HANDLING PRACTICES, MICROBIAL QUALITY AND WEIGHT LOSS OF BEEF IN SMALL AND MEDIUM ENTERPRISE BUTCHERIES IN NAIROBI AND ISIOLO COUNTIES, KENYA

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A research dissertation submitted in partial fulfilment of the requirements for the award of Master of Science Degree in Food Safety and Quality in the Department of Food Science, Nutrition and Technology of the University of Nairobi.

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DECLARATION

This dissertation is my original work and has not been presented for a degree in any other university.

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DEDICATION

I dedicate this work to my parents Mr. Elijah Kiplangat Soi and Rodha Chepkirui Sigilai for their support, love and encouragement they gave me during my study.

To my brothers Joel, Wesley, Bernard, Erickson and Geoffrey who supported me and ensured my stay in campus was not a struggle. My sisters Betty, Jackline and Caroline who encouraged and prayed for me.

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ABBREVIATIONS AND ACRONYM

ANOVA　　　　　　Analysis of variance.

ASALS　　　　　　Arid and Semi-Arid Lands

CAC　　　　　　　Codex Alimentarius Commission

CFU　　　　　　　Colony Forming Units

CM^2　　　　　　Centimeters　Square

EC　　　　　　　　*Escherichia coli*

EFSA　　　　　　　European Food Safety Authority

EPZA　　　　　　　Export Processing Zones Authority

ETEC　　　　　　　Enterotoxigenic Escherichia coli

EU　　　　　　　　European Union

FAO　　　　　　　Food and Agricultural Organization

FAOSTAT　　　　　FAO database (United Nations)

GDP　　　　　　　Gross Domestic Products

GMP　　　　　　　Good Manufacturing Practices

HACCP　　　　　　Hazard Analysis and Critical Control Point.

ICMSF　　　　　　International Commission of Microbiological Standards of Food

KNBS　　　　　　　Kenya National Bureau of Statistics.

MA　　　　　　　　Mesophilic Aerobes

ML	Milliliters
MOLD	Ministry of Livestock Development
MRSA	Multidrug Resistant Staphylococcus aureus
NIAID	National Institute of Allergy and Infectious Diseases
NMKL	Nordic Committee of Food Analysis
PCA	Plate Count Agar
SMEs	Small and Medium Enterprises
SPS	Saline Peptone Solution
SPSS	Statistical Package for Social Scientist
STEC	Shiga toxin *Escherichia coli*
TC	Total Count
TCC	Total Coliform Count
TFC	Total Fecal Coliform
TVC	Total Viable Count
UK	United Kingdom
USA	United States of America.
WHC	Water Holding Capacity
WHO	World Health Organization
±	Plus or Minus

GENERAL ABSTRACT

In Kenya, small and medium enterprise butcheries are faced with a number of challenges, especially poor sanitation and hygiene meat handling practices. This exposes meat to contamination by pathogenic and spoilage microorganisms leading to foodborne illnesses and meat post-harvest losses.

The current study was designed in three phases, each phase covering a specific objective. The first part of the study aimed at assessing sanitation and hygiene beef handling practices in small and medium enterprise butcheries in Nairobi and Isiolo counties. A cross-sectional survey was conducted among 134 and 71 randomly selected butcheries using semi-structured and pre-tested questionnaires in Nairobi and Isiolo counties, respectively.The second objective involved determination of microbial quality of beef in small and medium enterprise butcheries in Nairobi County, Kenya. A total of 150 meat and surface swabs samples were collected and subjected to total viable counts, total coliform counts, *S.aureus*, *E.coli*, *Pseudomonas* Spp. and *Listeria* Spp. The third objective assessed beef weight loss in small and medium enterprise butcheries in Nairobi County, where 6 small and medium enterprise butcheries were randomly selected.

It was found that there was high participation of more educated youth (20-35 years) in butchery operations in Nairobi County compared to middle age (31-40 years) in Isiolo County. Seventy percent and 82% of operators in Nairobi and Isiolo counties respectively did not wear protective clothing. About ninety and 88% of operators in Nairobi and Isiolo Counties respectively did not possess medical certificates. Most (86% and 69%) of operators in Isiolo and Nairobi counties respectively had no training on meat handling hygiene. The study established that 60% and 82% of operators in Nairobi and Isiolo Counties respectively did not wash their hands before handling meat. Higher (90% and 87%) proportion of operators in Isiolo and Nairobi Counties, respectively handled meat concurrently with handling money. Majority (60% and 34%) of operators in Isiolo and Nairobi Counties, respectively cleaned utensils by wiping with reused cloth. The study established that 50% and 27% of operators in Nairobi and Isiolo counties respectively used closed vehicles to transport

meat from the slaughterhouse to the butcheries. About 83% and 47% of the operators in Isiolo and Nairobi counties, respectively stored meat by hanging it in open space in butchery.

Microbiological results obtained indicated that, the highest mean TVCs (4.52 log CFU/cm^2) was from flank and the highest mean *Listeria* spp counts (2.17log CFU/cm^2) being from briskest of the beef from the butcheries. The highest mean *E.coli* counts (2.18 log CFU/cm^2) were observed from the neck while the highest mean *Pseudomonas* spp counts (3.59 log CFU/cm^2) were from cavity. It was found that the mean TCC was highest (3.39 log CFU/cm^2) from the neck whereas the mean *S.aureus* counts were highest (3.85 log CFU/cm^2) from cavity. There was significant (p<0.05) difference in mean *Pseudomonas* Spp. counts from meat samples. *S.aure*us counts significantly (p<0.05) differed from personnel hands and clothing.

The mean temperature of the air in the butchery ranged 22.4-24.5^{0}C while relative humidity of the air ranged 68.7-83.7% during the study period. Beef weight loss significantly (p<0.05) differed among the butcheries. The study established that the relative humidity of the air was significantly and negatively (r= -0.928, p<0.05) correlated to beef weight loss while the temperature of the air showed a positive (r=0.551) correlation with beef weight loss with no statistical significance (p>0.05). Beef weight loss showed a positive statistical significant(r=0.9, p<0.05) relationship with weight of portioned meat.

 The study revealed that majority of small and medium enterprise butchery operators from Nairobi and Isiolo counties did not adhere to the required sanitation and hygiene standards, low microbial meat quality with respect to *L.monocytogenes, S.aureus, E.coli and Pseudomonas* Spp with high beef weight loss. Training of butchery operators on sanitation and hygienic meat handling can be a way of preventing meat contamination hence avoiding possible occurrence of foodborne illness and meat post-harvest losses.

Keywords: *Beef, sanitation and hygiene practice, microbial quality, weight loss, butcheries.*

<div align="center">**CHAPTER ONE**</div>

1. GENERAL INTRODUCTION

1.1. Background information

Meat production, especially beef, significantly contributes to household food and nutrition security and income of Arid and semi-Arid Lands (ASALs) communities of Kenya (Irungu 2008).Beef production in Kenya is estimated at 390,000 metric tonnes with large amount of the supply coming from ASALs. Due to a growing population, urbanization and rising income, there is a growing demand and consumption of meat and animal products in Kenya and other developing countries (Delgado et al., 1999; Irungu et al.,2014).Just like other developing countries, there exist strict regulations on standard and hygienic methods of handling and processing meats in Kenya (GOK, 2012).However, the informal methods of meat handling and marketing meat by small and medium enterprise (SME) butcheries undermine meat quality and safety (Adzitey et al.,2011).This could be attributed to the less attention given to the implementation and enforcement of these regulations by butchery operators and public health authorities. However, supply of safe and quality meat is essential for protection of public health and access to regional and international market opportunities.

Meat is rich in nutrients and highly susceptible to microbial contamination that can cause foodborne illness to consumers and meat spoilage. This can result in quality deterioration hence meat quantity losses, economic losses and public health concerns (Komba et al., 2012). The types and extent of microbial contamination depend on sanitation procedures and hygienic practices during meat handling, storage, distribution and processing(Ercolini et al.,2006; Li et al.,2006; Adu-Gyamfiet al., 2012).Failure to observe good sanitation and hygiene practices such as washing of hands, use of potable water, wearing of protective clothing, cleaning and sanitization of butchery

equipment and utensils, transportation of meat in clean containers and storage of meat at appropriately low temperatures can lead to microbial contamination, meat quality deterioration and post-harvest meat losses. Postharvest losses of fresh meat (up to 50%) handled by SME butcheries have been reported in Kenya (ANON, 2012; Lewa, 2010). Standards and Trade Development Facility, World Trade organization on Specific Sanitary and Phytosanitary market access constraints in East African Community countries states that the high perishability and post-harvest losses of meat are due to unhygienic meat handling practices and facilities (Abegaz, 2008). The application of proper sanitation and hygiene techniques is therefore important in maintaining meat safety and quality.

The microbiological quality of beef and meat products is strongly influenced by the conditions of hygiene prevailing during their production and handling. Without proper hygiene control, the environment in slaughterhouses and butcher shops can act as an important source of microbiological contamination (Ercolini et al., 2006). Unhygienic meat handling practices in abattoirs and post-process handling at the butchery level are associated with potential health risk to consumers due to presence of pathogens in meat and contaminated equipment and utensils (Abdullahi et al., 2006). During selling in retail meat outlets, further contamination can occur through contact with handling contaminated equipment and utensils (tables, logs, hooks, meat chopping board ,weighing balances and knives), insects, contaminated air and butchery operators (Mtenga et al., 2000).Equipment used in the slaughtering and dressing operations (knives, saws and hooks) make significant contributions to the overall contamination through direct contact with hides and hair as well as by contact with steels, knife, hands and clothing of butchery operators (Marriot, 2004; Biswas et al., 2011; Omuruyi et al., 2011).

A great diversity of microbes inhabit fresh meat generally but different types may become dominant depending on pH, composition, textures, storage temperature and transportation means of raw meat (Ercolini et al., 2006; Li et al., 2006; Adu-Gyamfi et al., 2012).Raw meat may harbor many

important pathogenic microbes i.e. *Salmonella* spp. *Campylobacter jejuni/coli*, *Yersinia enterocolitica*, *Escherichia coli*, *Staphylococcus aureus* and *Listeria monocytogenes* making the meat spoilt as without the proper handling and control of these pathogens, meat losses may occur (Nørrung et al.,2009).With regard to raw meat products, their safety and quality can be estimated based on indicator microorganism counts including mesophilic aerobes (MA), total coliforms (TC) and *Escherichia coli* (EC) (Nørrung et al., 2009).

Water is the major component of muscle tissue; on average 75% of the lean meat consists of water. The water in meat is of great economic and technologic importance not only for the appearance in the store and the cooking properties but also for the meat processing industry. Water holding capacity measured as drip loss has high importance in beef meat production because of its' financial implications. Meat with a high moisture loss has an unattractive appearance and this leads to loss of sales (Kader et al., 2005). Unacceptable water holding capacity leads to millions of dollars loss in meat industry annually (Huff-Lonergan and Lonergan, 2005).Moisture losses (Drip losses), mechanical injuries and rate of composition changes that affect sensory attributes and nutritional quality of meat are other factors that cause meat losses (Kader et al., 2005).

Fresh meat available in retail butchery outlets in Kenya pass through a long chain of slaughtering and transportation where each step poses a risk of microbial contamination (Irungu, 2008).Although there exist meat hygiene and handling requirements for butcheries in Kenya, adherence to this requirements by most SME butcheries is low and not adequately documented. To facilitate improvements in sanitation and hygiene practices, determination of current compliant and noncompliant actions is necessary before designing and implementing any procedural changes. This study therefore, aimed at assessing the current sanitation and hygiene meat handling practices in SME butcheries in Nairobi and Isiolo counties of Kenya and to determine microbial quality and weight loss of beef in SME butcheries in Nairobi County. The findings of this study are useful in determining intervention strategies for improving hygienic meat handling practices to prevent meat

contamination and hence post-harvest meat losses and for minimizing beef weight loss in SME butcheries in Kenya.

1.2. Problem Statement

Meat is an important source of protein and a valuable commodity in resource-poor communities (Datt et al., 2003; Garcia, 2007).While meat is rich in nutrient source, it is highly susceptible to microbial contamination leading to foodborne illnesses and meat losses. Post- harvest meat losses reduce profitability and contribute to the operators' food insecurity (MoLD and Lewa, 2010). This means that there is possibility of ensuring food security and increasing earnings for the butchery operations by reducing meat losses hence increasing beef sales.

In spite of the increased consumer demand on food safety standards for beef in Kenya, there are still poor hygiene and sanitary practices in SME butcheries which contribute to unacceptable level of microbial loads in meat. Some of the factors contributing to poor hygiene include: lack of hand washing facilities, poor cleaning and lack of sterilization of butcheries equipment and utensils, lack of cold storage and transportation facilities and poor personnel hygiene. These factors provide avenues for microbial contamination of meat hence posing a health risk to consumers, meat quantity losses and quality deterioration. There is limited data on beef weight loss in small and medium enterprise butcheries in Nairobi County, Kenya. This study aimed at assessing sanitation and hygiene meat handling practices, microbial quality and beef weight loss in small and medium enterprise butcheries in Kenya.

1.3. Justification

Assessment of sanitation and hygiene meat handling practices would help point out the avenues for microbial meat contamination and hence recommend intervention strategies for hygienic meat handling to reduce meat losses. Determination of microbial quality of meat would create awareness on the microbial safety of meat and propose mitigation measure to reduce meat

contamination and hence meat losses. Determination of weight loss in beef would help determine economic losses for the butchery operator at the same time point out the factors influencing beef losses hence recommend possible ways of reducing beef weight losses in SME butcheries in Kenya.

1.4. Study aim

The overall aim of this study was to get the insight on sanitation and hygiene beef handling practices, microbial quality and weight loss of beef in small and medium enterprise butcheries in Kenya and ultimately suggest mitigation measures to improve sanitation and hygienic beef handling practices and beef weight loss in small and butcheries thereby reducing meat losses and contributing to food security in Kenya.

1.5. Purpose

To provide information on sanitation and hygiene beef handling practices, microbial quality and beef weight loss in SME butcheries in Kenya and determine main contamination points in order to recommend intervention strategies for improved sanitation and hygiene beef handling and for minimizing beef weigh loss in SME butcheries in Kenya.

1.6. Objectives

1.6.1. Broad Objective.

To overall objective of the study was to determine handling practices and microbial quality of beef in small and medium enterprise butcheries in Kenya.

1.6.2. Specific Objective.

1. To assess sanitation and hygiene beef handling practices in small and medium enterprise butcheries in Nairobi and Isiolo counties, Kenya.

2. To determine microbial quality in terms of *Listeria* spp, *E. coli*, *Pseudomonas* spp and *S. aureus* of beef in small and medium enterprise butcheries in Nairobi County, Kenya.

3. To evaluate weight loss of beef in small and medium enterprise butcheries in Nairobi County, Kenya.

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<center>**CHAPTERTWO**</center>

<center>**2. LITERATURE REVIEW**</center>

2.1. Global Beef Production

Generally, world beef production constitutes about 40 percent of the livestock output (FAO, 2005).The total beef output in 2009 was estimated to be 62 million metric tonnes (FAOSTAT, 2011).The United States of America (USA) is the leading producer of beef supplying 19percent (11.9 million metric tonnes) of the total output. Brazil is second with 15 percent (9.1million metric tonnes), followed by China at 10 percent (6.1 million metric tonnes), Argentina with 5 percent (2.8 million metric tonnes) and Australia with 4 percent (2.1 million metric tonnes) in 2009. On average, these five main producers supply about 53 percent of total beef output, while the EU produces a further 13 percent (FAOSTAT, 2011)

However, the growth rate in beef output from the five countries felt from about 11 percent per annum during the period 2001–2005, to only 1 percent in 2005–2009 (FAOSTAT, 2011). Beef output in the EU also declined during this period. To improve animal production, it entail use of better cattle breeds ,improving animal disease control methods and enhancing farm management practices including feeding (Scollan et al., 2010).

2.2. Livestock Production and Consumption in Kenya

2.2.1. Overview of Livestock Sub Sector in Kenya.

The livestock sector accounts for about half of Kenya's agricultural labour force and is the primary source of income for about 6 million pastoralists and agro-pastoralists living in the country's arid and semi-arid lands (ASALs) (FAO, 2005; Otieno et al., 2008). The country has an estimated livestock resource of 14.1 million indigenous cattle, 3.4 million exotic cattle, 17.1 million sheep, 27.7 million goats, 3.0 million camels and 1.8 million donkeys (Behnke and Muthami, 2011) which contributes up to 12.5 percent to Kenya's gross domestic product (GDP and about 47 percent of

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agricultural GDP (Behnke and Muthami, 2011; FAO, 2005; Otieno et al., 2008).It also supplies the domestic requirements of meat, milk and dairy products and other livestock products while accounting for about 30% of the total marketed agricultural products (FAO, 2005).Livestock marketing chains are complex and consist of primary producers, small- and large-scale traders, loaders, transporters and ranch operators among other actors. The sub-sector earns the country substantial foreign exchange through export of live animals, hides and skins.

2.2.2. Meat Consumption in Kenya.

Red meat represents 80 percent of domestic meat consumption in Kenya and cattle are Kenya's main source of red meat (EPZA, 2005). In fact, cattle meat accounted for 73 percent of the total meat consumed by Kenyans in 2009 (FAOSTAT, 2011). As mentioned previously, a bulk of the cattle meat supply comes from the country's ASALs, while only a small portion comes from dairy herds (EPZA, 2005). According to Kenya Livestock Sector Study (Deloitte,2006), meat consumption in Kenya is highest in Mombasa and Nairobi, where annual per capita beef consumption is estimated at 15 and 18.25 kg, respectively, while annual beef consumption in rural areas is estimated at 3.25 kg per capita.

2.3. Control of Meat Hygiene and Safety.

The safety of meat requires control throughout food chain from farm of origin and inspection before and after slaughter to handling and storage of meat and products until the time of consumption (FAO, 2005).The responsibility of the production of safe meat is shared by all the actors along meat chain and the controlling authority who have legal power to enforce safety and hygiene requirements in Kenya (FAO, 2005).The slaughterhouses have played important role in the surveillance of various diseases of human and animal health. This is because surveillance at this point allows for all animals passing into the human food chain to be examined for unusual signs, lesions or specific diseases (Vilas, 2008).

2.4. Common Microorganisms Present in Meat and Meat Products

The most frequently identified bacterial pathogen associated with consumption of beef products are *Salmonella* spp, *Campylobacter* spp, *Staphylococcus aureus, Escherichia coli, Listeria monocytogenes, Clostridium perfringens, Yersinia enterocolitica*, *Bacillus cereus and Vibrio parahaemolyticus* (Biswas et al., 2011). *Campylobacter* spp*, Salmonella* spp and *Escherichia coli* are often present in fresh meat and poultry (Zhao et al., 2001). Ali et al., (2010) reported the foodborne pathogens isolated from meat samples in retail meat shops. They included *Escherichia coli* O157:H7, *Listeria* Spp, *Salmonella enteritidis* and *Shigella* species while in meat handling equipment in retail shops were *Staphylococcus* and *Shigella* Spp. Soyiri et al., 2008 isolated *Staphylococcus aureus, Bacillus cereus, Clostridium perfringens* and *Escherichia coli* in beef samples from butchers. Moreover, the faecal coliforms such as *Escherichia coli* are generally considered as indisputable indicators of faecal contamination from warm blooded animals (Yousuf et al., 2008).

2.4.1. Effects of Bacteria in Meat and Meat Products

Raw meat remains an important and probably the major source of human food borne infection with pathogenic bacteria. In spite of decades of effort to control them, it has been difficult to obtain food animals free of pathogenic bacteria (Wilfred and Fairoze, 2011). The effects that microbial contaminants cause on meat include spoilage of the meat, food poisoning and condemnation of carcasses which results into reduction of income to farmers as well as meat sellers. Consumers and meat handlers may acquire bacterial diseases such as Anthrax, Q-fever, Campylobacteriosis, Ornithosis, Botulism, *Staphylococcus* food poisoning, Salmonellosis, Brucellosis, Erysipelas, Streptococcosis, Tetanus, Yersiniosis, Clostridiosis, Listeriosis, Glanders, Leptospirosis and Tuberculosis due to poor handling of food animals and meat (Adeyemo, 2002).

2.4.2. Incidences of Microbial Load in Meat, Handling Equipment and Facilities

The microbiological profile in meat products is the key criteria for determining quality and safety of fresh produce. Ideally, meat should be considered as wholesome when pathogens of concern are absent or if present should be at low number depending on their toxin or metabolites produced (Biswas et al., 2011). Bhandare et al. (2009) reported TVC at 5.8 ± 0.17 logs cfu/cm^2 and 6.05 ± 0.25 log cfu/cm^2 in modern Indian and traditional meat shops respectively. In abattoir, the highest TVC were observed on floor 7.19 ± 0.18 log cfu/cm^2 and the lowest values in water 3.90 ± 0.07 log cfu/cm^2 , while in retail meat shops the highest were observed on floor 7.45 ± 0.46 log cfu/cm^2 and the lowest on the plastic bags 3.08 ± 0.24 log cfu/cm^2. Barros et al. (2007) reported contamination level by mesophilic aerobe count in samples from retail establishments and slaughterhouse equipment at 4.68 log cfu/cm^2, Total Coliforms at 2.55 log cfu/cm^2 and that of *Escherichia coli* at 1.8 log cfu/cm^2 respectively.

In other studies Nouichi et al. (2009) reported microbial load as indicated by TVC, TCC and TFC in bovine carcass slaughtered at El-Harrach slaughter house in Algeria at 4.48 ± 0.63, 2.92 ± 0.43 log cfu/cm^2 and 2.60 ± 0.32 log cfu/cm^2 respectively. Kumar et al. (2010) found a high total aerobic plate count of 75.91 % in beef produced and marketed in some parts of Tigray region with high percentage of unsatisfactory quality. Ukut et al. (2010) reported microbial load on fresh meat sold in Calabar Metropolis markets at 2.24 x 104- 5.01 x10^4 CFU/g and 1.05 x 103 - 3.72 x 10^3 cfu/g for TVC and TCC respectively.

2.5. Source of Beef Contamination

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

source, on farm factors, transport factors, abattoir and butchers facilities, parasites and wild animals, meat van, abattoir and retail meat outlet workers.

2.5.1. Animal/carcasses and On Farm Factors

Faecal matter is a major source of contamination and can reach carcasses through direct deposition as well as by indirect contact through contaminated carcasses, equipment, workers, installations and air (Borch and Arinder, 2002). Faeces as well as soil adhering to animals are carried into abattoir on hair, hides, hooves and tail of animals. Contact between carcasses and hides allow a mixture of microorganisms to be introduced on the carcasses. These contaminating microorganisms are derived from the animal's pre slaughter environment that may be of faecal, soil, water or feed origin (Bell, 1997). Infected body fluid such as urine, milk, blood, mucus, rumen fluid, intestinal fluid and fluid from excised abscess can be another source of carcasses contamination (Galland, 1997).Contacts between animals at auction barns may increase the pathogen load (Galland, 1997). The exterior of the animals harbours large number and different types of microorganisms from soil, water, feed, manure as well as its natural flora (Mtenga et al., 2000).The source of bacteria is likely to be from the skin of the animal from which the meat was obtained (Adzitey et al., 2011). The exterior surfaces (hide, hair, skin) of healthy live animals are naturally contaminated with large numbers (10^7 organisms per cm ^{2} of hide) of a variety of organisms (Featherstone, 2003). Slaughter stock themselves are therefore a major source of carcass contamination. The hide or intestinal tracts of slaughtered animals are the main areas where potentially pathogenic and spoilage bacteria reside (Okonko et al., 2010).

The soil (ground) is also a major source of micro-organisms and has comparable numbers (10^7) of bacteria per gram of soil (Featherstone, 2003). Faeces are about 100 times more contaminated and have an aerobic plate count and coliforms of about 10^9 and 10^8 per gram of faeces, respectively (Unc and Goss, 2004). It can therefore be said that all of these can serve as sources of microbial contaminants of the meat. Dressing procedures currently available cannot be relied upon to prevent

or remove all of the bacterial contamination on the carcass surface. What is also important is that the skinning and evisceration steps are major sites of contamination. If these procedures are conducted carefully, the degree of contamination can be reduced (Marriot, 2004; Unc et al., 2004).

2.5.2. Contamination during Slaughter and Transportation of Slaughtered Animals

The instruments used in dressing and killing e.g. knives, saws, cleavers and direct contact with hair, the vessels, receptacles and the personnel may all act as sources of contamination during slaughter (Biswas et al., 2011).The transport factors such as the type and cleanliness of transport facility, distance travelled and duration of journey, harshness of ride, overpopulation of animals in the conveyance and frequency of stops, may affect and contribute to pathogen load (Galland, 1997). The vehicles used to transport meat from abattoir to retail meat outlets may act as sources of contamination since often lack regular cleanliness and are not well covered leading to contamination by dusts, insects and flies. Sulley, (2006) reported contamination of meat resulting from other means of transport such as motor-bikes and bicycles due to insufficient vans and trucks. On the other hand, the few transport available were not properly cleaned and thus contained high microbial loads (Sulley, 2006).

2.5.3. Abattoir and Butchers Facilities

Meat contamination in abattoirs and retail meat outlets result from the use of contaminated water, unhygienic practices like poor handling, use of contaminated tables to display meat intended for sale and the use of contaminated knives and other equipment in cutting operations (Fasanmi et al., 2010).The length of time animals are held at the abattoir before slaughter can affect the pathogen load by increasing the probability of exposure and infections. Sanitation of walk ways, pen floor, railings, feed and water affect the pathogen load (Galland, 1997). Dirt, soil, body discharges and excreta from animals in holding pens or lairages are primary sources of contamination of carcasses in the later stages of the operation. This happens irrespective of whether or not the animals are fit and have passed ante mortem inspection.

Adzitey et al. (2011) reported the possible sources of contaminations arising from the cutting knives, intestinal contents, chopping boards, hides, meat handlers, containers, vehicle for transporting carcasses and the meat selling environment. It has been reported by Ali et al. (2010) that knives, wooden boards and weighing scales from retail shops are sources of bacterial contamination particularly Staphylococcus aureus and Shigella species. Akinro et al. (2009) reported that with inadequate slaughtering and disposal facilities, the abattoir becomes a source of infection and pollution, attracting domestic and wild carnivores, rodents and flies, which are vectors of diseases. Refrigerator or freezers are essential storage facilities used to prevent spoilage of meat following prolonged storage at room temperature and hence keep meat safe for long period of time.

2.5.4. Abattoir and Retail Meat Outlet Workers

The hygienic condition of the abattoir and retail meat outlet workers has potential to contribute contamination in beef before and after processing. Adetunde et al. (2011) reported that unclean slaughter men's hands, butcher arms, clothing and equipment used in carcass dressing process accounted for the microbial contamination and also the study. Bacteriological quality of meat products is strongly influenced by the prevailing hygiene condition during their production and handling (Osama and Gehan, 2011). The carcass of a healthy animal slaughtered for meat and held in a refrigerated room is likely to have only minimal surface bacteriological contamination while the inner tissues are sterile. After chilling, further processing of beef carcasses can result in product contamination. When carcasses and cuts are subsequently handled through the food distribution channels where they are reduced to retail cuts they are subjected to an increasing number of micro-organisms from the cut surfaces (Okonko et al., 2010)

Contamination subsequently occurs by the introduction of micro-organisms on the meat surfaces in operations performed during cutting, processing, storage, and distribution of meat (Clarence et al., 2009). However, if the meat is kept clean by preventing contamination through dirty hands, clothing, equipment and facilities and the meat is kept cold and covered, there will be little or

no contamination by micro-organisms whether bacteria, yeasts, moulds, viruses or protozoa (Osama and Gehan, 2011). Fresh meat cut from the chilled carcasses has its surface contaminated with micro-organisms characteristic of the environment and the implements used to cut the meat (Biswas et al., 2011). Employees are the largest contamination source and employees who do not follow sanitary practices contaminate food that they touch with spoilage and pathogenic microorganisms.

Employees come in contact with these micro-organisms through work and other parts of the environment while their hands, hair, nose and mouth, harbour microorganisms that can be transferred to food during processing, packaging, preparation and service by touching, breathing, coughing or sneezing (Biswas et al., 2011; Cohen et al., 2006; Selvan et al., 2007). Therefore, in the prevention of meat contamination, personal hygiene plays an important role as there are as many as 200 different species of microorganisms on a healthy human body (Featherstone, 2003). Carcass contamination not removed by trimming or washing at slaughter is spread to newly exposed surfaces which in turn can potentially decrease the shelf life of retail cuts and ground beef in retail meat display cases (Stivarius et al., 2002; Marriot, 2004).

The process of chopping and grinding enables bacteria present on the meat surface to be distributed throughout the product (Siriken, 2004; Salihu et al., 2010). The ultimate shelf life of ground beef depends on the bacterial level of the trimmings, sanitary conditions during processing, time and temperature of processing and storage (Siriken, 2004; Salihu et al., 2010). Ground meat is especially good growth medium because of the extensive surface area provided by the grinding and because these organisms are distributed throughout the product, whereas on the uncut meat the bacteria would be present almost entirely on the outer surfaces (Siriken, 2004; Salihu et al., 2010). Freshly minced meat constitutes one of the most challenging of meat products for quality assurance and public health protection (Osama and Gehan, 2011). If retail mince samples show microbiological counts well in excess of 10^6 per gram it is an indication of poor quality and a potential hazard which

can markedly increase if the mince is held in ambient temperature and for these reasons, the storage of unfrozen minced meat is prohibited in many countries (Marriot, 2004).

The storage life of ground beef that contains 1 million bacteria per gram is approximately 28 hours at 15.5 °C. At a normal refrigerated storage temperature of approximately -1 to 3 °C, the storage life exceeds 8 days (Marriot, 2004). Shelf life is therefore obviously influenced by the initial load of contaminating microorganisms and there is evidence that poorly cleaned mincing equipment can contribute to a lot of contamination (Enabulele and Uraih, 2009). Minced meat, unless maintained under refrigerated conditions, rapidly deteriorates. Strict sanitary fabrication practices of beef carcasses can (a) reduce total bacterial counts of beefsteaks, (b) reduce the percentage of typical Gram-negative spoilage bacteria of steaks, and (c) reduce off-odour development of refrigerated vacuum-packaged steaks (Marriot, 2004).

2.6. Bacterial pathogens associated with food poisoning

2.6.1. *Staphylococcus aureus*

S. aureus is a normal flora in human and animals, their presence in foods being indications of excessive human handling (Clarence et al., 2009). *Staphylococcus aureus* is a Gram positive coccus, resistant to heat, drying and radiation. Its strains can be pathogenic and relatively non-pathogenic. They produce disease when the bacteria contaminate food. Since *Staphylococcus aureus* can colonize on various sites of food animals asymptomatically, such as pig or cow, these animals may serve as reservoir and/or a transmission vehicle of spreading *S. aureus* and Multidrug Resistant *Staphylococcus aureus* (MRSA). Food products derived from the animals may be contaminated with *S. aureus* or MRSA during slaughtering and processing. MRSA has been isolated from meat or dairy products in several countries including Netherlands, Italy, Australia, Japan and United States (Dinges et al., 2000).

2.6.2. *Escherichia coli*

E. coli O157:H7 and non-O157 STEC are mostly associated with raw beef products; it is capable of producing large quantity of toxin (shiga toxin) that causes severe damage to the intestinal lining of human being. Escherichia coli O157:H7 is one of the most important foodborne pathogens that cause significant losses among the human population in the past two decades. *Escherichia coli* and *Escherichia coli* 0157: H7 strain has previously been isolated from meat samples (Hussein, 2007). However, diarrhea caused by enterotoxigenic *Escherichia coli* (ETEC) is highly prevalent in young children in developing countries as well as in travelers. It spreads through contaminated water and food (Hussein, 2007).

More than 75,000 cases of foodborne illness attributed to *E. coli* O157:H7 occur annually (Perna et al., 2001).Transmission of *E. coli* serotype O157:H7 is via fecal-oral route, due to improperly washed hands or following ingestion of contaminated foods from animal origin harbouring the organism specially meat and the meat products as well as milk and dairy products which are not treated well by heat (Soomro et al., 2002).The pathogenicity of E. coli O157:H7 mostly attributed to the ability of the microorganism to produce the shiga toxins (stx1 and stx2), and the presence of the intimin (eae) gene, which is essential for adherence of the organism to the intestinal epithelium(attaching and effacing mechanism) (Vallance and Finlay, 2000).Haemolysins (hly) are an important virulence factor as they can induce extraintestinal lesions (Law et al., 2000) and have the ability to affect several cells, such as lymphocytes, granulocytes, erythrocytes, and renal cells causing severe effect.

2.6.3. *Listeria* **Spp.**

Listeria monocytogenes and other *Listeria* species are widely spread in the environment, the risk of contamination with *Listeria* in red meat processing industry has to be considered as rather probable, possible *Listeria* cross-contamination by employees, equipment and environment surfaces, animal skin, food additives, packing material and many other sources has been reported. (Grebenc

and Marinšek, 2002). Listeria monocytogenes is the causative agent of 0.02% of total annual foodborne illnesses in the US. However, Listeriosis accounts for approximately 28% of the total deaths due to food poisoning (Mead et al., 1999). It is widely distributed in nature, including soil, decaying vegetation, animal and human faeces, sewage, silage and water.

The carcasses and their products may be contaminated during slaughtering and meat processing thus they can be recognized as feasible transmission routes of *Listeria* to humans. (EFSA, 2006).It could be potentially transmitted by air and colonize various surfaces including raw and ready-to-eat meat products (Burfoot, 2003).

2.6.4. *Pseudomonas* Spp.

They are soil and water contaminants which are widely distributed among foods, especially fresh meats and meat products. They are by far the most important group of bacteria that bring about the spoilage of refrigerated fresh foods since many species are psychrophiles (Jay et al., 2000). *Pseudomonas aeruginosa* sometimes colonizes human tissue and it is the major human pathogens of the group. *P*. aeruginosa is invasive and toxigenic and produce infections in patients with impaired body defences. It is an important nosocomial pathogen (Brooks et al., 2001)

2.7. Water in meat

Water is the major component of muscle tissue; on average 75% of the lean meat consists of water. Water holding capacity is the ability of meat to retain its intrinsic water during subsequent manipulations or to take up and hold water added during processing (Offer and Knight, 1988).Water in meat of great economic and technologic importance, not only for the appearance in the store and the cooking properties but also for the meat processing industry. Water holding capacity measured as drip loss has high importance in beef meat production because of its' financial implications. In general it can be said that meat with a high drip loss has an unattractive appearance and this leads to

loss of sales (Otto et al., 2004).Unacceptable WHC leads to millions of dollars loss in meat industry annually (Huff-Lonergan and Lonergan, 2005).

Losses of water in meat can occur by evaporation and drip and during thawing and cooking (Offer and Knight, 1988). The mechanism of WHC is centred in the proteins and structures that bind and entrap water, specifically the myofibrillar proteins. The pH decline *post mortem*, ionic strength and oxidation are other factors that have effects on WHC (Huff-Lonergan and Lonergan, 2005).Number of cuts and size of the pieces affects water loss in meat and hence weight loss .In an intact muscle, very little drip occurs. Thus, while evaporative losses from the surface of the carcass may occur actual drip losses from carcasses are minimal. However once the muscles are cut the opportunity for drip to escape exists. Number of cuts and the size of pieces affect the percentage of the product that is lost as drip; smaller cuts causes more drip loss than do large cuts (Zarate and Zaritzky, 1985).In essence, it is thought that the shorter the distance to the surface of a piece of meat, the greater the percentage of drip that is lost, even though the absolute amount of drip lost may be small compared to a larger cut of meat.This is especially true when the longest cut is across the muscle cells rather than along them, because drip tends to flow along the length of the fibres (Offer and Trinick, 1983).

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CHAPTER THREE

3. Sanitation and Hygiene Meat (Beef) Handling Practices in Small and Medium Enterprise Butcheries in Kenya-Case Study of Nairobi and Isiolo counties.

Abstract

In Kenya, meat handling practices among small and medium enterprise (SME) butcheries do not meet the minimum sanitation and hygiene standards. This exposes meat to contamination by spoilage and pathogenic microorganisms. This study assessed sanitation and hygiene meat handling practices in SME butcheries in Nairobi and Isiolo counties, Kenya. A cross-sectional survey was conducted among 134 and 71 randomly selected butcheries in Nairobi and Isiolo counties, respectively. There was high participation of more educated youth (20-35 years) in butchery operation in Nairobi County compared to middle age (31-40 years) in Isiolo County. Seventy percent and 82% of operators in Nairobi and Isiolo counties respectively did not wear protective clothing. Ninety four percent and 88% of operators in Nairobi and Isiolo counties, respectively did not posse medical certificates. Eighty six percent and 69% of operators in Isiolo and Nairobi counties respectively had no training on meat handling hygiene. Sixty percent and 82% of operators in Nairobi and Isiolo counties respectively did not wash their hands before handling meat. Ninety percent and 87% of operators in Isiolo and Nairobi counties, respectively handled meat concurrently with handling money. Sixty percent and34% of operators in Isiolo and Nairobi counties, respectively cleaned utensils by wiping with reused cloth. Fifty eight percent and 27% of operators in Nairobi and Isiolo counties respectively used closed vehicles to transport meat from the slaughterhouse to the butcheries. The metallic containers or transport vehicles used were not refrigerated as the distances covered were below the minimum distance requiring refrigeration of meat during transportation. Eighty three percent and 47% of the operators in Nairobi and Isiolo counties, respectively stored meat by hanging

it in open space in butchery. The study showed that meat handling practices in SME butcheries do not meet the required minimum sanitation and hygiene standards.

3.1. Introduction

In Kenya, the livestock sector contributes about 47% to agricultural GDP (Irungu, 2008; FAO, 2005; Irungu et al., 2014) and 12% to overall national GDP (FAO, 2005). The majority of livestock are concentrated in the arid and semi-arid lands (ASALs), which cover about 75% of the total Kenyan land surface. The livestock sector contributes about 90% of employment and more than 95% of family incomes in the ASALs. Under Vision 2030 and Millennium Development Goal 1 (MDG 1) the Kenyan Government consider livestock production as an important economic activity that can be used to promote equity and reduce poverty particularly among the livestock keeping communities in ASALs and small and medium enterprises (SMEs) along the meat chain (Irungu et al., 2014).

Meat production, especially beef, significantly contributes to household food and nutrition security and income of ASALs communities of Kenya (Irungu, 2008). Beef production in Kenya is estimated at 390,000 metric tonnes with large amount of the supply coming from ASALs. Due to a growing population, urbanization and rising income there is a growing demand and consumption of meat and animal products in Kenya and other developing countries (Delgado et al., 1999; Irungu et al., 2014). Just like other developing countries, there exist strict regulations on standard and hygienic methods of handling and processing meats in Kenya (GOK, 2012).However, the informal methods of meat handling and marketing meat by SMEs butcheries undermine meat quality and

safety (Adzitey et al., 2011). This could be attributed to the less attention given to the implementation and enforcement of these regulations by butchery operators and public health authorities. However, supply of safe and quality meat is essential for protection of public health and access to regional and international market opportunities.

Meat is rich in nutrients and highly susceptible to microbial contamination that can causes foodborne illness to consumers and meat spoilage. This can result in quality deterioration hence quantity losses, economic losses and public health concerns (Komba et al., 2012). The types and extent of microbial contamination depend on sanitation procedures and hygienic practices during meat handling, storage, distribution and processing(Ercolini et al.,2006; Li et al., 2006; Adu-Gyamfiet al., 2012).Failure to observe good sanitation and hygiene practices such as washing of hands, wearing of protective clothing, cleaning and sanitization of butchery equipment and utensils, transportation of meat in clean containers and storage of meat at appropriately low temperatures can lead to microbial contamination, meat quality deterioration and post-harvest meat losses. Postharvest losses of fresh meat (up to 50%) handled by SME butcheries have been reported in Kenya (ANON, 2012; Lewa, 2010).A report by Abegaz (2008) for the Standards and Trade Development Facility, World Trade organization on Specific Sanitary and Phytosanitary market access constraints in East African Community countries states that the high perishability and post-harvest losses of meat are due to unhygienic meat handling practices and facilities. Therefore, the application of proper sanitation and hygiene techniques is important in maintaining meat safety and quality.

Fresh meat available in retail butchery outlets in Kenya passes through a long chain of slaughtering and transportation where each step poses a risk of microbial contamination (Irungu, 2008).Although there exist meat hygiene and handling requirements for butcheries in Kenya, adherence to this requirements by most SME butcheries is low and not adequately documented. To facilitate improvements in sanitation and hygiene practices, determination of current compliant and noncompliant actions is necessary before designing and implementing any procedural changes. This

study, therefore, aimed at assessing the current sanitation and hygiene meat handling practices in SME butcheries in Nairobi and Isiolo counties of Kenya. The findings of this study are useful in determining intervention strategies for improving hygienic meat handling practices to prevent occurrence of foodborne illness and post-harvest meat losses in SME butcheries in Kenya.

3.2. Material and Methods

3.2.1. Study Sites

The study was carried out in arid and semi-arid pastoral Isiolo County and Nairobi County of Kenya between August 2014 and May 2015. Nairobi County has a total area of 696km^2.It is divided into 8 administrative Sub Counties, namely Makadara, Kamukunji, Starehe, Langata, Dagoretti, Westlands, Kasarani, and Embakasi Sub-Counties. According to 2009 population and housing census report, the Nairobi county has a population estimated at 3,138,295 (KNBS 2010); with half of the population living in slum areas. Lower, middle and upper middle income people are located in the North Central areas of the county while low and lower income estates are located in Eastern part of the county. SME butcheries are found in low and middle income parts of the County. The slaughterhouses clusters in Dagoretti, Kiserian and Njiiru, on the outskirts of Nairobi County, provides meat to the county. However there are a few emerging slaughterhouses in the eastern part of the county that supplier meat to the county also.

Isiolo County, located about 285 km north of Nairobi, covers an area of 25,336km^2 and has population of 143,294 people (KNBS 2010). It is divided into 3 administrative sub-counties, namely Isiolo Central, Merti and Garbatulla-Kinna Sub-Counties. Rainfall ranges between 150mm to 650mm per annum and the county experiences temperature ranging from 12^{0}Cto 28^{0}C, typical of ASALs in Kenya. Livestock (cattle, sheep, goats and camels) keeping under pastoral system is main source of livelihood of the population in Isiolo county.

3.2.2. Study Design and Data collection

The study units were SME butcheries while the study population were either butchery owners or butchery operators who were directly involved in the handling and selling of meat in the SME butcheries. One hundred and thirty four (134) and 71 SME butcheries were randomly selected in Nairobi and Isiolo County, respectively. A cross-sectional survey using semi-structured and pre-tested questionnaires was conducted to collect demographic information of the respondents and the sanitation and hygiene meat handling practices employed in SME butcheries. The questionnaires were administered to butchery owner or one selected butchery operator in each SME butchery. The key elements of the questionnaire included: age and education of the butchery operators, possession of medical health certificate, attendance of meat handling hygiene training, cleaning and sanitization of butchery equipment and utensils, status of meat transportation, distance from the slaughterhouse to the butchery, meat storage and personnel hygiene. Critical observations of premises and personnel actions and key informant discussion were done during the administration of questionnaires. Permission to conduct the study was obtained from the country Ministry of Health, Public Health Office and the respondents gave written informed consent before responding to the questionnaire. The confidentiality of the respondents was maintained throughout the study.

3.2.3. Statistical Analysis

All data from this study were analyzed using SPSS version 16.Frequencies and percentages were run to determine distributions while association between training and education level of butchery operators with meat handling practices was determine using Pearson's Chi-square (x^2).

3.3. Results and Discussion

The age distribution of SME butchery operators in Nairobi and Isiolo counties is shown in Figure 1.In Isiolo County, 62% of the SME butchery operators were within age range of 31-40 years, while 49% of the butchery operators in Nairobi County were within age range of 20-30 years (Figure 1).This indicates that there is high participation of the youth (20-35 years) in SME butchery operations in more urban Nairobi County compared to middle age adults (31-40 years) in rural Isiolo County. It has been reported by several authors that meat retailing business requires a lot of physical strength and need to be carried out by more energetic and active youth and middle aged men. Salifu and Teye (2006) reported that the butcher operations are quite energy demanding and may involve alot of travelling to livestock markets hence the inability of older men to cope.
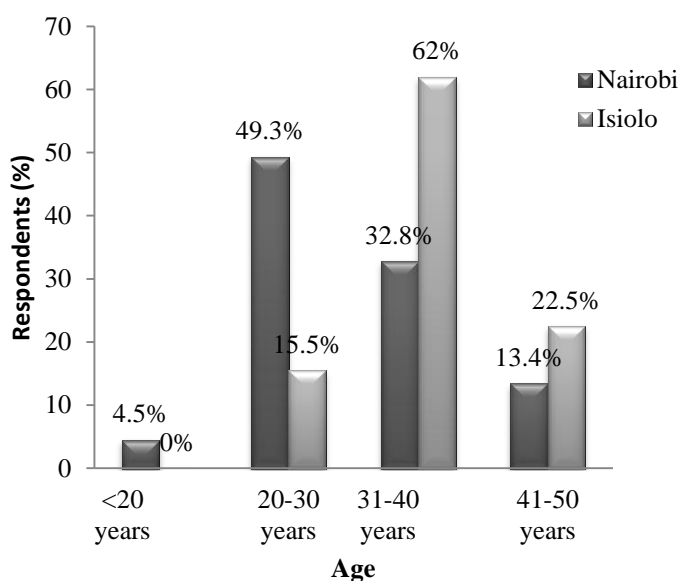
Figure 1: *Age distribution of the butchery operators inNairobi and Isiolo counties.*

Adzitey et al. (2011)also reported that meat retailing activity in Bawku Municipality of the Upper Region, Ghana was dominated by youth and middle aged men within the ages of 41-50 (45%) followed by 31-40 (23%) and 21-30 (13%). Alhaji and Baiwa (2015) reported that majority (34.3%) of the workers in slaughterhouses in north-central Nigeria were in the age group 30–39 years. Ntanga

(2013) also reported that the age of workers in abattoir and retail meat outlets in Morogoro, Tanzania ranged between 18-40 years.

Figure 2 shows the education levels of the SME butchery operators in Nairobi and Isiolo counties. In Nairobi County, 74% of SME butchery operators had secondary school level of education and 10% had not gone to school. While 50% of the SME butchery operators in Isiolo County had primary school level of education and 2% had not gone to school (Figure 2). The butchery operators in urban Nairobi County were more educated than the butchery operators in the rural Isiolo County, however these differences in education levels were not statistically significant ($P>0.05$).

These findings are in agreement by studies done by other researchers in developing countries. Ntanga (2013) and Ntanga et al. (2014) reported that 85% of the butchery operators in Morogoro Municipality, Tanzania had primary school education and 7.5% had not gone to school. The low level of education of SME butchery operators in Isiolo counties could make it difficult for them to comprehend and adhere to strict sanitation and hygienic meat handling practices necessary for prevention of microbial contamination of meat. Best conception of hygiene practices has been attributed to those employees with basic level (least a primary) of education, while bad practices to those who were illiterate (Afnabi et al. 2014).
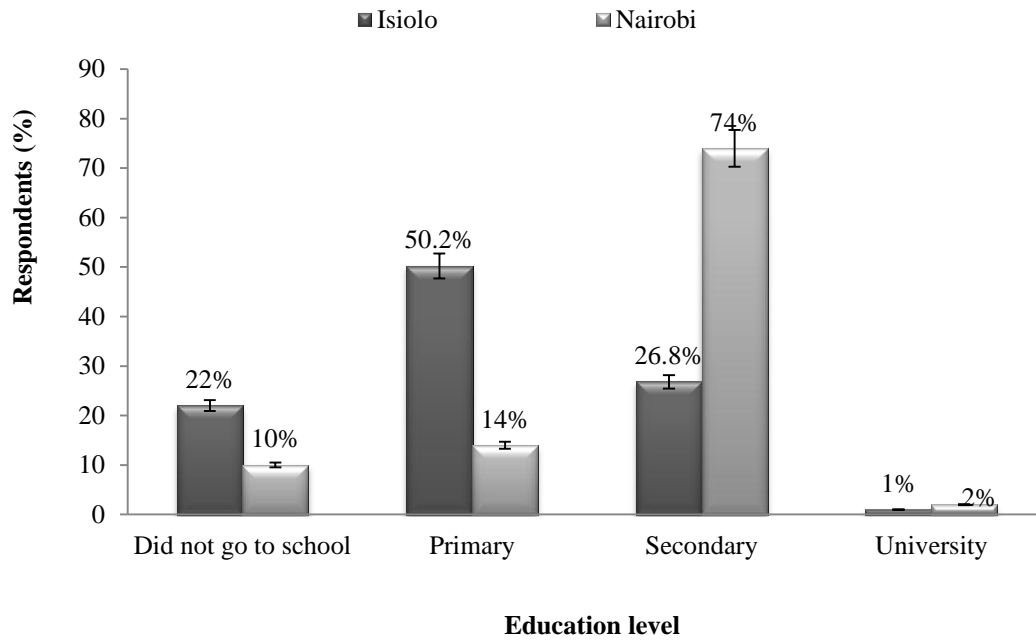
Figure 2: *Education level of butchery operators in Isiolo and Nairobi counties.*

Figure 3 shows the results of SME butchery operators possessing medical health certificates in Nairobi and Isiolo counties. Ninety four (94) percent and 88% of the SME butchery operators in Isiolo and Nairobi Counties, respectively did not possess medical health certificates (Figure3).
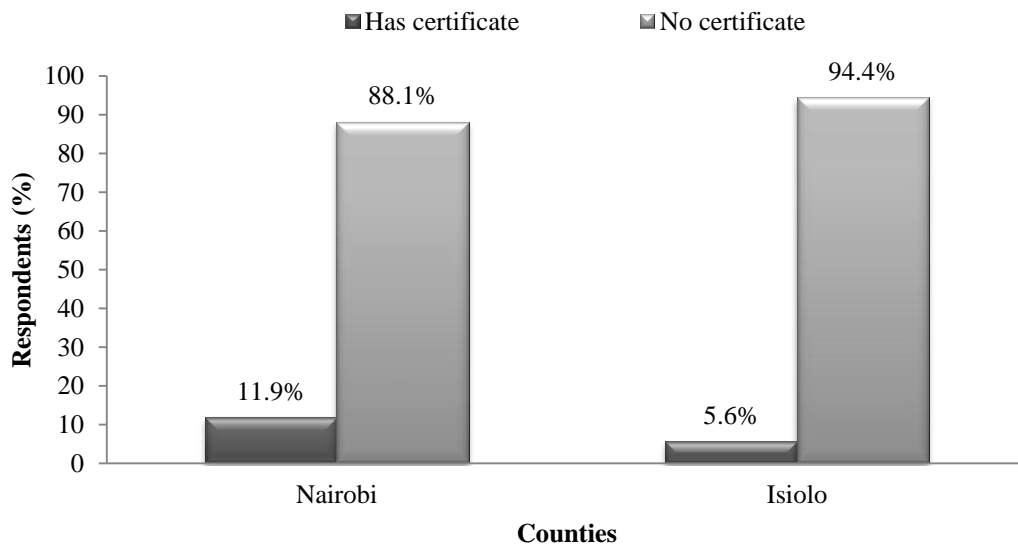
Figure 3: *The percentage of butchery operators with medical health certificates in Nairobi and Isiolo counties.*

Therefore there is a high possibility of the butchery operators contaminating meat with spoilage and pathogenic microorganisms. This study confirms that although there exist personnel medical health requirements in Kenya (FAO, 2005; GOK, 2012) there is very little attention given to their implementation and enforcement in a food enterprise like butcheries. Various studies, in other developing countries have shown different and varying possession of medical health certificate compliance rates. Our study showed higher non-compliance rate than the study by Haileselassie et al. (2013) who reported that 15.4% of the butchery operators in Makelle city, Ethiopia did not pose medical health certificates. Similar observation was made by Annan-Prah et al. (2011) that 44.5% of street food handlers in Cape Coast, Ghana were not certified medically to handle food.

The percentage of SME butchery operators wearing protective clothing while handling and selling meat in Nairobi and Isiolo counties are shown in Figure 4.Seventy (70) percent and 82% of the SME butchery operators in Nairobi and Isiolo Counties, respectively did not wear protective clothing while selling meat (Figure 4).Ntanga (2013) and Ntanga et al. (2014) reported that 62.5% of the butchery workers in Morogoro municipality, Tanzania did not use protective clothing while selling meat. Haileselassie et al. (2013) also reported that 11.3%of butcher shop workers in Makelle city, Ethiopia did not use protective clothing while selling meat.
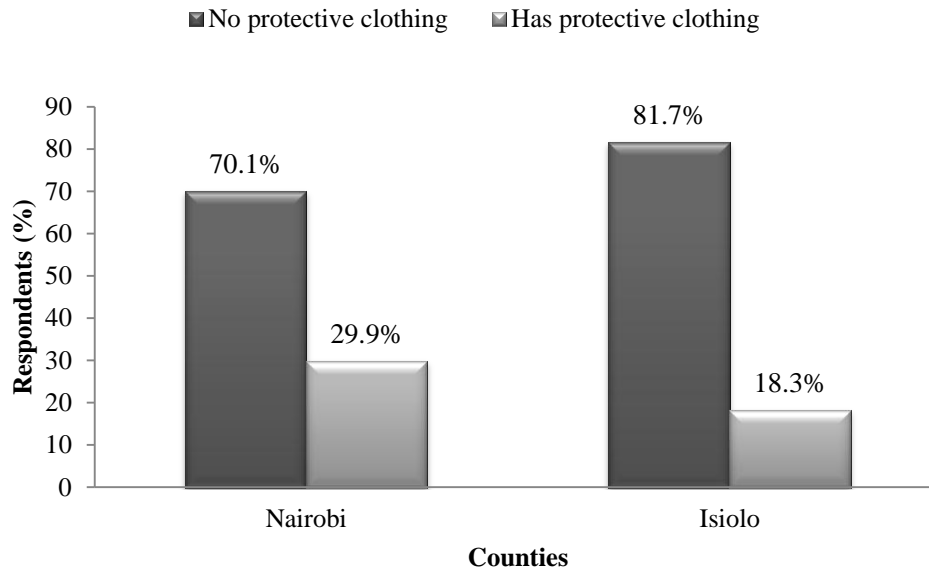
Figure 4*: The percentage of butchery operators wearing protective clothing in Nairobi and Isiolo counties*

Mirembe et al. (2015) reported that only 31.5% of butchery workers in Kampala district, Uganda had personal protective wear. As reported by other studies (Nel et al., 2004; WHO, 2004; Muinde and Kuria, 2005) the low usage of protective clothing in the SME butcheries in the study sites is indicative of increased risk of microbial contamination of meat by butchery workers. Bryan et al. (1988) also reported that food handlers can be vectors for cross contamination of food whenever good personal hygiene or proper food handling practices are not practiced. Meat handler clothing can be possible sources of bacteria which can be transferred to meat during handling, resulting in foodborne diseases and meat spoilage hence post-harvest meat losses.

The percentage of SME butchery operators in Nairobi and Isiolo counties washing or not washing their hands are shown in Figure 5.Sixty (60) percent and82**%** of the SME butchery operators in Nairobi and Isiolo counties, respectively did not wash their hands before handling meat(Figure 5).Ntanga et al. (2013); Ntanga et al. (2014) and Little et al. (1999) also reported that 37.5% and 29% of the butchery workers in Morogoro municipality, Tanzania and United Kingdom, respectively did not wash their hands before handling meat.
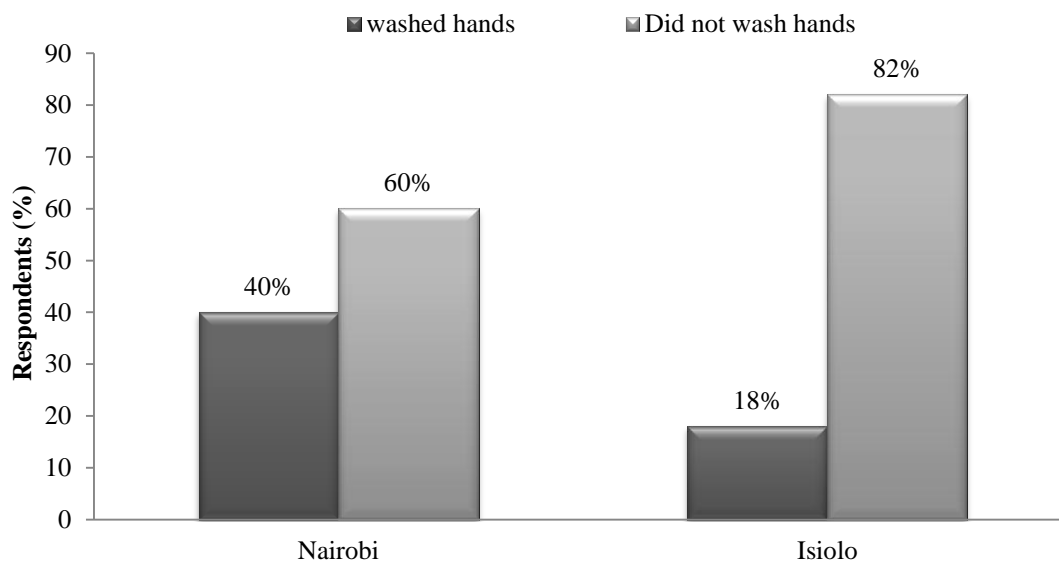
Figure 5: *The percentage of butchery operators washing hands before handling meat in Nairobi and Isiolo counties.*

Hand hygiene is not a new concept for prevention of microbial contamination of food in food industry. Unfortunately, hand hygiene is neither not always carried out nor carried out effectively. Washing hand with a detergent has long been recognized as a major step toward avoiding microbial contamination and occurrence of foodborne pathogens in food production, preparation and service facilities. It has been established over decades that foodborne outbreaks occur in food operations because of lapses in hand hygiene. (Muinde and Kuria 2005; Greig et al. 2007). In an extensive review on hand washing Todd et al. (2010) stated that the reasons for food handling personnel not washing their hands at appropriate times are laziness, time pressure, inadequate hand washing facilities and supplies, lack of accountability, and lack of involvement by industry management and workers in supporting proper hand washing.

However, strategies on how best to achieve complete hand washing compliance has not been resolved even after many years of study and research (Todd et al., 2010). From our observation it was clear that the SME butchery operators were not practicing hand washing possibly due to lack of hand-washing facilities like running tap water, washing basin, soap etc. Training of workers on

personnel hygiene should therefore be conducted for the SME butchery operators and hand washing facilities availed to enable the butchery workers access washing water.

The results of SME butchery operators trained in meat handling hygiene in Nairobi and Isiolo counties are shown in Figure 6.The percentage of SME butchery operators who had not undergone training in meat handling hygiene were 86%and 69% for Isioloand NairobiCounties,respectively (Figure 6).This results are comparable to those of other researcherswho reported that 61.5%(Haileselassie et al. 2013) of the butchery operators in Makelle City, Ethiopia and 81% (Little et al. 1999)and 75% (Little and de Louvois 1998) of managers in butcherspremisesin the United Kingdom had received no food hygiene training. Similar findings have been reported in other food or meat handling establishment by other researchers.
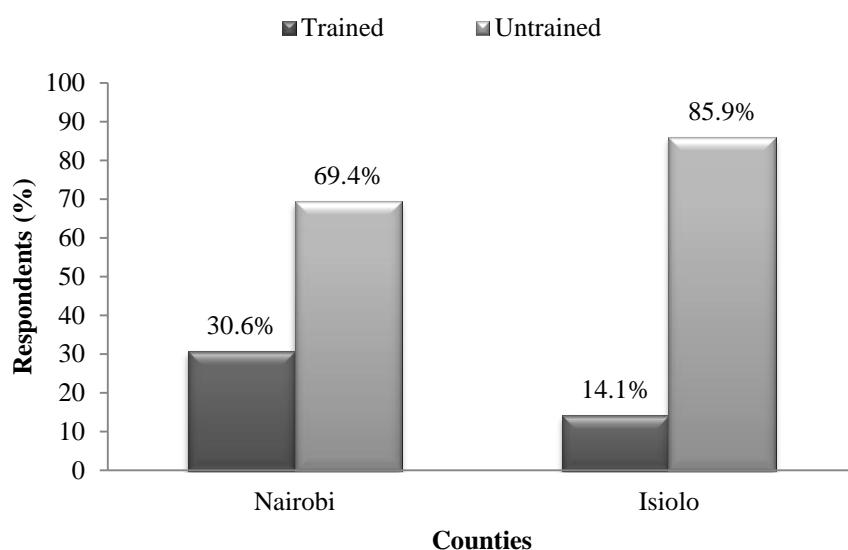
Figure 6:*The percentage of butchery operators trained on meat handling hygiene in Nairobi and Isiolo counties*

Alhaji and Baiwa (2015) also showed that 95.6% and 96.4% of the workers in slaughterhouses in north-central Nigeria did not have any previous training in meat handling hygiene and sanitation, respectively. However, Yakubu, et al. (2015) reported that 97% of abattoir workers in Metropolitan Kano State, Nigeria had received training on meat hygiene. Gillespie et al. (2000)

reported that managers in 88% of catering premises retailing ready-to-eat sliced meat in United Kingdom had received some form of food hygiene training and only 9% had received no food hygiene training. Significantly($p < 0.001$)fewer unsatisfactory samples were from premises where the managers had received advanced food hygiene training (14%) compared with those from premises where the managers had received intermediate (23%), basic (26%) or no (33%) food hygiene training (Gillespie et al. 2000).Although most butchery operators in our study had not received formal training on meat handling hygiene, a fewindicated that they had received informal interactivetraining through worker to workerinteraction.Ourstudy indicates the need to organize food hygiene training and sensitize the SME butchery workers on meat sanitation and hygiene in order to improve their knowledge of standard sanitary and hygienic operations for production of quality and safemeat (Alhaji and Baiwa, 2015).Personnel working in food establishment can be carriers of pathogens. Therefore, if improper personnel hygienic practices like not washing hands after visiting toilets, lack of periodic medical heath examination, careless sneezing and coughing (Nervy et al., 2011) are practiced, personnel can contaminate meat and pose public health concern. Training of food handlers regarding the basic concepts and requirements of personnel hygiene can play intergral part in assuring safe products to the consumer and reduction of meat post-harvest losses due to spoilage.

Literature suggests that food hygiene training as a means of improving food safety is limited by a lack of understanding of those factors contributing to successful outcomes.Trainingcan not be effective unless its outcomes are evaluated (Manpower Services Commission, 1981).Critical factors for evaluating the effectiveness of any training programme include, among others, knowledge acquisition, changes in job-related personnel behaviour and performance, and improvements in organisational-level results.Therefore, training given in sanitation and hygiene should be able to change personnel behaviour and attitude as well as impart knowledge (Egan et al. 2007).However, training alone is not sufficient for long-lasting improvement in personnel hygiene. Several published articles indicate that more than training is needed to convince food industry workers to wash their

hands to protect public health (Michaels and Ayers, 2000; Michaels et al., 2002; Todd et al., 2010).Designed strategies must include modification of the organization culture to encourage good hygienic practices, motivation of employees, willing to use peer pressure on non-compliant co-workers and an operational design that facilitates regular hand hygiene.

Figure 7 shows percentage of SME butchery operators handling money and meat when retailing meat in Nairobi and Isiolo counties. Ninety (90) percent and 87% of the SME butchery operators in Isiolo and Nairobi County, respectively handled money concurrently with handling of meat (Figure 7).The results of our study are higher than those reported by Haileselassie et al. (2013) in Makelle City, Ethiopia who found that 47.9% of the butchery operators handled money while handling meat. Muinde and Kuria, (2005) also reported that all the street food vendors in Nairobi, Kenya handled money while serving food. The person handling money should not be allowed to handle food during retailing or serving. This is because money is dirty and can contaminate food. The unhygienic conditions and habits of handling money in circulation usually subject the money to contamination with a variety of microorganisms. The money can thereafter act as a vehicle for contaminating the hands of the food seller/handler and thus cross contamination of food (FAO, 1997; Muinde and Kuria 2005; Alemu 2014).

Therefore, during retailing of meat in butcheries, money should not be handled concurrently with meat. According to Ferron et al. (2000) and Todd et al. (2010), the hands of food handlers who also proceed to carry out non-food related tasks e.g. handling money from customers, emptying bins, wiping counters with cloth are the most critical means of transmitting pathogens from contaminated places and items, hence finally resulting cross contamination of food.
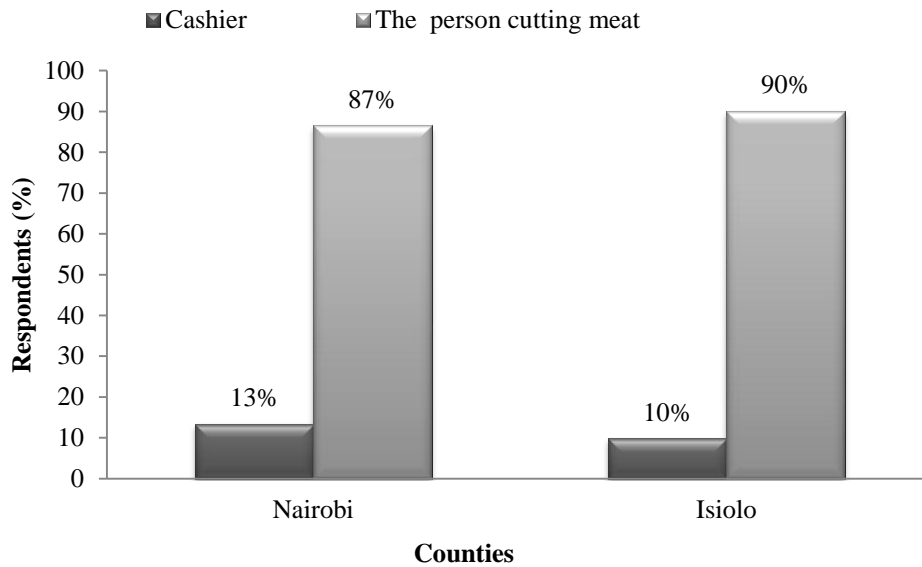
Figure 7: *The percentage of butchery operators handling money while retailing meat in Nairobi and Isiolo counties.*

Table 1 shows results of cleaning of the butchery utensils in SME butcheries in Nairobi and Isiolo counties. Thirty four (34) and 60% of the SME butcheries in Nairobi and Isiolo County, respectively cleaned butchery utensils like cutting knives, cutting boards, weighing scales and working surfaces by wiping with reusable piece of cloth. Cleaning of butchery utensils was well observed more in urban Nairobi County than in rural Isiolo County. Gillespie et al. (2000) reported that 53% of catering premises in United Kingdom used reusable dishcloths during cleaning. Twenty seven (27) percent and 30% of the butcheries in Nairobi County used cold water with soap or hot water with soap, respectively during cleaning, while only 4% and 7% of the butcheries in Isiolo County used cold water with soap or hot water with soap, respectively (Table 1)

Table 1: *Methods of cleaning utensils by the butchery operators in Nairobi and Isiolo counties.*

Ways of cleaning butchery Utensils	Responses Nairobi County (%) n=134	Responses Isiolo County (%) n=71
Cold water only	4.5	10.5
Cold water and soap	26.6	4.2
Hot water only	6.0	25.4
Hot water and soap	30.1	7.0
Wiping with a piece of cloth	33.8	59.9

The results of this study agree with the work done by Adzitey et al. (2011) in Bawku Municipality, Ghana. He reported that butchery workers did not clean butchery utensils appropriately and that 35% of the butchery operators wiped butchery utensils with a piece of cloth, 10% used hot water with soap, 39% used knives to scrap off chipped meat on tables and other surfaces while 16% used cold water and soap. Muinde and Kuria (2005) also reported that 70% of the street food vendors in Nairobi, Kenya cleaned their utensils in cold water. Alhaji and Baiwa (2015) reported that cleaning of utensils and surface (17.4%) was the most common preventive hygiene practice and that only 16.3% knew about the protective capacity of frequent cleaning and sanitation of meat handling facilities. Our observation during the survey showed that the personnel retailing meat also wiped cutting board and scales surfaces after sale of organ meat, with dirty reusable cloth. We also observed that the piece of cloth used was not washed or frequently changed. Although the intention was good, the wiping cloth was reused the whole day and can accumulate microorganisms that can be transferred to the butchery operators' hands, to utensil surfaces and finally to meat. The study revealed that utensils in SME butcheries in Isiolo County were not cleaned adequately as 35.9% of operators did not use detergent during cleaning of utensils and surfaces. As observed during administering of the questionnaire, the majority of butcheries did not have running tap water and that

water for cleaning utensils was kept in open plastic containers, was inadequate and reused, hence compromising on hygiene. These inadequate cleaning practices exposes meat to contamination by spoilage and pathogenic microorganisms, leading to meat post-harvest losses and public health concerns, respectively Mirembe et al. (2015) reported that cleaning practices varied among butchers, with 75.3% of the butcheries in Kampala district, Uganda cleaning their butcheries daily and that 90.4% of most utensils were cleaned.

The results of means of transportation of meat from the slaughterhouse to the butchery by SME butchery operators in Nairobi and Isiolo counties are shown in Figure 8.Fifty eight (58) percent and 27% of the SME butchery operators in Nairobi and Isiolo County, respectively used closed vehicles to transport meat from the slaughterhouse to the butchery. However, motorbikes (39%) and animal (donkey) transport (32%) are the most preferred means of transporting meat from slaughterhouse to the butchery in Isiolo County (Figure 8). Similar observations on transportation of meat were made by Adzitey et al. (2011) in Bawku Municipality, Ghana who reported that 33% of butchery operators transported meat using motorbikes and bicycles, 30% used motorbikes, bicycles and push trucks while 19% used push track only. Despite the Meat Control (Transport of Meat) Regulations stating that NO other products except meat shall be transported in a carrier or container in which meat is transported (GOK, 2012), we observed that meat transport vehicles were also used to transport other food and non-food items. This could be a possible source of microbial contamination and may compromise on safety and shelf-life of meat. It was also observed that some closed vehicle used for meat transportation had blood stains from previous transported meat, indicative of inadequate cleaning.
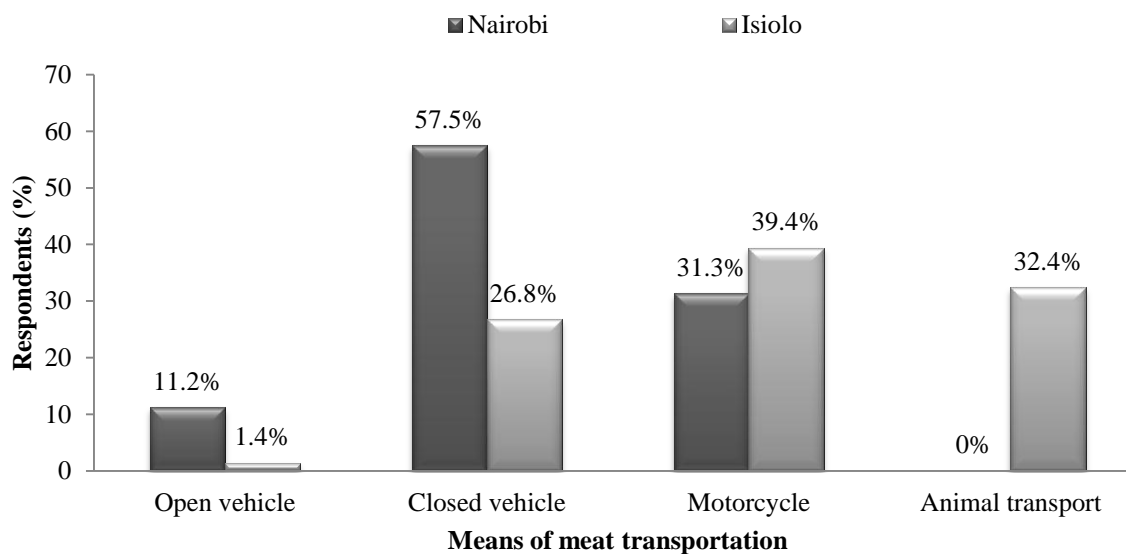
Figure 8: *Means of meat transportation from slaughterhouse to the butchery in Nairobi and Isiolo counties.*

Figure 9 shows how meat is stored by SME butchery operators in Nairobi and Isiolo counties. Despite being aware of the risk of meat getting spoiled when stored at room temperature, 83% and 47% of the SME butchery operators in Nairobi and Isiolo counties, respectively stored meat by hanging it in open space in designated room during retailing. A higher percentage (39.4%) of SME butchery operators in Isiolo County kept their meat in refrigerators than in Nairobi County (11%) (Figure 9). This could be attributed to high ambient temperatures (25- 30°C) in arid and semi-arid Isiolo County. Nonga et al. (2009) and Haruya (2012) reported that 85% of the butcher shops in Morogoro Municipality, Tanzania and 76.7% of butchers in Arusha, Tanzania, respectively did not have refrigerators. To overcome problem of lack of cold storage facilities the SME butchery operators usually stock only daily meat sale capacity. It was also observed that since most of the butcheries are located along dusty streets or roads, hanging meat in open space in the butchery exposes it to environmental contamination from dust and flies. However, the serious concern of butchery operators in hanging meat in open space was weight reduction due to moisture loss.
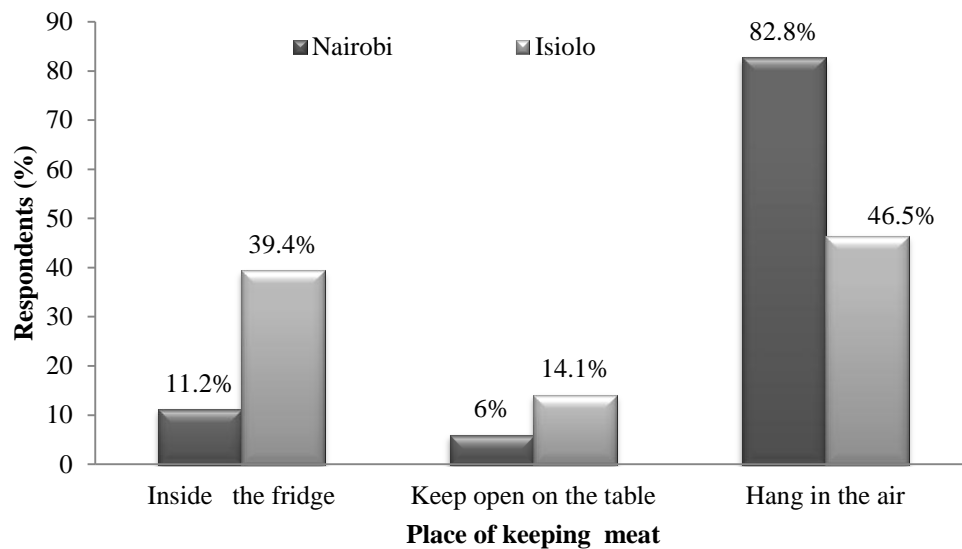
Figure 9:*Meat storage by the butchery operators in Nairobi and Isiolo counties.*

Meat storage at refrigeration, chilling or freezing temperatures has been reported to reduce the growth of spoilage and pathogenic bacteria that may be present on meat surfaces (Koutsoumanis and Taoukis, 2005), thus prolonging meat shelf-life.

Table 2 shows the distance covered during transportation of meat and the type of containers used by SME butchery operators when transporting meat from the slaughterhouses to the butcheries in Nairobi and Isiolo Counties. The SME butchery operators in both counties cleaned meat transport containers with cold water without any detergent. Majority of the SME butchery operators (95%) in Nairobi County transported meat from the slaughterhouse to the butchery using closed metallic containers which are cleaned with cold water (67%) and transported over a distance of 11-20km (40%).Whereas, 92% of the SME butchery operators in Isiolo County transported meat from the slaughterhouse to the butchery using closed metallic containers cleaned with cold water (57%) and transported over a distance of 21-30km (58%) (Table 2).

Table 2: *The distance of meat transportation and the type of meat transport containers used by SME butchery operators for transportation of meat from the slaughterhouse to the butchery in Nairobi and Isiolo counties.*

Parameter		Nairobi County (%) N=71	Isiolo County (%) N=134
Distance from slaughterhouse to butchery (Km)			
	<5	7.5	8
	5-10	34.3	6
	11-20	40.3	12
	21-30	8.2	58
	>30	9.7	16
Type of Transport containers			
	Plastic crates	4	5
	Closed metallic	95	92
	Open metallic	1	3
Cleaning the transport container			
	Cold water only	66.9	56.7
	Cold water &soap	5.1	12.3
	Hot water only	6.8	16.8
	Hot water &soap	21.2	14.2

It was observed that some of the closed metallic containers had indentations which may harbour microorganism which can result in meat contamination during transport. The metallic containers or transport vehicles were not refrigerated as the distances covered were below the minimum stipulated distance requiring refrigeration of meat during transportation (GOK, 2012).

Depending on the external environment temperature, temperature fluctuations may occur in meat if it is transported for long distance from the slaughterhouse to the butcheries, thus promoting growth of contaminating spoilage microorganism leading to meat spoilage and reduced shelf-life. The Kenyan Meat Control (Transport of Meat) Regulations state that if the distance of meat transportation is less than 50km or two hours transportation duration, meat should be transported in non-insulated vehicles provided that they are fitted with sub-protection in the form of a double roof or protected from direct sunlight. However, if the transportation distance is more than 50km but less than 200km or four hours transportation duration, meat should be transported in insulated carriers and the insulation should allow only a maximum increase in the meat temperature of 1°C per hour. If the transport distance is more than 200km or more than four hours transportation duration, meat should be transported in insulated carriers equipped with mechanical refrigeration or otherwise refrigerated sufficiently enough to ensure that the increase in the temperature of meat is less than 3°C during 12 hours daylight transportation (GOK, 2012).

Association between training of butchery operators on meat handling hygiene and handling practices in small and medium enterprise butcheries in Nairobi and Isiolo counties, Kenya.

Training of butchery operators on meat handling hygiene was significantly associated $(x^2=9.09, p\leq0.05)$ with wearing of protective clothing and washing of hands$(x^2=4.32, p\leq0.05)$ but no significant association $(x^2=1.575, p\geq0.455)$ was found in washing of butchery utensils between trained and untrained butchery operators in Nairobi County while training of butchery operators on meat handling hygiene significantly associated $(x^2=4.422, p\leq0.05)$ with wearing of protective clothing and washing of hands$(x^2=6.187, p\leq0.05)$ with no significant association$(x^2= 3.953,p\geq0.05)$ in washing of butchery utensils between trained and untrained butchery operators in Isiolo County. Butchery operators who had attended training on meat handling hygiene were found to be wearing protective clothing and washing hands before handling meat but not cleaning utensils in effectively

in both counties. This means that, butchery operators with training on meat handling hygiene were able to practise hygienic meat handling practices and vice versa and hence possibility of avoiding contamination of meat by pathogenic and spoilage microorganisms through cross contamination. Personnel working in food establishment can be carriers of pathogens. Therefore, if improper personnel hygienic practices like not washing hands after visiting toilets, lack of periodic medical heath examination, careless sneezing and coughing (Nervy et al., 2011) are practiced, personnel can contaminate meat and pose public health concern. Personnel with training on meat handling hygiene were found to be adhering to hygienic meat handling practices.Therefore,training of food handlers regarding the basic concepts and requirements of personnel hygiene can play intergral part in assuring safe products to the consumer and reduction of meat post-harvest losses due to spoilage.

Association between education level of butchery operators and handling practices in small and medium enterprise butcheries in Nairobi and Isiolo counties, Kenya.

Education level of butchery operators showed a significant association (x^2=9.80, p≤0.05, x^2=9.883, p≤0.05) with cleaning of butchery utensils and wearing of protective clothing , respectively but no significant association (x^2=3.841, p≥0.05) was observed between education level with washing of hands by butchery operators in small and medium enterprise butcheries in Nairobi County. There was a significant association(x^2=19.186, p≤0.05) between education level of butchery operators and cleaning of butchery utensils while education level showed no significant association (x^2=5.514, p≥0.05, x^2=0.622, p≥0.05)with wearing of protective clothing and washing of hands ,respectively by butchery operators in SME butcheries in Isiolo County. Butchery operators with high level of education in both counties were found to be cleaning butchery utensils effectively but not washing hands before handling meat. Hand washing before handling meat was found to have no significant relationship with education level of the butchery operators because it requires basic knowledge to practise hand washing but not necessarily to study up to a higher level of education. Butchery operators with low education levels in both counties failed to practise hygienic meat

practices and vice versa such as wearing of protective clothing and cleaning butchery utensils effectively.This is because the low level of education of SME butchery operators in Nairobi and Isiolo counties could make it difficult for them to comprehend and adhere to strict sanitation and hygienic meat handling practices necessary for prevention of microbial contamination of meat. Best conception of hygiene practices has been attributed to those employees with basic level (least a primary) of education, while bad practices to those who were illiterate (Afnabi et al. 2014).

3.4. Conclusion and Recommendation

The study revealed that majority of SME butchery operators in the Nairobi and Isiolo counties did not adhere to the required sanitation and hygiene standards. All the sanitation and hygiene handling practices investigated could provide avenues for microbial contamination of meat and possibility of occurrence of foodborne pathogens and spoilage organism, hence raising public health concerns and meat spoilage. Training of butchery operators on meat handling hygiene was found to be significantly associated with wearing of protective clothing and washing of hands before handling meat by the butchery operators while education level was significantly associated with wearing of protective clothing and cleaning of the butchery utensils by the butchery operators. To ensure that every butchery operator follow the required rules for proper hygiene and sanitation, this study recommends that issuing of operating license should be pegged on butchery operators undergoing basic training on meat handling hygiene.

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4. Microbial Quality of Beef in Small and Medium Enterprise Butcheries in Nairobi County, Kenya

Abstract

The microbiological quality of meat and meat products is strongly influenced by the conditions of hygiene prevailing during their production and handling. This exposes meat to contamination by spoilage and pathogenic microorganisms hence posing a risk of food borne illnesses and meat losses. This study assessed microbial quality of meat in small and medium enterprises (SME) butcheries in Nairobi County, Kenya. A total of 150 meat and surface swabs samples were collected and subjected to total viable counts, total coliforms counts, *S.aureus*, *E.coli*, *Pseudomonas* spp. and *Listeria* Spp. The mean TVCs from flank, neck, brisket, cavity and rump were 4.52, 3.90, 3.83, 3.89 and 4.00 log cfu/cm^2 respectively whereas the mean *Listeria* spp. counts were 1.95, 2.11, 2.17, 1.91 and 2.00 log cfu/cm^2 from flank, neck, brisket, cavity and rump respectively. The highest mean *E.coli* counts (2.18 log cfu/cm^2) were observed from the neck while the highest mean *Pseudomonas* Spp counts (3.59 log cfu/cm^2) were recorded from cavity. The mean TCCs were highest (3.39 log cfu/cm^2) from the neck whereas the mean *S.aureus* counts were highest (3.85 log cfu/cm^2) from cavity. The mean TVC, *E.coli* counts, TCC and *S.aureus* from hands were 4.32, 2.29, 2.85 and 4.61 log CFU/cm^2 respectively whereas the mean TVC, *E.coli*, TCC and *S.aureus* from clothing were 4.13, 2.68, 2.73 and 3.55 log cfu/cm^2 respectively.The mean TVCs for weighing scales, chopping boards and knives were 4.02, 3.98 and 4.66 log cfu/cm^2 respectively, mean *E.coli* counts for weighing scales, chopping boards and knives were 2.29, 2.05 and 3.24 log cfu/cm^2 respectively while mean TCC for weighing scales, chopping boards and knives were 2.45, 2.21 and 3,55 log cfu/cm^2 respectively. There was a significant (p<0.05) difference in mean *Pseudomonas* Spp counts from meat samples. Mean *S.aureu*s counts from personnel hands, clothing and butchery utensils were also significantly (p<0.05)

different. The microbial quality of meat was low and this could be attributed to poor hygiene meat handling practices. Hence the need for training of butchery operators on hygienic meat handling practices in order to prevent possible foodborne illness and meat losses.

Keywords: *Microbial quality, Small and medium enterprise butcheries, Meat losses, Beef, Kenya.*

4.1. Introduction

Food borne illnesses occur commonly in developing countries particularly Africa because of the prevailing poor food handling and sanitation practices, inadequate food safety laws, weak regulatory systems, lack of financial resource to invest in safer equipment and lack of education for food handlers (WHO, 2004). Meat is an excellent source of protein in human diet and is highly susceptible to microbial contamination due to its nutritive value (Komba et al., 2012; Soyiri et al., 2008). Although muscles of healthy animals do not contain microorganisms, meat tissues get contamination during the various stages of slaughter and transportation to the butchery (Ercolini et al*.,* 2006). Contamination of meat can occur in multiple steps along the meat production chain including production, processing, distribution, retail marketing and handling or preparation (Zhao et al*..,* 2001)

A great diversity of microbes inhabit fresh meat but different types may become dominant depending on pH,composition,texture, storage temperature and means of transporting raw meat to the butchery (Li et al., 2006; Adams and Moss, 2008). Raw meat may harbour many important pathogenic microbes such as *Salmonella* spp., *Escherichia coli*, *Campylobacter jejuni/coli*, *Yersinia enterocolitica*, *Staphylococcus aureus* and *Listeria monocytogenes* making the meat a risk for human health as without the proper handling and control of these pathogens, meat spoilage will occur resulting in food borne illness and meat losses(Nørrung et al., 2009).Major spoilage organisms in meat are *Pseudomonas* Spp and members of Enterobacteriaceae (Doulgeraki et al., 2012).Unhygienic practices in abattoirs and post-process handling at the butchery level are associated with potential

health risk to consumers due to presence of pathogens in meat and contaminated equipments and utensils (Abdullahi et al., 2006).

At the butchery level, contamination of meat can occur during selling through contact with handling contaminated equipment and utensils (tables, logs, hooks, meat chopping board, weighing balances and knives), insects, contaminated air and butchery operators (Mtenga et al., 2000).Equipment used in slaughtering and dressing operations (knives, saws and hooks) make significant contributions to the overall contamination through direct contact with hides and hair as well as by contact with steels, knives, hands and clothing of butchery operators (Marriot et al.,2004; Biswas et al., 2011; Omuruyi et al., 2011).

Limited studies have been reported on microbial quality of meat in SME butcheries in Nairobi County, Kenya. Therefore, the aim of the study was to assess the level of meat contamination in small and medium enterprise butcheries in Nairobi County so as to create awareness of the microbial safety of meat.

4.2. Materials and Methods

4.2.1. Study Area

The study was carried out in Nairobi County, Kenya between January and March 2016. Nairobi County has a total area of 696km^2.It is divided into 9 administrative Sub counties, namely; Makadara, Kamukunji, Njiiru, Starehe, Langata, Dagoretti, Westlands, Kasarani and Embakasi Sub-counties. The study was done in 8 randomly selected sub-counties namely: Starehe, Kamukunji, Kasarani, Kibra, Roy Sambu Sub County, Westlands Dagoretti North and Dagoretti South Sub County. According to 2009 population and housing census report, Nairobi County has a population estimated at 3,138,295 (KNBS 2010); with half of the population living in slum areas. Lower, middle and upper middle income people are located in the North Central areas of the county while low and lower income estates are located in Eastern part of the County.SME butcheries are found in low and middle income parts of the County. The slaughterhouses clusters in Dagoretti, Kiserian and Njiiru on the

outskirts of Nairobi County provides meat to the County. However there are a few emerging slaughterhouses in the eastern part of the County that also supplier meat to the County.

4.2.2. Study Design and Data collection

Across sectional study was employed whereby 8 sub counties were randomly selected for the study namely; Starehe, Kamukunji, Kasarani, Kibra, Roy sambu, Westlands, Dagoretti North and Dagoretti South Sub County. Meat and surface swabs samples from the meat handling equipment /utensils and from the personnel were collected aseptically for microbial analysis. Meat swabs samples were obtained from the following parts: neck, brisket, flank , rump and cavity using sterile moistened cotton wool swab by rubbing firmly over an area of $100cm^2$ using parallel line strokes with slow rotation for 30 seconds and the swabs transferred to the respective screw-capped sterile labelled tubes containing 10ml buffered peptone water. In meat handling equipment, (weighing scales and meat chopping boards) an area of $100cm^2$ while in knives an area of $10 cm^2$ was swabbed for 30 seconds with sterile moistened cotton wool swabs using parallel line strokes with slow rotation and the swabs transferred to the respective screw-capped sterile labelled tubes containing 10ml of buffered peptone water. Personnel hygiene samples were collected from hands and clothing of the personnel by swabbing an area of $25cm^2$ for 30 seconds with sterile moistened cotton wool swab using parallel line strokes with slow rotation and the swabs transferred to the respective screw-capped sterile labelled tubes containing 10ml of buffered peptone water. The swabs were agitated up and down in the tubes to aid in rinsing the bacteria from the surface of the swabs. The meat and surface swab samples were packed in cool box maintained at 4^0C and transported to the University of Nairobi laboratory for microbial analysis.

The proximal part of the neck, the brisket, flank and the rump of the sampled carcasses in the butcheries were considered appropriate for bacteriological analysis. The sampling regions were based on ones recommended by the Meat (Hazard Analysis and Critical Control Point) (Scotland) Regulations 2002 No. 234

4.2.3. Enumeration of organisms from the meat samples, personnel and equipment from SME butcheries in Nairobi County, Kenya

4.2.3.1. Sample preparation

In the laboratory, each test tube with meat and surface swabs samples were mixed thoroughly using a vortex (PEQLAB, made in USA) and opened aseptically by flaming the mouth part of test tubes. One (1) ml of the sample was transferred to a small dilution bottle containing 9ml of buffered peptone water using sterile pipette tips. Serial dilution was further carried out up to 10^{-5}.

4.2.3.2. Microbiological analysis

The meat swab samples were analysed for Total Viable count, *Staphylococcus aureus*, *Escherichia coli*, total coliforms, *Listeria monocytogene* and *Pseudomonas* Spp. Swabs obtained from the butchery equipment/utensils were analyzed for Total Viable count, total coliforms, *Escherichia coli*, while personnel hygiene samples were analyzed for Total Viable count, *Staphylococcus aureus, E.coli and* Total coliforms.

4.2.3.2.1. Determination of Total viable count

The total viable count was determined by pour plating 1ml of 10^{-3}, 10^{-4} and 10^{-5} sample dilutions using plate count agar. The plates were incubated at 35^0C for 48 hours and all grown colonies were counted and recorded using colony counter after incubation.

4.2.3.2.2. Determination of Total Coliforms and *Escherichia coli*

One (1) millilitre of 10^{-1}, 10^{-2} and 10^{-3} sample dilution were plated on Chromocult® Coliforms Agar ES (Enhanced Selectivity) and plates incubated at 35^0C for 24 hours. Dark-blue to violet colonies was the characteristic of *E.coli* while Salmon –red colonies was other coliforms total of the two made up of total coliforms. Distinct colonies were counted and recorded .The simultaneous detection of total coliforms and *E.coli* was achieved using the combination of two chromogenic substrates. The substrate Salmon™-b-D-GAL is split by b-D-galactosidase

characteristic for coliforms resulting in a salmon to red colouration of coliform colonies. The detection of the b-D-glucuronidase characteristic for *E.coli* is cleaved via the substrateX-b-D-glucuronide causing a blue colouration of positive colonies. As *E.coli* splits Salmon™-b-D-GAL as well as X-b-D-glucuronide, the colonies turn to a dark violet colour and could be easily differentiated from the other coliforms being salmon-red.

4.2.3.2.3. Determination of *Staphylococcus aureus*

Enumeration of *S. aureus* was done by spreading 1ml of 10^{-3}, 10^{-4} and 10^{-5} sample dilution of meat swab samples and personnel swab samples on Baird Parker agar plates with egg yolk tellurite emulsion followed by incubation at 35°C for 48hrs .Typical *Staphylococcus aureus* colonies appeared black, shiny, convex colonies 1-5 mm with a narrow, wide edge surrounded by a clear zone 2-5mm wide and opaque ring within the clear zone only appeared after 48 hours of incubation. Black distinct colonies were counted and recorded.

Staphylococcus aureus colonies showed two characteristic features when grown in this opaque medium (opaque, because of its egg-yolk content), characteristic zones and rings are formed as a result of lipolysis and proteolysis and reduction of tellurite to tellurium produces a black colouration.

4.2.3.2.4. Determination of *Listeria Monocytogenes*

One (1) Millilitre of 10^{-1}, 10^{-2} and 10^{-3} of sample dilutions were spread on Chromocult Listeria selective agar plates with added Chromocult Listeria selective supplement and incubated at 35˚C for 48 hour. *Listeria monocytogene* colonies appeared grey–green colonies with a black zone. This is because *Listeria monocytogenes* hydrolyses esculin to esculetin and forms a black complex with iron (III) ions. Therefore *Listeria monocytogenes* produces brown-green coloured colonies with a black halo. Distinct colonies were counted and recorded.

4.2.3.2.5.   Determination of *Pseudomonas* **Spp**.

One (1) millilitre of 10^{-1}, 10^{-2}, and 10^{-3} of the sample dilutions were spread on Pseudomonas selective agar plates with added Pseudomonas selective supplement and incubated at 28^{0}C for 48 hours. Grown colonies showed a positive oxidase reaction as the oxidase disc changed the colour from white to purple with no glucose fermentation. The use of selective supplement and incubation temperature made the medium selective for *Pseudomonas* spp. Grown distinct colonies were counted and recorded.

4.2.4 Statistical analysis

Microbial counts (cfu/cm^{2}) were represented as log10 cfu/cm^{2}.All the data was subjected to analysis of variance (ANOVA) and the means separated by Fisher's protected test using Genstat 15th Edition. The significance level was set at P=0.05.

4.3 Results and Discussion

4.3.1 Microbial counts (log cfu/cm^2) of meat samples from small and medium enterprise butcheries in Nairobi County, Kenya

Table 3 shows the microbial counts of meat samples from SME butcheries in Nairobi County sampled from five different parts of carcass: flank, neck, brisket, cavity and rump .There was a significant (p<0.05) difference in mean *Pseudomonas* counts from meat sampled from the different parts of the carcass (Table 3).

Table 3: *Microbial counts (Log cfu/cm^2) of meat samples from small and medium enterprise butcheries in Nairobi County.*

Meat Sample	N	Microorganisms					
		TVC	*Listeria* spp.	E.coli	*Pseudomonas* spp.	TCC	*S.aureus*
Flank	15	4.52±4.35[a]	1.95±2.13[a]	1.99±2.01[a]	2.59±2.38[a]	2.21±1.97[a]	3.61±3.51[a]
Neck	15	3.90±4.13[a]	2.11±2.06[a]	2.18±2.29[a]	2.63±2.51[a]	2.39±2.19[a]	2.71±2.45[a]
Brisket	15	3.83±3.87[a]	2.17±2.24[a]	2.00±2.10[a]	2.48±2.33[a]	2.28±2.11[a]	3.79±3.75[a]
Cavity	15	3.89±3.88[a]	1.91±2.00[a]	2.03±2.20[a]	3.59±3.45[b]	2.29±2.19[a]	3.85±3.47a
Rump	15	4.00±4.01[a]	2.00±2.04[a]	1.85±1.88[a]	2.52±2.33[a]	2.26±2.13[a]	3.79±3.59[a]

Values = Means ± Standard deviation; Means in the same column with different superscripts are significantly different (P< 0.05).*TVC*= Total viable count, TCC=Total Coliforms Count and N=Number of samples.

4.3.1.1 Total Viable Counts

The mean TVC from flank, neck, brisket, cavity and rump were 4.52, 3.90, 3.83, 3.89 and 4.00 log cfu/cm^2, respectively.The Higher TVC recorded in this study was attributed to poor

handling and hygienic practices leading to cross contamination and recontamination of meat (FAO, 2004). Although the results of TVC obtained from the meat samples in the SME butcheries were high, they are lower than the recommended standard of less than 6.00 logs cfu per g/cm^2 set by the ICMSF (1985).According to FAO, (2007), microbiological standard, the safe level of aerobic plate count is less than 4 log cfu/cm^2 or 1×10^4 cfu/g and the critical condition lies between 4-5 log cfu/cm^2 or 1×104 - 1×105 cfu/g and more than 1×10^5 cfu/g is not acceptable and alarm signals on meat hygiene in the butcheries. Results from the current study are higher than the findings reported by Abdalla et al. (2010) who found mean TVCs value of 2.79± 0.10, 3.72±0.02, 3.65±0.02 and 3.18± 0.03 from flank, neck, brisket and rump respectively in Khartoum North, Sudan. The figures from the present study also are higher than the findings obtained by Ronoh et al. (2011) who reported mean TVCs values of 3.55, 3.58 and 3.41 log cfu/cm^2 from loin, neck and rump region respectively in Nyagacho slum in Kericho, Kenya. Adoption of good hygiene practices will reduce meat contamination thus improving the safety and quality of meat and hence reduction of foodborne illnesses and meat losses. These results also agree with Koutsoumanis and Taoukis, (2005) and Delmore, (2009), who claimed that, the adoption of proper storage temperature and hygienic practices contribute to improving the safety and quality of raw meat.

4.3.1.2 Total Coliforms Counts

The highest (2.39 log cfu/cm^2) mean TCC was observed from the neck region and lowest (2.21 log cfu/cm^2) from flank region. This is becauseneck is close to the gastrointestinal tract and faeces contamination resulted in high TCC. There was no significance ((P< 0.05) difference   observed in TCC from meat samples. The TCC are within the limits of (< 4.00 log cfu/cm^2) set by International Commission of Microbiological Specification on Food (ICMSF, 1985). The high coliform counts reported from raw beef from the butcheries indicated a high level of contamination resulting possibly from the mixing of the offals, the gut and carcass. Most Enterobacteriaceae in beef stem from faecal contamination and their occurrence in high numbers indicate unsanitary handling and/or

inappropriate storage conditions for the beef in butcheries (Agbodaze et al., 2005). Zalalem et al. (2006) also reported that presence of coliforms indicate contamination from either faecal or non-faecal sources.

4.3.1.3 *Escherichia coli* Counts

The mean *E.coli* counts from the sampled areas in meat ranged 1.85 to 2.18 log cfu/cm^2. High level of *E.coli* counts at the butcheries could be due to poor handling by retailers and exposure to direct air; it could also be from contamination of the vehicle used for transportation of meat from the slaughterhouse to the butchery. Most retailers transport their meat with carriages which do not protect the products from flies but rather expose the produce to the open atmosphere. Chepkemoi et al. (2015) reported that 58% of the butchery operators in Nairobi County, Kenya transported meat from slaughterhouse to the butchery using closed vehicles which were observed to have blood stain from previous transported meat, indicative of inadequate cleaning This is in agreement with the findings by Bhandare et al. (2007) who reported that the unhygienic practices of meat processing and meat transportation in developing countries results in the meat being contaminated with *E.coli.*. The high levels of *E.coli* in raw beef from the butcheries could also be due to contamination of beef from feacal matter as a result of poor handling of the contents of the intestines during slaughtering (Soyiri et al., 2008). This may result in meat contamination and hence foodborne illnesses and meat losses.

4.3.1.4 *Staphylococcus aureus* Counts

Cavity region recorded the highest (3.85 log cfucm^2) mean *S. aureus* counts while the neck recording the least (2.71 log cfu/cm^2) mean *S.aureus* counts. Presence of *S.aureus* contamination can be due to contamination from the skin of the animal/humans or other unhygienic places in the abattoir during the process of slaughtering.The presence of Staphylococci in the nasal passages, throats, hair and skin of healthy individuals including food handlers have been reported (FDA/CFSAN, 2007). This is in agreement with report by Postgate (2000) that *Staphylococcus* Spp. can be part of the normal flora on the skin of humans and animals which can be transmitted from

person to product through unhygienic practices. A similar work has been done by Adzitey et al. (2011) in the Tamale Metropolis revealed that; animals are slaughtered in abattoirs and sometimes in backyards without observing strict hygienic meat handling practices. It is also a common practice to see carcasses just after dressing on their bare shoulders (Adzitey et al., 2011).Although the counts recorded in this study are less than the 5.00 log10 cfu/g required to produce enough enterotoxins to cause staphylococcal food poisoning (FDA/CFSAN, 2007), they raise food safety concerns and related health implications.

4.3.1.5 *Pseudomonas* Spp Counts

The mean Pseudomonas spp count from meat sampled was highest in the cavity with mean values of 3.59 log cfu/cm^2 and lowest in the rump with a mean value of 2.52 log cfu/cm^2.There was a significant (p<0.05) difference in *Pseudomonas* spp count observed from the meat samples. Highest *Pseudomonas* spp counts were observed from the cavity region could be due to presence of blood in the cavity region which is a rich nutrient promoting microbial growth. The presence of the pathogen on the meat during this study may be accounted for by its association with water, soil, and vegetation that the personnel use or come in contact with during the processing or retailing of the product and more so human beings reported to act as carriers of the pathogen (Rodríguez-Calleja et al., 2005). It is also attributed to poor sanitation and hygiene practices employed by the butchery workers. *Pseudomonas* are generally not harmful but they will cause food to deteriorate or lose quality by getting mouldy, developing a bad odor, or feeling sticky on the outside (Siragusa et al., 1998).

4.3.1.6 *Listeria* Spp. Counts

The mean Listeria spp. count from the flank, neck, brisket, cavity and rump from meat samples was 1.95, 2.11, 2.17, 1.91 and 2.00 log cfu/cm^2, respectively.The high Listeria counts recorded in this study could be attributed to poor handling of meat and poor sanitation of butchery equipment leading to high cross contamination and recontamination of meat.This agrees with the study by Marinsek and Grebenc. (2002) who reported that contamination of meat with

L.monocytogene generally occurs after slaughter and may come from the skin of the animals, hands of the workers, the equipment and tools used. Jemmi and Stephen (2006) gave similar suggestions that cross-contamination between raw materials, equipment, utensils, humans, rodents, insects, animals and birds could contribute to the spread of *L.monocytogenes* in butcheries.

4.3.2 Microbial counts (log cfu/cm$^{2)}$ from personnel hands and clothes in small and medium enterprise butcheries in Nairobi County, Kenya.

Microbial counts from personnel hands and clothes in small and medium enterprise butcheries in Nairobi County, Kenya are shown in table 4. There was a significance (p<0.05) difference in mean *S.aureus* count from personnel hands and clothes (Table 4).

Table 4: *Microbial counts (Log cfu/cm^2) from personnel hands and clothes in small and medium enterprise butcheries in Nairobi County.*

Personnel Sample	N	Microorganism			
		TVC	*E.coli*	TCC	*S.aureus*
Hands	15	4.32±4.27[a]	2.29±2.45[a]	2.85±3.00[a]	4.61±4.35[b]
Clothes	15	4.13±4.17[a]	2.68±2.89[a]	2.73±2.76[a]	3.55±3.69[a]

Values = Means ± Standard deviation; Means in the same column with different superscripts are significantly different (P<0.05).*TVC*= Total viable count, TCC=Total Coliforms Count and N=Number of samples.

4.3.2.1 Total Viable Counts

The average TVC from hands and clothing recorded in this study were 4.32 and 4.13 log cfu/cm^2 respectively. Chepkemoi et al. (2015) reported that 60% of the butchery operators did not wash their hands before handling meat in Nairobi County, Kenya. This could have contributed to high TVC counts in personnel hand.It has been established over decades that foodborne outbreaks occur in food operations because of lapses in hand hygiene (Muinde and Kuria 2005;Greig et al.,

2007).Therefore failure to wash hands results in meat contamination and hence food borne illnesses and meat losses. Bryan et al. (1988) reported that food handlers can be vectors for cross contamination of food whenever good personal hygiene or proper food handling practices are not practiced. Meat handler clothing can be possible sources of bacteria which can be transferred to meat during handling, resulting in foodborne diseases and meat spoilage hence post-harvest meat losses.The result for TVC from hands are higher than the findings from Osama et al. (2011) who reported mean TVC value of 3.63 ± 0.11 log cfu/cm^2 in Cairo, Egypt. The higher TVC count in personnel hands and cloth in this study can be attributed to lack of awareness by the butchery operators on good   hygiene practices. Hygiene during handling of meat is paramount. The personnel handling the meat and surfaces in contact with meat have been found to be sources of contamination of carcasses (Gill et al., 1999; Schlegelova´ et al., 2004). FAO. (1991) outlines the hygienic requirements during meat handling to increase on its shelf life. Kenya Meat Control Act Cap 356 also states that protective clothes worn by personnel should be clean and personnel hands be cleaned before loading and offloading of meat.

4.3.2.2 *Escherichia coli* Counts

The mean *E.coli* count from personnel hands and cloth were 2.29 and 2.68 log cfu/cm^{2}respectively. *E.coli* count was higher in the cloth than the personnel hands .This could be due to the fact that most butchery operators do not wash their protective clothing. Similar studies were found by Osama et al. (2011) who reported mean *E.coli* count of 2.00 log cfu/cm^2 from personnel hands in Cairo, Egypt.

4.3.2.3 Total Coliform Counts

The mean TCC from personnel hands and clothe were found to be 2.85 and 2.73 log cfu/cm^2, respectively. Coliforms from personnel hands and clothing resulting in cross contamination of meat.This agrees with the findings by Ali, (2007) who revealed that the workers hands and the equipment were the sources of meat contamination.These results are higher than the findings by

Osama et al. (2011) who reported a mean value of 1.55±1.10 log cfu/cm^2 of TCC from hands of a butchery worker in Cairo, Egypt. These higher counts in TCC are attributed to unsanitary practices performed in the plant and employees' ignorance on personnel hygiene.

4.3.2.4 *Staphylococcus aureus* Counts

The mean *S.aureus* counts from personnel hands and cloth were 4.61 and 3.55 log cfu/cm^2 respectively. There was a significant (P<0.05) difference in *S.aureus* counts from personnel hands and cloth. This is because *S.aureus* is natural flora of skin and mucous membranes of animals and human and it can be transferred from personnel hands to meat hence causing meat contamination (Nørrung et al., 2009). Results from this study are higher than those found by Osama et al. (2011) who reported a mean value of 2.69±0.11log cfu/cm^2 of *S.aureus* from personnel hands in Cairo, Egypt. The difference in the results may be due the ignorance of butchery workers to observed personnel hygiene rules or lack of knowledge on personnel hygiene practices (Elisel and Linton, 1997).A condition like injure hands or having abscess greatly enhances *S.aureus* contamination.

4.3.3 Microbial counts (log cfu/cm^2) from utensils/equipment in small and medium enterprise butcheries in Nairobi County.

Table 5 shows microbial counts from meat weighing scales, meat chopping boards and knives in Nairobi County. There was a significance (p<0.05) difference in microbial counts from butchery equipment/utensils in SME butcheries in Nairobi County (Table 5).

Table 5: *Microbial counts (Log cfu/cm^2) from utensil/equipment in small and medium enterprise butcheries in Nairobi County, Kenya*

Butchery Utensils	N	Microorganisms		
		TVC	*E.coli*	TCC
Weighing scales	15	4.02±4.05[a]	2.29±2.44[a]	2.45±2.56[a]
Chopping Board	15	3.98±3.98[a]	2.05±2.22[a]	2.21±2.16[a]
Knives	15	4.66±4.80[b]	3.24±3.64[b]	3.55±3.58[b]

Values = Means ± Standard deviation; Means in the same column with different superscripts are significantly different (P≤ 0.05).*TVC*= Total viable count, TCC=Total Coliforms Count and N=Number of samples.

4.3.3.1 Total Viable Counts

The mean TVC from weighing scales, chopping boards and knives studied were 4.02, 3.98 and 4.66 log cfu/cm^2 respectively. High mean TVC counts from knives recorded in this study may be attributed to lack of knives sterilization and majority of butchery operators could be wiping the knives with a piece of cloth.This statement agrees with the finding by Chepkemoi et al. (2015) who reported that 33.8% of the butchery operators wiped butchery utensils with a piece of cloth in SME butcheries in Nairobi County, Kenya. Results from the current study are higher compared to Bredeeba et al,(2013) who reported mean TVC values of 2.23±0.06,0.81±0.02 and 2.89± 0.08log cfu/cm^2 from knives, weighing scales and chopping board respectively in Chidambaram, Tamil Nadu.The figures from the present study are however lower compared to those reported by Ntanga et al. (2014) who found the mean values of 6.16 ±1.25, 5.77±1.49 and 5.86±1.53 logs cfu/cm^2 in knives, weighing scales and meat chopping boards respectively in retail meat outlets Morocco Municipality, Tanzania. Bhandare et al.(2009) also reported a higher mean TVC value of 7.33 ± 0.20, 6.45 ± 0.26 and 5.93 ± 0.31 logs cfu/cm^2 in meat chopping boards, knives and weighing balances respectively.The higher levels of TVC in these meat handling equipment (meat chopping boards, knives and weighing scales) in the butcheries could be attributed to inadequate cleaning and poor disinfection.

4.3.3.2 Total Coliform Counts

The mean TCC from the utensils in SME butcheries ranged 2.21- 3.55log cfu/cm^2 respectively. Knives had the highest mean TCC values and this may be because of continuous use without washing. Inadequate cleaning practices exposes meat to contamination by spoilage and pathogenic microorganisms leading to meat post-harvest losses and public health concerns. The

findings from results are lower than the findings of Ntanga et al. (2014) who reported TCC of 4.66, 4.45 and 4.13 log cfu/cm^2 from Knife, weighing balance and meat chopping board respectively in retail meat outlets in Morocco Municipality, Tanzania. Higher mean TCC in butcheries might have originated from the abattoir due to unhygienic practices and as a result contamination transferred to butcheries. Therefore, meat hygiene in the butcheries and abattoirs must be improved to avoid meat contamination which will result in public health concerns and meat losses.

4.3.3.3 *Escherichia coli* Counts

The highest (3.24 log cfu/cum^2) mean *E.coli* counts were recorded from knives while lowest (2.05 log cfu/cm^2) mean *E.coli* count being recorded from the chopping boards. The presence of *E.coli* on the meat handling utensils/equipment (meat chopping board. knife and weighing scale) in this study may be attributed to the poor level of personnel hygiene and poor sanitation at the butcheries and lack of knowledge by the butchery operators on personnel hygiene.

4.4 Conclusions and Recommendations.

Beef from small and medium enterprise butcheries in Nairobi County was found to contaminate with *E.coli*, *Listeria monocytogene*, *S.aureus* and *Pseudomonas spp*. Well-tailored sanitation and hygiene education aimed at improving butchery operators' knowledge on sanitation and hygiene meat handling practices is a recommended strategy to minimise contamination of meat by pathogenic microorganisms and hence improving quality and safety of beef.

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CHAPTER FIVE

5 Assessment of Beef Weight Loss in Small and Medium Enterprise Butcheries in Nairobi County, Kenya

Abstract

Beef weight loss from various causes can have a significant effect on overall product yield. Water is the major component of meat with an average of 75% of the lean meat consisting of water. High water loss in meat results in loss of sales and affects nutritive value of meat. Losses of water in meat can occur by evaporation, drip and during thawing and cooking. This study determined relative humidity and temperature of air in the butchery, beef weight loss and correlation of relative humidity and temperature of the air and weight of portioned meat with beef weight loss. The study was conducted in six (6) randomly selected small and medium enterprise butcheries in Nairobi County. Mean temperature of the air in small and medium enterprise butcheries ranged 22.4-24.5^{0}C while the mean relative humidity of the air ranged 68.7-83.7%. Highest beef weight loss was (3.3%) while the lowest beef weight loss was (1.3%).There was a statistical significant (p<0.05) difference in beef weight loss among the small and medium enterprise butcheries in Nairobi County. Relative humidity of the air in SME butcheries in Nairobi County was significantly negatively (r= -0.928), (p<0.05) correlated to beef weight loss while temperature of the air in the butchery showed a positive (r= 0.551) correlation with beef weight loss with no statistical significance (p>0.05). Beef weight loss showed positive statistical significant (r=0.9, p<0.05), correlation with weight of portioned meat in small and medium enterprise butcheries. The study showed that relative humidity of air in the butchery and amount of portioned meat influence beef weight loss while temperature of air had no influence on beef weight loss. Reducing the amount of portioned meat and regulating relative humidity of the air in the butchery can be away of minimizing beef weight loss.

5.1Introduction

The livestock sector accounts for about half of Kenya's agricultural labour force and is the primary source of income for about 6 million pastoralists and agro-pastoralists living in the country's arid and semi-arid lands (ASALs) (Behnke and Muthami, 2011; FAO, 2005; Otieno et al., 2008). Red meat in Kenya accounts for over 80 percent of all the meat and is derived mainly from cattle, sheep, goats and camels. Cattle are the main source of red meat (EPZA, 2005) and represented about 73 percent of the total meat consumed in Kenya in 2009 (FAOSTAT, 2011). Cattle accounts for approximately 77 percent of Kenya's ruminant off-take for slaughter (Behnke and Muthami, 2011).

The ability of fresh meat to retain moisture is arguably one of the most important quality characteristics of raw products since it affects consumer acceptance and final weight of the product (Huff-Lonergan and Lonergan, 2005; Miller et al., 2001).Water can be lost from meat by evaporation, in the form of drip and during thawing and cooking (Offer and Knight, 1988).).Any system prolonging shelf-life of beef will be subjected to purge (Troy and Kerry, 2010).Drip loss from fresh meat is influenced by many storage variables such as method of suspension, cutting, packaging and storage temperature ((Huff-Lonergan and Lonergan, 2005).

It has been estimated that as much as 50% or more of the pork produced has unacceptably high purge or drip loss (Stetzer and McKeith, 2003).Weight loss due to purge can average as much as 1-3% in fresh retail cuts (Offer and Knight, 1988) and can be as high as 10% in pale soft exudative products (Melody et al., 2004). In addition to the loss of salable weight, purge loss also entails the loss of a significant amount of protein (Offer and Knight 1988). On average, purge can contain approximately 112 mg of protein per milliliter of fluid; mostly water-soluble, sarcoplasmic proteins (Savage, 1990).The loss of water from cell compartments is associated to different mechanisms which may occur at distinct storage phases (Lonergan and Lonergan, 2005).Purge

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affects the economic traits for the industry, loss of yield in fresh meat and processed products as well as decreased palatability for the consumer. Unacceptable weight loss costs the meat industry millions of dollars annually (Huff-Lonergan and Lonergan, 2005).

Water in the muscle fibre serves as a lubricant, as well as a medium to transport metabolites (Puolanne and Halonen, 2010).Approximately 85% of the water in the muscle cell is held in the myofibrils (Huff-Lonergan and Lonergan, 2005).The majority of water in muscle is held either within the myofibrils, between the myofibrils and between the myofibrils and the cell membrane (sarcolemma), between muscle cells and muscle bundles (groups of muscle cells). Once muscle is harvested the amount of water and location of that water in meat can change depending on numerous factors related to the tissue itself and how the product is handled (Honikel et al., 2004).

Several factors influence ability of meat to retain moisture such as pH decline, ionic strength and oxidation (Huff-Lonergan and Lonergan, 2005).Temperature during storage also affects ability of meat to retain moisture; high temperature gives more purges. Sample size also affects water holding capacity; a thin slice gives higher purge compared with a larger cut (Huff-Lonergan, 2009).The quality of fresh meat depends to a large extent on drip loss which is technologically and economically important not only for food-processing industry but also for consumers as an important attribute during purchasing meat (Prevolnik et al., 2010)From economic point of view, low drip loss is extremely desirable because meat is sold by weight and any water loss leads to a reduction in yield due to loss in the total weight of the meat and significant loss of protein thus affecting the nutritive value of meat (Hoving-Bolink et al., 2005).

Meat in retail outlets in Kenya are displayed on the designed room in the butcheries without control of temperature and relative humidity. There is limited data on the amount of beef weight loss and the correlation between temperatures, relative humidity of the air in the butchery and weight of portioned beef with beef weight loss in SME butcheries in Kenya. Therefore, the main objective of this study was to determine beef weight loss and the correlation between temperature, relative

humidity of the air and weight of portioned beef with beef weight loss in SME butcheries in Kenya in order to inform on possible intervention strategies for reducing beef weight loss among SME butcheries in Kenya.

5.2 Materials and Methods

5.2.1 Study Area

The study was carried out in Westlands sub County of Nairobi County for constant monitoring of beef weight loss in SME butcheries due to its proximity to the University of Nairobi between 6th and 17th November 2015.Westlands Sub County has a total area of 72.40sq km.It is divided into 5 county assembly wards, Kitusuru, Parklands/Highridge, Karura, Kangemi and Mountain View. According to 2009 population and housing census report, Westlands Sub County has a population estimated at 176,689 (KNBS, 2010). Small and Medium butcheries are found in low and middle income parts of the County. The slaughterhouses clusters in Dagoretti, Kiserian and Njiiru on the outskirts of Nairobi County, provides meat to the County. However there are a few emerging slaughterhouses in the eastern part of the County that also supply meat to the County.

5.2.2 Study Design and Data Collection

The study units were SME butcheries. Six (6) SME butcheries randomly selected for the study in Kangemi and Mountain View wards because of proximity to the University for constant monitoring of beef weight loss. Fresh carcass was weighed on receipt and the normal operations carried out. The weight of the sold and the remaining carcass during the normal operations both   hanged carcass and portioned meat was measured at an interval of 1hour from time of opening to closure until the whole carcass was finished. Hanged carcass was measured using a weighing scale hanged at the roof of the butchery while the portioned meat was measured using weighing balances placed on the tables. Beef weight loss was determined as the difference between the weight of unsold meat and the weight of sold meat. The initial total weight of the portioned meat before the start of any sale in each butchery was also recorded. Temperature and relative humidity of the air within the butchery was monitored

by taking dry and wet bulb temperature readings of the hygrometer at interval of 1 hour.The same experiment was performed in each of the 6 butcheries for two days. Beef weight losses were mainly due to water loss by evaporation and in form of drip.

5.2.3 Statistical Analysis

The data was entered into Microsoft Excel 2013 to generate graphs and table presentation of the results. Data on relative humidity and temperature of the air in the butchery was analysed using Excel 2013 and results were then presented as the geometric means and range. Data on beef weight losses in butcheries were subjected to analysis of variance (ANOVA) and the means separated by Fisher's protected test and correlation between relative humidity, temperature of the air in the butchery and weight of portioned beef was determined using Spearman's Rank correlation. ANOVA and correlation was done in GENSTART statistical package 15th Edition at 5% level of significance.

5.3 Results and Discussion

5.3.1 Temperature (0C) and relative humidity (%) of the air in small and medium enterprise butcheries in Nairobi County, Kenya.

Table 6 shows result of temperature and relative humidity of the air in small and medium enterprise butcheries in different butcheries in Nairobi County:BUTCH1 (butchery1) BUTCH2 (butchery2) BUTCH3 (butchery3) BUTCH4 (butchery4) BUTCH5 (butchery5) BUTCH6 (butchery 6) (Table 6).

Table 6. *Temperature (^{o}C) and relative humidity (%) of the air in small and medium enterprise butcheries in Nairobi County, Kenya.*

Butchery Name	Temperature			Relative Humidity		
	Min	Mean	Max	Min	Mean	Max
BUTCH1	19	22.7	27	53	73.3	85
BUTCH2	20	23.9	26	58	70.5	85
BUTCH3	20	24.5	27	53	69.3	84
BUTCH4	19	22.4	26	64	83.7	92
BUTCH5	20	23.8	28	46	68.7	77
BUTCH6	22	24.2	26	56	75.2	92

The mean temperature of the air in SME butcheries ranged 22.4-24.5^{0}C with BUTCH 3 having the highest temperature readings while the mean relative humidity of the air ranged 68.7-83.7% with BUTCH 4 having the highest value of RH.The difference in temperature and RH of the air in butcheries is because of changing environmental weather conditions since each butchery was visited in different days.

5.3.2 Percentage beef weight loss in different small and medium enterprise butcheries in Nairobi County, Kenya

Highest (3.3%) beef weight loss was recorded in BUTCH5 while the lowest (1.3%) beef weight loss was recorded in BUTCH4.There was a significant ($p < 0.05$) difference in beef weight loss in butcheries in Nairobi County (Figure 10).
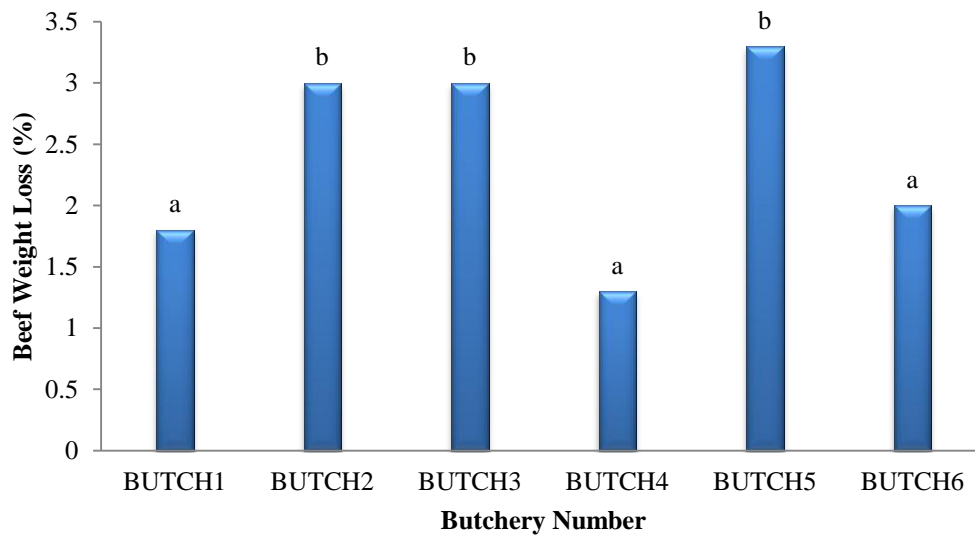
Figure 10:*Percentage beef weight loss in different small and medium enterprise butcheries in Nairobi County, Kenya.* ***The bars with different letters show that there is significant difference at 5% level of significance.***

The beef weight losses observed in this study may be attributed to high amount of portioned meat kept on the poorly designed cabinets and fluctuating conditions weather environmental in the butcheries. This facilitated high moisture loss since moisture could easily escape from the small cut pieces of meat kept in cabinets as opposed to large pieces of meat in butcheries hence resulting in high percentage beef weight loss. Fluctuating temperature and relative humidity also could have cause beef weight losses in the butchery. Low relative humidity facilitates evaporation of moisture from the meat hence leading to beef weight loss. High environmental temperature on the other hand increases the temperature of the muscles and hence denaturation of protein resulting in shrinkage of the myofibrillar spacing and the subsequent purging development (Offer et al., 1991) resulting in beef weight loss. The difference in beef weight loss in the butcheries may be due to difference in meat handling and storage practices employed in the butcheries. It was observed that most butchery operators kept small cut pieces of meat in cabinets while others displayed meat in an open air on the

table while large pieces of meat were hanged in an open space. This statement agrees with the findings by Chepkemoi et al. (2015) who reported that 6% of the butchery operators kept open on the table, 82.8% hanged meat on the air while 11.2% kept meat inside the fridge in SME butcheries in Nairobi County, Kenya. Exposing meat on the air may facilitate evaporation of water from meat resulting in beef weight loss.

5.3.3 Correlation between beef weight loss and relative humidity of the air in small and medium enterprise butcheries in Nairobi County.

Beef weight loss showed a negative statistical significant association with relative humidity of the air in SME butcheries in Nairobi County($r= -0.928$, $p<0.05$) (Figure 11). This means that beef weight loss increased with decrease in relative humidity of the air. Lower RH facilitates evaporation of moisture from meat resulting in beef weight loss and also high drip losses hence loss of nutrients from meat thus affecting the nutritive value of meat.This statement agrees with Drehmer et al. (2005),who reported that low relative humidity results in losses of organoleptic characteristics of the carcass. The more active the air velocity, the greater is the loss of RH.
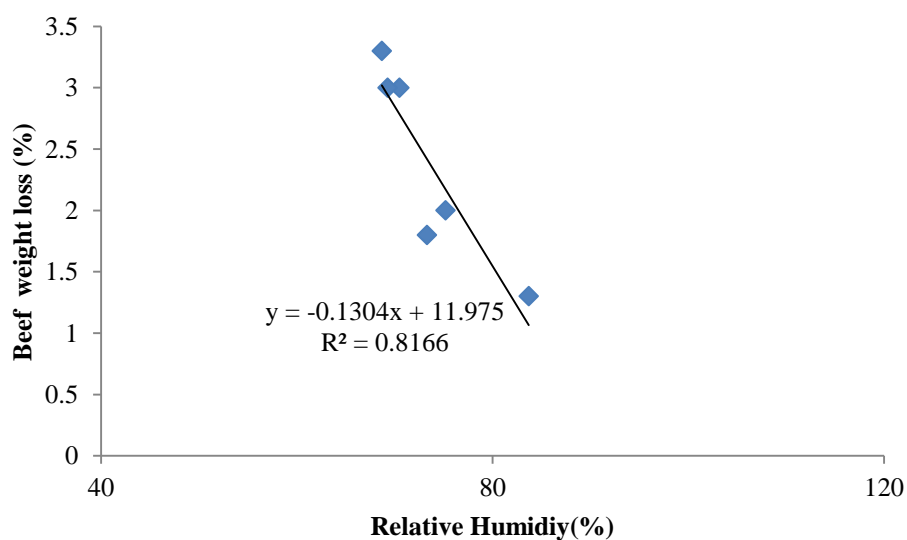
Figure 11: *Correlation between beef weight loss and relative humidity of air in small and medium enterprise butcheries in Nairobi County, Kenya*

Therefore, there is need to harmonize the atmosphere with relative humidity around 80-90%.These conditions provide greater moisture in the carcasses in such a way preventing desiccation which causes the weight losses.

5.3.4 Correlation between beef weight loss and temperature of air in small and medium enterprise butcheries in Nairobi County.

There was a positive relationship between beef weight loss and temperature of the air in the butcheries in Nairobi County(r=0.551, p<0.05) (Figure 12). Although beef weight loss and temperature of air in the butchery showed a positive association, it was not statistically significant. This is because the experiments were done in Nairobi County where temperatures were the same throughout the study.
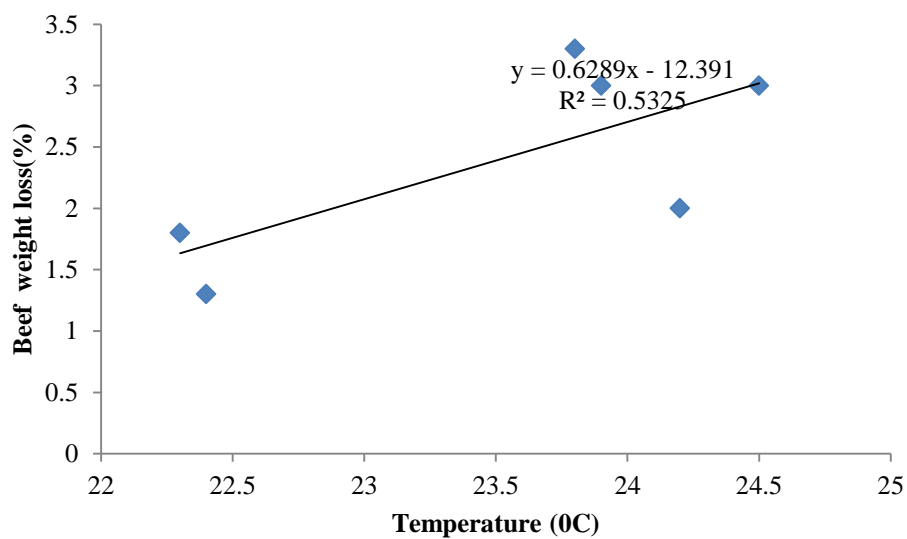
Figure 12: *Correlation between beef weight loss and temperature of air in small and medium enterprise butcheries in Nairobi County, Kenya*

5.3.5 Correlation between beef weight loss and weight of portioned beef in small and medium enterprise butcheries in Nairobi County, Kenya.

Beef weight loss was significantly and positively (p<0.05,r=0.9 and) correlated to weight of portioned meat in SME butcheries in Nairobi County (Figure 13). This implies that, butcheries with

high amount of portioned meat had higher beef weight loss. This could be attributed to the fact that when the carcass is cut, a large surface area is exposed and hence opportunities for moisture to escape is created. Number of cuts of the meat pieces also affect the rate of moisture loss in meat; in an intact muscle, very little water loss and drip loss occurs (Huff-Lonergan, 2009).The size of the piece of meat can also affect the percentage of the product that is lost as drip. Smaller cuts of meat lose relatively more drip than do larger pieces of meat (Zarate and Zaritzky, 1985).
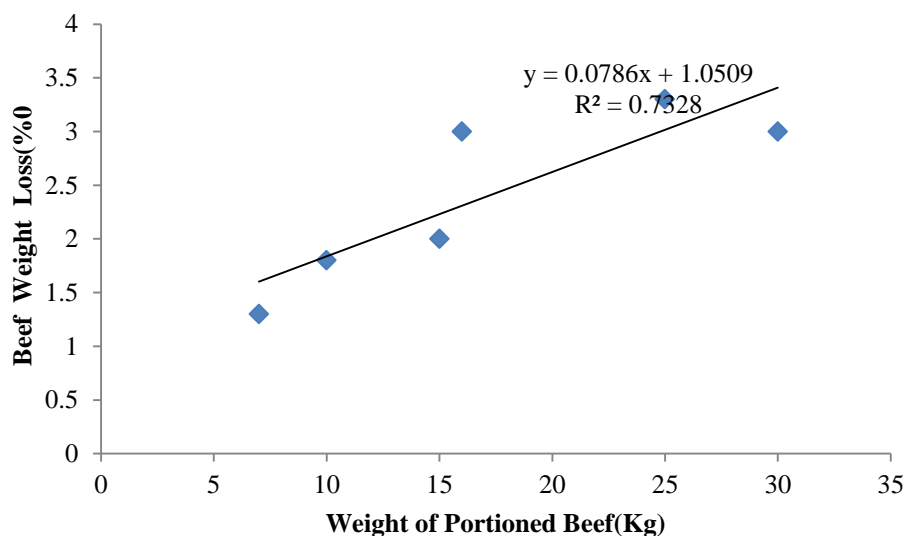
Figure 13: *Correlation between beef weight loss and weight of portioned beef in small and medium enterprise butcheries in Nairobi County, Kenya.*

It is thought that the shorter the distance to the surface of a piece of meat, the greater the percentage of drip that is lost, even though the absolute amount of drip lost may be small compared to a larger cut of meat. This is especially true when the longest cut is across the muscle cells rather than along them, because drip tends to flow along the length of the fibers (Offer and Trinick, 1988).

5.4 Conclusion and Recommendations

The study revealed that relative humidity of the air had an influence on beef weight loss and that beef weight loss increased with decrease with relative humidity of the air in the butchery and vice versa. Temperature of air in the butchery had no influence on the beef weight loss while beef weight loss significantly differed among small and medium butcheries. It was also found that beef weight loss increased significantly with weight of portioned meat in small and medium enterprise butcheries in Nairobi County. To reduce beef weight loss, butcheries should minimize amounts of portioned meat and keep the meat in large cuts as long as possible. Limiting the meat on display to what can be sold in a day may also minimize beef weight loss.

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CHAPTER SIX

6 GENERAL CONCUSION AND RECOMMENDATIONS

6.1General Conclusions

The study revealed that majority of small and medium enterprise butchery operators in the Nairobi and Isiolo counties did not adhere to the required sanitation and hygiene standards. All the sanitation and hygiene handling practices investigated could provide avenues for microbial contamination of meat and possibility of occurrence of foodborne pathogens and spoilage organism, hence raising public health concerns and meat post-harvest losses. Beef from small and medium enterprise butcheries in Nairobi County were found to be contaminated with *E.coli*, *Listeria monocytogene*, *S.aureus* and *Pseudomonas spp*. These microorganisms may lead to meat spoilage resulting in foodborne illnesses and meat losses .The study also showed that relative humidity of air in the butchery and amount of portioned meat influence beef weight loss while temperature of air had no influence on beef weight loss.

6.2 General recommendations

Well-tailored sanitation and hygiene education aimed at improving butchery operators' knowledge on sanitation and hygiene meat handling practices is a recommended strategy to minimise contamination of meat by pathogenic and spoilage microorganisms and hence improving quality and safety of beef and reducing post-harvest meat losses. Minimizing amount of cut piece of meat on display in the butcheries and limiting the meat on display to what can be sold in a day will help reduce evaporative water loss and drip losses in meat hence preventing losses of nutrients from meat and enable the butchery operators increase their profits by selling meat by their weights.

7 ANNEXES

7.1ANNEX 1: Consent form

University of Nairobi Department of Food Science, Nutrition and Technology-Food Safety and Quality Masters Programme

I am ……………………………………. a student at the University of Nairobi studying MSc in Food Safety and Quality. In order to get information about how meat is handled by the butchery operators in small and medium Enterprise butcheries in Kenya in order to enable me determine intervention strategies to reduce meat losses, I am conducting this survey in Nairobi County among the butchery operators and I am pleased to have you take part in the study.

The information you provide will be useful in determining intervention strategies for improving meat handling in small and medium butcheries in Kenya and hence reducing quality deterioration and meat losses.

All information you give is confidential. The information will aid in the preparation of a general report but no names will be included. There will therefore be no way to identify that you are the source of information. I encourage you to participate in the study and your cooperation will be highly appreciated.

If it is okay with you, may I proceed to ask you some questions related to how you handle the meat in the butchery.

I accept to take part in the study: Yes………….   No………………

Name of the interviewer……………………………………

Signature of interviewer ……………………………………

Date………………………………………........
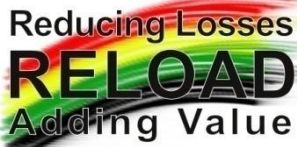
Sanitation and Hygiene Meat handling Practices of Small and Medium Enterprise Butcheries in Isiolo and Nairobi counties, KENYA

Structured and observational questionnaire for conducting survey among the small and medium size butchers in Isiolo and Nairobi counties – Kenya

Butchery name .... Questionnaire number ....

Introduction

This is to introduce you to a study on sanitation and hygiene meat handling practices that have an impact on beef quality in Kenya. The study is being conducted in two counties, Nairobi and Isiolo. The aim of this study is to assess the sanitation and hygiene practices of butchery operators in relation to hygienic handling of meat in SME butcheries. As a key stakeholder. Kindly accord us the necessary support to ensure the success of the survey. You are requested to spare some time to answer questions in this questionnaire. Your responses shall be used in strict confidentiality and shall not be attributed to you without your express permission. Please feel free to end the interview any time if you feel uncomfortable with it. Do you wish to continue with the interview?

I accept to take part in the study: Yes [ ]   No [ ]

Section A. Personal Identification

County……………………....   Sub-county………………………………….

Ward……………………........

Respondent's Name.......................

Section B. Demographic characteristics

Gender	Age	Religion	Highest Level of education reached	Marital status	Form of employment	Work experience
[.......]	[.......]	[.......]	[.......]	[.......]	[.......]	[.......]
1=Male	1=<20	1=Christian	1=Did not go to school	**1=**Married	1=Self employment	1=<1
2=Female	2=20-30	2=Muslim	2=Primary	2=Separated	2=Salaried employee (permanent)	2=1-5
	3=31-40	3=Other	3=Secondary	3=Widowed		3=5-10
	4=41-50		4=Tertiary	4=Single	3=Salaried employee (temporary)	4=>10
	5=>50		5=University	5=Divorced	4=Other	

SECTION C: Meat transportation, Storage and Selling (please tick one)

1. From which slaughterhouse do you get your meat from?

    1) Municipal slaughterhouse [   ]   2) Private slaughterhouse [   ]

2. How many kilograms do you buy from the slaughterhouse per day?

    1) <10 kg [   ] 2)10-40kg [   ] 3)41-70kg [   ] 4)71-100kg [   ] 5) 101-130kg [   ] 6) 131-160kg [   ]

3. What is the distance from the point of purchase to the point of sale?

1) <5km [   ] 2) 5-10km [   ] 3)11-20km 4)21-30km [   ] 5) >30km [   ]

4. How long does it take to transport meat from the point of purchase to your butchery?

   1) <1hr [   ] 2)2-4 hrs [   ] 3) >4 hrs [   ]

5. What type of containers do you use to transport meat to your butchery?

   1) Plastic crates [   ] 2) closed metallic containers [   ] 3) open metallic containers [   ] 4)

   refrigerated containers [   ]

6. How do you clean meat transport container?

   1) Cold water only [   ] 2) Cold water and soap [   ] 3) Hot water only [   ] 4) Hot water and soap [

7. At what temperatures do you transport your meat?

   1) Room temperature [   ]   2) refrigeration temperature [   ]

8. What is the type of road used?   1)Tarmac [   ]   2)Murram[   ]   3)earth [   ]   4)narrow path[   ]

9. What are the means of transportation of meat from slaughter site to the butchery?

   1)Open vehicle [   ]2)closed vehicle [   ]3)motorbike [   ]4)bicycle[   ] 5)animal transport[   ]

10. Where do you keep the meat after reaching the butchery while before selling?

    1) Inside the fridge [   ]   2) keep openly on the table [   ]   3) hang in the air [   ]

11. How long do you keep your meat before selling?

    1) Sell immediately [   ]   2) >1hr [   ]   3) 1-2hrs [   ]   3) 3-4hrs [   ] 4) <4hrs [   ]

12. How many kilograms do you sell per day? (Average quantity)

    1) <30kg [   ]   2) 31-60kg [   ] 3)61-90kg []4) 91-120kg [   ] 5)121-150kg[ ] 6)>150kg [   ]

13. How many hours do you spend in selling the volume of the meat you have

    1) <2hrs [   ] 2) 3-4hrs [] 3) 5-7hrs [   ] 4)8-10hrs [] 5)>10hrs [   ]

14. Do you have a cold storage? 1)[   ] yes 2)No[   ]

15. How much carry-over do you have?1)none[   ] 2)<10kg [   ]3)10-40kg[   ]4)41-70kg[   ]4)>70kg

    SECTION D: Training on meat handling hygiene and owning of medical certificate.

    16. Have you attended any training on meat handling hygiene? 1) Yes [   ] 2) No [   ]

17. What was the frequency of training? 1) Annually [   ] 2) Twice a year [   ] 3) other (specify).........

18. If yes, how was the effectiveness of the training? 1) effective [ ]   2) not effective[ ]

19. If no, do you have willingness to attend training on meat hygiene? 1) Yes [ ] 2) No [ ]

20. Are there sanitary regulation systems   1)yes[ ]   2) No[ ]

21. Frequency of regulations, if yes 1) Once a month [ ]   2) Twice –monthly [ ]   3) No –fixed time [   ]   4) other (specify).........

22.   Do you have a medical health certificate? 1) Yes [ ] 2) No [   ]

23. Do you/ your conduct medical check-up prior to employment? 1) Yes [   ]   2) No [ ]

24. How frequently do you conduct the medical check-up after employment? 1) Once a year [   ] 2) twice a year [ ]   3other (specify)..**.**

25. Who handlers the money in the butchery ?1) Cashier [ ] 2) The same person cutting the meat [ ]

SECTION E: Knowledge of butchery operators in relation to hygienic handling of meat in the butcheries

26. Meat spoilage is caused by spoilage micro-organisms 1) Yes [   ] 2) No [ ] 3) Not sure [ ]

27. Environmental contamination of meat is highly risky for meat shelf life

    1) Yes [ ]   2) No [ ]   3) Not sure [ ]

28. Food handlers with unhygienic practice could be the source for meat contamination

    1) Yes [ ]   2) No [ ]   3) Not sure [ ]

29. Chilling meat at less than 2^0C helps retard microbial spoilage

    1) Yes [ ]   2) No[ ]   3) Not sure [ ]

30. Contacting offals then meat with bare hands cause meat contamination

    1) Yes [ ]   2) No [ ]   3) Not sure [ ]

31. Microbial contamination can cause severe diseases that end in hospitalization and sometimes death1) Yes [   ] 2) No [ ] 3) Not sure [ ]

32. Apparently healthy food handlers might carry microbes 1) Yes [   ]   2) No [   ]   3) Not sure [   ]

33. Handling meat when I have diarrhea is risky 1) Yes [   ]   2) No [   ]   3) Not sure [   ]

34. Water can be a source of microbial contamination 1) Yes [   ] 2) No [   ] 3) Not sure [   ]

35. Treated water can be source of contamination1) Yes [   ] 2) No [   ] 3) Not sure [   ]

SECTION F: Practices of butchery operators in relation to hygienic handling of meat in the SME butcheries.

36. Do you wash your hands before handling meat? 1) Yes[   ]   2) No[   ]

37. How do you clean your hands? 1) With cold water only [   ]   2) with cold water and soap [   ]

   3) with hot water only [   ] 4) with hot water and soap[   ]   5)Smearing with piece of cloth[   ]

38. Do you clean your butchery? 1) Yes [   ] 2) No [   ]

39. How often do you clean your butchery? 1)daily [   ]   2)twice a day[   ]   3)weekly [ ]   4)hourly[   ]

40. Do you have a meat working table? 1) Yes [   ] 2) No[   ]

41. What type of meat working table do you use?   1) Wooden [   ]   2) metallic [] 3) plastic [   ] 4) other (specify)..

42. How do you clean your meat working table1) With cold water only [   ] 2) with cold water and soap [   ]3)with hot water only[   ] 4)with hot water and soap[   ]5)Smearing with piece of cloth[   ]

43. How often do you clean meat working table?1)immediately after use[   ] 2)daily [   ]3)twice a day[   ] 4)weekly [   ]5)hourly[   ]

44. Do you have a meat chopping board?   1) Yes [   ]   2) No[   ]

45. Do you clean meat chopping board?   1) Yes[   ]   2) No[   ]

46. How do you clean your meat chopping board 1) With cold water only [   ] 2) with cold water and soap [   ]3)with hot water only[   ] 4)with hot water and soap[   ]5)Smearing with piece of cloth[   ]

47. How often do you clean meat chopping board?1)immediately after use[ ]2)daily [ ]3)twice a day[ ] 4)weekly [ ]5)hourly[ ]

48. Do you clean meat chopping board after using it for offals before using it for lean meat?

Yes [ ] 2) No [ ]

49. How do you clean your meat chopping board after using it for offals before using it for lean meat? With cold water only [ ] 2) with cold water and soap [ ]3)with hot water only[ ] 4)with hot water and soap[ ]5)Smearing with piece of cloth[ ]

50. Do you clean meat weighing scale before using it? 1) Yes[ ] 2) No[ ]

51. How do you clean your meat weighing scale? 1) With cold water only [ ] 2) with cold water and soap [ ]3)with hot water only[ ] 4)with hot water and soap[ ]5)Smearing with piece of cloth[ ]

52. Do you clean your meat weighing scale after weighing different meat products like matumbo? 1)Yes[ ] 2) No[ ]

53. How do you clean your weighing scale after weighing different products like matumbo?1) With cold water only [ ] 2) with cold water and soap [ ]3)with hot water only[ ] 4)with hot water and soap[ ]5)Smearing with piece of cloth[ ]

54. Do you clean your meat weighing scale in the evening before leaving the butchery?

     1) Yes [ ] 2) No [ ]

55. Do you clean your knives before using them for cutting the meat? 1) Yes [ ] 2) No [ ]

56. How do you clean your knives before cutting meat? 1) With cold water only [ ]

    2) With cold water and soap [ ] 3) with hot water only [ ] 4) with hot water and soap [ ]

    5) Smearing with piece of cloth [ ]

57. Do you clean your knives after cutting matumbo (offals) and before cutting the lean meat?

    1)Yes[ ]   2) No [ ]

58. How do you clean the knives after cutting matumbo before cutting lean meat?

1) With cold water only [   ]   2) with cold water and soap [   ] 3) with hot water only [   ] 4) with

hot water and soap [   ]   5) Smearing with piece of cloth [   ]

59. How often do you clean your knives? 1)immediately after use[   ]   2)daily [   ]

3) Twice a day [   ] 4) weekly [   ]   5) hourly [   ]

60. Do you wear gloves when handling meat?   1) Yes[   ]   2) No [   ]

61. Do you wear head cover while selling meat?   1) Yes[   ]   2) No [   ]

62. Do you wear protective coat while selling meat?   1) Yes[   ]   2) No [   ]

63. Do you wash your protective coat? 1) Yes[   ]   2) No [   ]

64. How often do you wash your protective coat?1)daily[ ]2)twice a day[ ]3) hourly[   ] 4)weekly[   ]

65. Do you wash your hands after using the bathrooms? 1) Yes[   ] 2) No [   ]

66. Do you handle meat when you have lesions on your hands? 1) Yes[   ] 2) No [   ]

67. Do you handle meat when you have diarrhea? 1) Yes[   ] 2) No [   ]

68. Do you keep your finger nails long? 1) Yes[   ] 2) No [   ]

69. Do you keep beards? 1) Yes[   ] 2) No [   ]

70. If yes, do you cover beards while handling meat? 1) Yes[   ] 2) No [   ]

71. If yes, How do you cover your beards?1)with a beard cover[   ] 2)with a piece of a cloth[   ]

SECTION G: Meat losses in the butcheries

72. Do you weigh your fresh carcass after purchase from the slaughterhouse?1)Yes [   ] 2) No [

73. Do you sell the entire carcass purchased from the slaughterhouse the same day?

1) Yes [   ]2) No [   ]

74. Do you weigh the meat left in the evening? 1) Yes [   ] 2) No [

75. Do you weigh the carry over the next day in the morning? 1) Yes [   ] 2) No [   ]

76. What is the weight loss when the meat in weighed the next day 1) <1kg [   ] 2) 2kg [   ]

3) >3kg [   ]

77. Do you incur any meat spoilage? 1) Yes [   ] 2) No [   ]

78. What do you think is the cause of meat spoilage?1) Poor handling [ ]2) Poor storage [ ]

   3) Other (specify)...

79. Do you incur any microbial spoilage? 1) Yes [ ] 2) No [ ]

80. If yes, how often do you lose meat due to microbial spoilage? 1) daily [ ]   2)weekly[ ] 3) monthly

   [   ] 4)rarely[ ]5)other(specify)...

81. Do you incur any meat losses? 1) Yes [ ] 2) No [ ]

82. What are the major causes of meat losses in your butchery? 1)Chopping/splitting[   ]2) microbial

   spoilage[ ] 3) moisture loss[   ] 4)other(specify)..............................

83. In general how many kilograms of meat do you normally lose?

   1) <1kg [ ]   2) 2kg [   ]   3)>2kg [   ]

SECTION H: List for observational check

Q	Statement
1	What is the type of butchery structure? 1)kiosk[ ] 2)open shelter [ ]3)under tree[ ]
2	Does the butcher wear specific cloth for selling meat? 1) Yes [ ] 2) No [ ]
3	Is there a hand washing station? 1) Yes [ ] 2) No [ ]
4	Is there availability of toilets?1) Yes [ ] 2) No [ ]
4	Is there availability of waste disposal facilities? 1) Yes [ ] 2) No [ ]
5	Does the butcher wash his/her hands before handling meat? 1) Yes [ ] 2) No [ ]
6	Does the butcher allow the customer to touch the meat before buying? 1) Yes [ ] 2)No[ ]

Thank you for your time

7.3 ANNEX 3: Inferential Statistics
Chi-Square (x^2)

Association between training and washing of hands by butchery operators in SME butcheries in Nairobi County, Kenya.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	4.32[a]	1	0.04		
Continuity Correction[b]	.000	1	1.000		
Likelihood Ratio	.013	1	.909		
Fisher's Exact Test				1.000	.542
Linear-by-Linear Association	.013	1	.910		
N of Valid Cases[b]	134				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 7.76.

b. Computed only for a 2x2 table

Association between training of butchery operators and wearing of protective clothing by butchery operators in SME butcheries in Nairobi County, Kenya.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	9.09[a]	1	0.013		
Continuity Correction[b]	.000	1	1.000		
Likelihood Ratio	.017	1	.895		
Fisher's Exact Test				1.000	.658
Linear-by-Linear Association	.018	1	.894		
N of Valid Cases[b]	134				

a. 2 cells (50.0%) have expected count less than 5. The minimum expected count is .90.

b. Computed only for a 2x2 table

Association between training of butchery operators and washing of utensils by butchery operators in SME butcheries in Nairobi County, Kenya.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.575[a]	2	.455
Likelihood Ratio	1.745	2	.418
Linear-by-Linear Association	.006	1	.937
N of Valid Cases	134		

a. 3 cells (50.0%) have expected count less than 5. The minimum expected count is .60.

Association between Education level and wearing of protective clothing by butchery operators in SME butcheries in Nairobi County, Kenya.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	9.883[a]	4	.042
Likelihood Ratio	5.693	4	.223
Linear-by-Linear Association	.207	1	.649
N of Valid Cases	134		

a. 7 cells (70.0%) have expected count less than 5. The minimum expected count is .07.

Association between education level and cleaning of butchery utensils by butchery operators in SME butcheries in Nairobi County, Kenya.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	9.8a[a]	8	.017
Likelihood Ratio	2.346	8	.969
Linear-by-Linear Association	.304	1	.581
N of Valid Cases	134		

a. 12 cells (80.0%) have expected count less than 5. The minimum expected count is .04.

Association between education level and washing of hands by butchery operators in SME butcheries in Nairobi County, Kenya.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.841[a]	4	.428
Likelihood Ratio	4.494	4	.343
Linear-by-Linear Association	3.499	1	.061
N of Valid Cases	134		

a. 5 cells (50.0%) have expected count less than 5. The minimum expected count is .58.

Association between training of butchery operators on meat handling hygiene and cleaning of butchery utensils in SME butcheries in Isiolo County, Kenya.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	3.953[a]	1	.047		
Continuity Correction[b]	2.548	1	.110		
Likelihood Ratio	6.386	1	.012		
Fisher's Exact Test				.056	.042
Linear-by-Linear Association	3.897	1	.048		
N of Valid Cases[b]	71				

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 2.54.

b. Computed only for a 2x2 table

Association between training of butchery operators on meat handling hygiene and washing of hands by butchery operators in SME butcheries in Isiolo County, Kenya.

Chi-Square Tests					
	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	6.187[a]	1	.013		
Continuity Correction[b]	1.081	1	.298		
Likelihood Ratio	4.010	1	.045		
Fisher's Exact Test				.141	.141
Linear-by-Linear Association	6.100	1	.014		
N of Valid Cases[b]	71				

a. 2 cells (50.0%) have expected count less than 5. The minimum expected count is .14.

b. Computed only for a 2x2 table

Association between training of butchery operators on meat handling hygiene and wearing of protective clothing by butchery operators in SME butcheries in Isiolo County,Kenya

Chi-Square Tests					
	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	4.422[a]	1	.035		
Continuity Correction[b]	2.715	1	.099		
Likelihood Ratio	3.649	1	.056		
Fisher's Exact Test				.058	.058
Linear-by-Linear Association	4.359	1	.037		
N of Valid Cases[b]	71				

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 1.69.

b. Computed only for a 2x2 table

Association between education level of butchery operators and cleaning of butchery utensils in SME butcheries in Isiolo County, Kenya.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	19.186[a]	3	.000
Likelihood Ratio	17.283	3	.001
Linear-by-Linear Association	5.890	1	.015
N of Valid Cases	71		

a. 4 cells (50.0%) have expected count less than 5. The minimum expected count is .25.

Association between education level and washing of hands by butchery operators in SME butcheries in Isiolo County, Kenya.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.622[a]	3	.891
Likelihood Ratio	.966	3	.810
Linear-by-Linear Association	.101	1	.750
N of Valid Cases	71		

a. 5 cells (62.5%) have expected count less than 5. The minimum expected count is .01.

Association between education level of butchery operators and wearing of protective clothing by butchery operators in SME butcheries in Isiolo County, Kenya.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.514[a]	3	.138
Likelihood Ratio	7.193	3	.066
Linear-by-Linear Association	.481	1	.488
N of Valid Cases	71		

a. 4 cells (50.0%) have expected count less than 5. The minimum expected count is .17.