Deviation	Site
*	5.03±1.62	**Neck**
* *	4.88±1.49	**Shoulder**
* *	4.96±1.66	**Brisket**
*	5.16±1.62	**Rump**

*Significant difference at P value of<0.05. NS not significant (P value of > 0.05).

* * Highly significant difference at P value of <0.001

Table (3) Mean and standard deviation of total viable count of bacteria on washing operation before treatment

Significance	(CFU/cm^2) Mean Log_{10} and Standard Deviation	Site
*	4.56±1.34	**Neck**
*	4.64±1.43	**Shoulder**

* *	4.68±1.54	**Brisket**
* *	4.41±1.39	**Rump**

*Significant difference at P <0.05. * * Highly significant difference at P <0.001

Table (4) Mean and standard deviation of Total viable count of bacteria on skinning operation after treatment

Significance	**Mean Log_{10} and Standard Deviation (CFU/cm^2)**	**Site**
NS	2.39±1.03	**Neck**
NS	2.39±1.03	**Shoulder**
*	2.50±0.91	**Brisket**
* *	2.62±1.01	**Rump**

*Significant difference at P <0.05. NS not significant (P > 0.05).

* * Highly significant difference at P <0.001

Table (5) Mean and standard deviation of total viable count of bacteria on evisceration operation after treatment

Significance	Mean Log_{10} and Standard Deviation (CFU/cm^2)	Site
* *	2.30±1.1	**Neck**
* *	2.31±0.93	**Shoulder**
*	2.01±1.01	**Brisket**
NS	2.37±0.90	**Rump**

*Significant difference at P <0.05. NS not significant (P > 0.05).

* * Highly significant difference at P <0.001

Table (6) Mean and standard deviation of total viable count of bacteria on washing operation after treatment

Significance	Mean Log_{10} and Standard Deviation (CFU/cm^2)	Site
* *	2.35±0.98	**Neck**
* *	2.14±0.91	**Shoulder**
* *	2.20±0.90	**Brisket**
*	2.04±0.84	**Rump**

* * Highly significant difference at P <0.001

Table (7): Total viable counts (Log_{10} CFU cm^2) at different sites on carcasses, at different operational points before (control) and after treatment

Site	Operational points						
	Control			Treatment			Significant Difference
	Skinning	Evisceration	Washing	Skinning	Evisceration	Washing	
Neck	4.90±1.62	5.03±1.62	4.56±1.34	2.39±1.03	2.30±1.1	2.35±0.98	*
Shoulder	4.74±1.63	4.88±1.49	4.64±1.43	2.39±1.03	2.31±0.93	2.14±0.81	*
Brisket	4.90±1.69	4.96±1.66	4.68±1.54	2.50±0.91	2.01±1.01	2.20±0.96	*
Rump	4.80±1.62	5.16±1.62	4.41±1.39	2.62±1.01	2.37±0.90	2.04±0.84	*

*Significant difference at P <0.05.

Table (8): Total viable counts (Log_{10} CFU cm^2) on hands of the workers and knives before (control) and after treatment

Site	Operational points						
	Control			Treatment			Significant Difference
	Skinning	Evisceration	Washing	Skinning	Evisceration	Washing	
Hand	4.91±1.57	5.14± 1.55	4.59±1.45	2.23± .99	2.12± 1.33	2.12±1.01	*
Knives	4.85±1.48	4.75± 1.90	NS	2.17±1.06	2.17± 1.14	NS	*

*Significant difference at P <0.05.

This study revealed only two species of bacteria which were *E.coli* and *Salmonella* spp. They were isolated in all operations (post skinning, evisceration and washing)

Table (9) Bacteria isolated and identified (N %) at different sites on carcasses, at different operational points before and after treatment

N (%) Total	Salmonella		E.coli		
			Bacteria isolated		Skinning
	Post. N (%)	Pre. N (%)	Post. N (%)	Pre. N (%)	
19(6.7)	6(31.6)	5(26.3)	3(15.8)	5(26.3)	1.neck
19(6.7)	4(21.1)	2(10.5)	6(31.6)	7(36.8)	2.shoulder
16(5.7)	3(18.8)	4(25.0)	5(31.3)	4(25.0)	3.Brisket
19(6.7)	2(10.5)	3(15.8)	7(36.8)	7(36.8)	4.Rump
18(6.3)	1(5.6)	2(11.1)	7(38.9)	8(44.4)	5.Hand
12(4.2)	2(16.6)	2(16.7)	4(33.3)	4(33.3)	6.Knife
					Evisceration
13(4.6)	2(15.4)	1(7.7)	3(23.0)	7(53.8)	1.neck
17(6.0)	3(17.6)	3(17.6)	5(29.4)	6(35.3)	2.shoulder
17(6.0)	3(17.6)	2(11.8)	4(23.5)	8(47.0)	3.Brisket
17(6.0)	2(11.8)	2(11.8)	6(35.3)	7(41.0)	4.Rump
14(4.9)	3(21.4)	2(14.3)	3(21.4)	6(42.9)	5.Hand
16(5.7)	1(6.3)	2(12.5)	6(37.5)	7(43.8)	6.Knife
					Washing
18(6.3)	1(5.6)	1(5.6)	10(55.6)	6(33.3)	1.neck
20(7.0)	1(5.1)	4(20.0)	9(45.0)	6(30.0)	2.shoulder
18(6.3)	0(0)	2(11.0)	8(44.5)	8(44.5)	3.Brisket
17(6.0)	2(11.8)	2(11.8)	7(41.2)	6(35.3)	4.Rump
14(4.9)	4(28.6)	3(21.4)	5(35.7)	2(14.3)	5.Hand
284	40(14.1)	42(14.8)	98(34.5)	104(36.6)	**Total N (%)**

The count of *E.coli* was 10^4 organisms which represent 36.6% of the sum of
E.coli and salmonella (284 organisms), and the number of salmonella was 98 organisms, it represent 34.5% of the total number.
The highest contamination with *E.coli* was noticed on the neck post washing after treatment (55.6%), where as the lowest level was found on the neck post skinning after treatment (15.8%) .

The highest number of *Salmonella* was found on the neck post skinning after treatment (31.6), and the lowest level was recorded on the shoulder site post washing (5.1%).

The contamination of the workers hands reached a highest level of *E.coli* (44.4%) at the post skinning point before treatment and highest level of Salmonella (28.6%) at the post washing point after treatment.

An important observations in this study is the slight increase in the number of *E.coli* post washing, this may be due the contaminated water used for the washing process. Potable water is an essential requirement in the quality assurance of meat produced at the abattoir. Adeyemo et al. (2002) *Salmonella* was not detected on the brisket post washing.

Table (10) Food safety knowledge among 30 food workers at abattoir in Khartoum state

Statements	Responses, n (%)		
	True	**False**	**Do not know**
Washing hands before work reduces the risk of food contamination	28(93.3)	2(6.7)	
Using gloves during work reduces the risk of food contamination	27(90)	1(3.3)	2(6.7)

Statements	Responses, n (%)		
	True	**False**	**Do not know**
Proper cleaning and handling of instruments reduces the risk of food contamination	28(93.3)	2(6.7)	
Eating and drinking in the work place increases the risk of food contamination	23(76.7)	1(3.3)	6(20)
All persons, including children, adults, pregnant women and old-ages are at equal risk for food poisoning	15(50)	6(20)	9(30)
Typhoid can be transmitted by food	17(56.7)	4(13.3)	9(30)
Jaundice can be transmitted by food	22(73.3)	2(6.7)	6(20)
Diarrhea can be transmitted by food	23(76.7)	4(13.3)	3(10)
AIDS can be transmitted by food	12(40)	4(13.3)	14(46.7)
Brucellosis can be transmitted by food	24(80)	4(13.3)	2(6.7)
Bloody diarrhea can be transmitted by food	18(60)	6(20)	6(20)
Abortion in pregnant women may be induced by foodborne disease	16(53.3)	4(13.3)	10(33.3)
Salmonella is among the foodborne pathogens	22(73.3)	4(13.3)	4(13.3)
Hepatitis A virus is among the foodborne pathogens	23(76.7)	2(6.7)	5(16.7)
Hepatitis B virus is among the foodborne pathogens	21(70)	3(10)	6(20)

Statements	Responses, n (%)		
	True	**False**	**Do not know**
Staphylococcus is among the foodborne pathogens	17(58.6)	5(17.2)	8(24.2)
Clostridium botulinum is among the foodborne pathogens	19(63.3)	4(13.3)	7(23.3)
The correct temperature for refrigerator is	24(80)	6(20)	
During infectious disease of skin, it is necessary to take leave from work	28(93.3)	1(3.3)	1(3.3)
During infectious disease of eye, it is necessary to take leave from work	23(76.7)	3(10)	4(13.3)

Almost all of the participants in the study (92–99%) agreed with various statements in the attitudes part of the questionnaire. Small percentages were disagree (1–3%) or did not have any idea (1–5%) about some of the statements (Table11).

Table (11) food safety attitudes among 30 food workers at abattoir in Khartoum state

Statements	Responses, n (%)		
	Agree	**Disagree**	**No idea**
One of the most important responsibilities of the food handlers is washing hands to food safety measures	23(76.7)	6(20)	1(3.3)
Using gloves is important in reducing risk of food contamination	25(83.3)	5(16.7)	0.00
Using apron is important in reducing risk of food contamination	25(83.3)	5(16.7)	0.00
Using masks is important in reducing risk of food contamination	27(90)	1(3.3)	2(6.7)
Using caps is important in reducing risk of food contamination	24(80)	4(13.3)	2(6.7)
Food handlers who have abrasions or cuts on hands should not touch foods without gloves	28(93.3)	2(6.7)	0.00
Raw and cooked foods should be stored separately to reduce risk of food contamination	26(86.7)	4(13.3)	
Food hygiene training for workers is an important issue in reducing risk of food contamination	27(90)	2(6.7)	1(3.3)
It is necessary to check the temperature of the refrigerator periodically to reduce risk of food contamination	28(93.3)	2(6.7)	0.00
Health status of the workers should be evaluated before employment	25(83.3)	4(13.3)	1(3.3)
Foodborne illnesses can have deleterious health	26(86.7)	2(6.7)	2(6.7)

Statements	Responses, n (%)		
	Agree	**Disagree**	**No idea**
and economic effects on the society			

Good hygienic practices of food workers were evaluated. The results (table 12) indicated that 96% of the respondents always wear aprons, while corresponding measures for using gloves and washing hands before it were 69.1% and 76.3%, respectively. Two to three percent reported that they never use gloves or wash their hands. About 56.7% of the respondents reported that they always use masks and 11% stated that they rarely or never use masks during their work. Results showed that only 67% never eat or drink and 10% reported that they always eat or drink in their work place. Considering smoking in the work place, 97% indicated that they never smoke. Approximately 85.6% of respondents reported that they always or often recommend the products of their plants, but only 50.5% reported that they always or often consume their products by own.

Table (12). Food hygienic practices among 30 food workers at abattoir in Khartoum state

Statements	Responses, n (%)				
	Never	Rarely	Sometimes	Often	Always
Do you use gloves during work?	**10(33.3)**	**2(6.7)**	2**(6.7)**	0.00	16**(53.3)**
Do you wash your hands before using gloves?	9**(30.0)**	4**(13.3)**	0.00	0.00	17**(56.7)**
Do you wear apron during work?	1**(3.3)**	0.00	0.00	1**(3.3)**	28**(93.3)**
Do you use mask during work?	14**(46.7)**	2**(6.7)**	6**(20)**	2**(6.7)**	6**(20)**
Do you use cap during work?	17**(56.7)**	2**(6.7)**	4**(13.3)**	1**(3.3)**	6**(20)**
Do you wash your hands before you touch raw meat?	12**(40)**	2**(6.7)**	1**(3.3)**	2**(6.7)**	13**(43.3)**
Do you wash your hands after you touch raw meat?	10**(33.3)**	0.00	3**(10)**	1**(3.3)**	16**(53.3)**
Do you wash your hands after rest time when you come back to work?	10**(33.3)**	3**(10)**	0.00	1**(3.3)**	16**(53.3)**
Do you eat or drink in your work place?	12**(40)**	0.00	0.00	1**(3.3)**	17**(56.7)**
Do you smoke in your work place?	14**(46.7)**	1**(3.3)**	2**(6.7)**	4**(13.3)**	9**(30)**
How often do you use the products of your working	7**(23.3)**	3**(10)**	1**(3.3)**	2**(6.7)**	17**(56.7)**

Statements	**Responses, n (%)**				
	Never	**Rarely**	**Sometimes**	**Often**	**Always**
plant?					

There was positive correlation between knowledge and attitude ($r_s = 0.35$, $P < 0.001$); however, knowledge and practices ($r_s = -0.20$, $P = 0.04$) as well as attitudes and practices ($r_s = -0.25$, $P = 0.01$) were negatively associated.

Chapter Four

Discussion

The results of this study revealed that the bacterial count is high in the four sites (neck, shoulder, brisket and rump) before treatment at skinning, evisceration and washing with most contamination at the rump post evisceration and least total count were found at the rump after washing. Selmer- Olsen (1985) reported that the most contaminated sites are the neck and the sternal region also Le Touze et al (1985) and Zweifel and Stephan (2003) revealed that the neck and flank had the most increased contamination levels. On the other hand, McEvoy et al (2000) revealed that the brisket is the most often contaminated site. Yalçin et al (2001) equally pointed out that the coliforms contamination arises rather frequent at the brisket level, whereas the rump is least contaminated. El-Hadef et al (2005) indicated that the rump has the lowest contamination level. Christensen and Soerensen (1991); Karib et al (1994) and Dennaï et al (2001), revealed that the back region of the rump has the most increased contamination level.

Abdalla et al. (2009a) reported that contamination and high prevalence of Staphylococcus aureus, Bacillus spp and Escherichia coli (16% each) was noticed on ovine carcasses during different operations in the abattoir at Khartoum State. The prevalence of Listeria Spp , E. coli and Salmonella Spp. on ovine carcasses in different slaughterhouses at Khartoum State was studied by Abd Alla (2012) and found different degrees of contamination in different carcass cites during skinning, evisceration and washing. Bacteria, including coliforms that were largely E. coli, were deposited in high numbers during skinning operations, mainly on the butts and shoulders of carcasses. The mean numbers of coliforms and E. coli on carcasses were little affected by eviscerating and trimming operations, although they were redistributed from the sites they occupied after skinning. Total counts were redistributed and augmented by eviscerating and trimming operations. Washing reduced the log numbers of all of the bacteria by approximately 0.5. The general hygienic characteristics of the sheep carcass dressing process were similar to those of a previously examined beef carcass–dressing process (Gill and Baker, 1998) The contamination of meat at different parts showed statistical difference in the microbial count (Mboto et al., 2012). In the present study the reduction of TVC after treatment may be attributed to proper work clothing and cleaning of the worker's hands and knives before and after skinning which decreased the level of contaminated bacteria. The same statement was concluded by Aftab et al., (2012). Rahkio and Korkeala (1996) said that the enforcement of hygienic practice such as regular disinfection of working tools and worker hands is important in reducing the microbiological contamination of carcasses. John et al., (2000) reported the reduction of bacterial contamination during slaughtering after using a degree of sanitation. The evisceration process has important role in contamination of the muscles because the feces are rich with coliform bacteria (Collobert et al., 2002). Worldwide it is a common procedure in evisceration to tie the ends of the esophagus and colon before evisceration to prevent spillage of fecal material on the body of the carcass (Elrasheed Abdalla 2007).

Red meat animals can be infected or carry a wide range of microorganisms, which are potentially pathogenic for man (Pal, 2012). The most important of these are zoonotic bacteria, principally pathogenic serotypes of E. coli, such as O157:H7, Salmonella and Campylobacter spp (Humphrey and Jorgensen, 2000; Pal, 2007). In this study the microbiological examination of carcasses revealed the presence of Salmonella and E.coli in all stages of processing (skinning, evisceration and washing) before and after treatment. Sheep fleeces can carry a high numbers of microbes and the condition of the fleece can significantly affect the microbial levels on all parts of the dressed carcass, with carcasses derived from sheep with increasingly dirty fleeces carrying up to 1000 times more total mesophilic microorganisms, and a higher proportion of the carcasses being contaminated with the faecal indicator group Enterobacteriaceae (Hadley et al., 1997). Zahra et al, (1985) found that E.coli was the most predominant bacterium in fresh meat and Amani (2000) who isolated E.coli from meat at all stages of the processing procedure. Alaboudi (1989) and Sperber (2005) isolated E.coli and Salmonella from raw meat as well as from handlers and utensils when studying the hygienic quality of cooked meat and the potential sources of contamination. The presence of E.coli and Salmonella in fresh meat can be attributed to carcass contamination with the gastrointestinal contents during the processing. The highest contamination level with E.coli recorded in the washing point may be due to contamination of water or bad handling during washing. Microbial count depend on various factors, the ambient temperatures, personal hygiene, the efficiency of applied sanitary programmes, changes in the water supply and quality, levels of cleaning of the meat surface and the general management procedures applied throughout the meat production (Nortije,1990).

Ali (2007) isolated E.coli from hands of the workers at the skinning stage which is in agreement with the findings of this study but not with those of Khalid (2004) in this point who isolated the same bacterium from skinning knives and eviscerator's hands. He suggested that the contents of gastro-intestinal tract of slaughtered animals could reach the left hand of the eviscerator knife. Omer (1990) suggested feacal contamination as a cause of large numbers of isolates of E.coli from hands and worker's knives. The most elaborate hygiene precautions in the slaughterhouse can be modified by poor handling of the meat (AbdElrahman, 1999).

Grau and Smith (1974) found that Salmonella on sheep carcasses can be found close to half of the carcass and times on all carcasses, this in agreement with the findings of this study but disagree with Ali (2007) who didn’t isolate Salmonella from fresh meat. There can be about 1oo fold increase in E.coli and a significant increase of Salmonellae on sheep carcasses without any detectable increase in the total aerobic viable count (Grau 1986).

As observed in the result of this study, not very much difference were noticed in the most P.N. of E.coli and Salmonella. This might be attributed to the fact that although some safety measures were applied but the traditional way of slaughtering was still practiced in the slaughterhouse e.g. skinning assistance with the elbow and /or while skinning , dipping of the dirty skinning knife inside the carcass flesh.

Washing of the carcass is reduced the level of organisms with complete wearing of protective clothes as shown in this study, whereas in another study of Ali (2007) and Abdalla et al. (2009b) who recorded that post washing might increase the level. This study revealed that the bacterial count from workers hands after treatment showed significant reduction compared with control; this result is similar to the results of Abdalla et al. (2010). Omemu Adebukunola Mobolaji and Oloyede Folake Olubunmi (2014) found that 31.5% among food handlers never wear apron while handling food, 56.4% wear apron at least once in a day. Majority (90.1%) of the food handlers never wear gloves when handling food, while found that About one third of food shop handlers did not wear aprons and one sixth did not wear hair nets, while almost all food stall food handlers did not wear hair nets and about one fourth of food handlers did not wear an apron. Furthermore, the food handlers did not wash their hands before handling food again. All of these problems have been shown to possibly lead to unsafe food. In the present study the respondents have high knowledge in washing hands, wearing of gloves, aprons, mask, caps and proper cleaning and handling of instruments which reduce the risk of contamination and this leading to reduction of transmission of food borne diseases (Feglo and Nkansah , 2010; Elhaj et al., 2012; Magda et al., 2012). Our results revealed that 90% of the persons participated in the questionnaires food hygiene training for the workers is important in reducing food contamination, this results in agreement with the results of Howes et al., (1996) and Abdalla et al., (2009a) who stated that education of abattoir workers and meat handlers is important that providing wholesome and safe meat for consumers. Also 86.70% of them have knowledge that food borne illness can harm health and economic loss in the society (Jones and Angulo, 2006).

Nee and Norrakiah (2011), found that the food handlers' knowledge was high with a mean percentage score of 84.83% ± 11.71%. They demonstrated excellent knowledge in the categories of high risk foods, foodborne diseases and sources of food contamination. they found that the participants had good knowledge on personal hygiene and definition of foodborne diseases with mean score of 93.85% and 73.85%, respectively . The overall attitudes of the food handlers in our study know well food safety managements, but there is significant negative association between correct handling of food and food borne diseases prevention (Bas et al., 2004). In this results food hygienic practice are low, which indicated that proper personal hygienic practices is not implemented. But Abdalla et al., (2010) who explained that all persons working in contact with food and food products must be adhered to hygienic practices while on duty to prevent corruption of product. In our study we found that knowledge and practices as well as attitudes and practices were negatively associated. Tones and Tilford (1994) who stated that accepted knowledge alone is insufficient to trigger preventive practices and that some mechanism is needed to motivate action and generate positive attitudes. In an evaluation of food hygiene education (Rennie 1994) concluded that knowledge alone does not result in changes in food handling practices. Angellilo, Viggiani, Rizzio, & Bianco,(2000) found that the majority of food handlers and managers expressed a positive attitude to food safety but this was not supported by self reported practices. Also

Griffith,(2005) said that improved knowledge will lead to behavioral changes involving improved practices, and also suggested that other factors, including staff attitudes, can limit the improvements of practices among staff . A study done by Tebbutt (1992) has furthermore confirmed that management's attitude is an important determinant in training standards. It was found that on premises where training programs had been implemented for staff working with high-risk foods, working practices and personal hygiene improved, while the risk of contamination decreased significantly.

By the application of proper and systemic hygienic practices, food will be safe and a number of food borne diseases will be eradicated (Ali, 2007). The U.S. Food and Drug Administration reported that the most common food handler behaviors contributing to foodborne outbreaks include obtaining food from unsafe sources, using improper holding times and temperatures, inadequately cooking food, having poor personal hygiene, and contaminating equipment (Lynch et al., 2003, 2006; Jones and Angulo, 2006).

The training of managers is seen by many as a necessary precursor to the implementation of realistic food safety practices within the workplace. If managers were trained to advanced levels they would then provide basic training for food handlers in-house and make training more sectors specific. On the contrary, the managers here can't afford the cost of periodic training on hygienic practices because of the seasonality of the working meat handlers. The effectiveness of training is very dependent on both management attitude and their willingness to provide the resources and systems for food handlers to implement good practice (Egan, et al., 2007). In conclusion, the management of the slaughterhouse facilities should be properly utilized to fulfill and maintain the required hygienic standards.

Conclusion

The presence of bacteria in meat in slaughterhouse indicated that unhygienic handling of meat. The decontamination processes are important to eliminate the sources of contamination that by applying an appropriate training for personnel, application of personal and good hygienic practices and the result reduction of bacterial contamination of the meat.

Recommendation

- Management should ensure that all staff are medically fit, adequately trained in both personal and food hygiene practices, and wearing clean, protective clothes when entering or working on the food premises
- Cleaning and sterilization of hands and knives must be used in slaughterhouses so as to reduce the contamination.
- Reducing contact of exposed tissue with external surfaces of the skin by using machines to remove hides.
- Periodical aerobic plate count of bacteria to detect the slaughter hygienic status of carcasses.
- Water sources must be checked periodically.
- The results of the study assess the need for further training.

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