Pre-Slaughter and Slaughter Factors Associated with Post-Harvest Beef Quality Loss in Small and Medium Enterprise Slaughterhouses in Kenya

By

Joseph Mwaniki Wambui

A56/71942/2014

(B.Sc. Food Science and Technology (UON))

A Dissertation report submitted in partial fulfilment of the requirement for the degree of Master of Science in Food Safety and Quality in the University of Nairobi

Department of Food Science, Nutrition and Technology

19th October 2016

UNIVERSITY OF NAIROBI

Plagiarism Declaration Form

Name of Student ____

Registration Number ____

College ____

Faculty/School/Institute_______________________________________

Department ____

Course Name ____

Title of the work____

____

____

____

DECLARATION

1. I understand what Plagiarism is and I am aware of the University's policy in this regard
2. I declare that this **DISSERTATION** is my original work and has not been submitted elsewhere for examination, award of a degree or publication. Where other people's work, or my own work has been used, this has properly been acknowledged and referenced in accordance with the University of Nairobi's requirements.
3. I have not sought or used the services of any professional agencies to produce this work
4. I have not allowed, and shall not allow anyone to copy my work with the intention of passing it off as his/her own work
5. I understand that any false claim in respect of this work shall result in disciplinary action, in accordance with University Plagiarism Policy

Signature ______________________Date: ___________.

Declaration

I, Joseph Mwaniki Wambui, hereby declare that this dissertation is my original work and that it has not been presented for a degree in any other University.

Sign:…………………………………… Date ……………………..

Approval

As University supervisors, we have read and appoved the submission of this dissertation for examination.

Signed………………………………… Date………………………………………

Prof. Edward G. Karuri

Department of Food Science, Nutrition and Technology

University of Nairobi

Signed………………………………… Date………………………………………

Mr. Peter O. Lamuka

Department of Food Science, Nutrition and Technology

University of Nairobi

Signed………………………………… Date………………………………………

Prof. Joseph W. Matofari

Department of Dairy and Food Science and Technology

Egerton University

Dedication

To my mother, Ruth Wambui Mwaniki for your prayers, financial and moral support, patience and encouragement.

Acknowledgement

I sincerely thank my supervisors, Prof. Edward Gichohi Karuri, Mr. Peter Obimbo Lamuka and Prof. Joseph W. Matofari for their professional guidance, constructive comments and encouragement throughout the study period and in particular during the dissertation write-up. Your critical thinking, insight and attention to detail made the writing process easier. Your contribution is highly treasured.

I am forever indebted to you Prof. Patrick Murigu Kamau Njage for your contribution throughout my study period even though you were not my supervisor. Your selfless act contributed to this wonderful dissertation write-up.

I am also indebted to Mr. Khalif Abdi Abey for making the fieldwork possible through organized Key Informants Interviews and Focus Group Discussions and never ending moral support.

My special thanks go to the stockpeople and meat handlers without whom this study would not have been possible. I sincerely thank everyone who granted me interviews and took time off their busy schedules to respond to the long questionnaires. I am grateful to all Veterinary Officers and managers of the SME slaughterhouses for their consent to collect swab samples for microbial analysis.

I would also like to acknowledge the Federal Ministry of Education and Research (BMBF) of Germany for fully funding the study through the RELOAD (Reducing Losses Adding Value) Project.

Finally, I express my sincere gratitude to the DFSNT Microbiology Lab staff, especially Jacinta Muchiri, Monica Njoroge, Edith Cherotich and Jared Omondi for their guidance and assistance during the sample analysis period.

Table of Contents

List of Tables

List of Figures

List of Appendices

Operational Definition of Terms

Animal welfare: the state of the *animal*; the treatment that an *animal* receives is covered by other terms such as *animal* care, *animal* husbandry, and humane treatment

Attitude: those factors which may influence a person's behaviour while doing something

Food Hygiene: all conditions and measures necessary to ensure the safety and suitability of food at all stages of the food chain

Hygiene indicator microorganism: micro-organisms used as a measure of the hygienic or sanitary conditions of surfaces or product quality in a food-processing environment

Knowledge: an individual's understanding of a topic, including the intellectual ability to remember and recall related activities and specific pieces of information and facts

Kruskal-Wallis H test: a nonparametric alternative to a one-way ANOVA. It is used when the assumptions of ANOVA are not met. The test does not require the data to be normal, but instead uses the rank of the data values instead of the actual data values for the analysis

Mann-Whitney U test: a nonparametric alternative to independent T-test. The test does not require the data to be normal, but instead uses the rank of the data values instead of the actual data values for the analysis

Meat handler: any person who directly handles packaged or unpackaged meat, meat equipment or meat contact surfaces and is therefore expected to comply with food hygiene requirements

Meat quality: a generic term that describes properties and perceptions of meat such as carcass composition and conformation, the eating quality of the meat and safety

Meat: all parts of an animal that are intended for, or have been judged as safe and suitable for, human consumption

Microbial contamination: the introduction or occurrence of a microbiological agent to food that may compromise food safety or suitability

Microbiological criteria: a definition of acceptability of a product or a food lot, based on the absence or presence, or number of microorganisms, per unit(s) of mass, volume, area or lot

Practice: observable actions of an individual that could affect whatever they are doing or handling

Pre-slaughter: conditions and practices that apply during the period when the animal is moved or mustered on-farm to entry into the knocking box at the slaughterhouse

Slaughter: conditions and practices that apply during the period when an animal is killed for food

Slaughterhouse: an establishment where animal slaughter takes place

Small and Medium Enterprise: in Kenya, it refers to those firms that engage 5 to 99 workers

Stockperson: a person involved in the management of animals in a safe, effective, and low-stress manner for both the person and animals involved

Stress: the inevitable consequence of the process of transferring animals from farm to slaughter

Abbreviations

APC: Aerobic plate count

ASAL: Arid and Semi-Arid Land

CA $: Canadian Dollar

CAC: Codex Alimentarius Commission

cfu: Colony forming units

EFSA: European Food Safety Authority

EU: European Union

FAO: Food and Agriculture Organisation of the United Nations

GOK: Government of Kenya

IFAD: International Fund for Agricultural Development

KAP: Knowledge, attitude and practices

KES: Kenyan Shilling

MH: Meat handlers

MT: Metric tonnes

***N*:** Sample size

OIE: World Organisation for Animal Health

***p*:** P value, or calculated probability

PCP: Potential contamination point

SD: Standard deviation

SME: Small and medium enterprise

SPSS: Statistical Package for the Social Sciences

U.S. $: United States of American Dollar

WFP: Welfare friendly products

WHO: World Health Organisation

General Abstract

Pre-slaughter and slaughter practices are important for meat quality. Unfortunately, in Kenya, codes of practices for both pre-slaughter and slaughter are missing most notably in the Small and Medium Enterprise (SME) slaughterhouses increasing the risk of low quality meat. The main objective of this study was therefore to assess the pre-slaughter and slaughter factors contributing to post-harvest quality loss of beef in SME slaughterhouses in Kenya. The study was carried in 10 livestock markets located in Kenya's pastoral areas and Nairobi County and its environs and five SME slaughterhouses in Nairobi County and its environs. The main objective was divided into four specific objectives. The first specific-objective assessed the design of trucks currently used to transport cattle and quantify losses during trucking. Modified floor and smooth interior walls were present in 95.8% and 80.0% of the trucks, while 77.1% and 94.3% of the trucks had side vents and open roofs, respectively. None of the trucks was divided into compartments. Cattle mortality rate during trucking was 6.16% and the major cause was injuries from other animals. In the second specific-objective, the animal welfare knowledge, attitude and practices (KAP) was assessed among 266 stockpeople. Out of a high possible score of 100%, the mean percentage scores of knowledge, attitude, and practice were 78.0 ±14.1%, 75.6 ±16.0% and 64.5 ±17.6%, respectively. The stockpeople scored <70% in knowledge and attitude questions related to animal feeding and watering, and mixing of unfamiliar groups of animals and practices questions related to mixing unfamiliar groups, cooperation with other stakeholders and agitation of animals during handling. In the third specific objective, the level of personal hygienic practices among 207 meat handlers (MH) was assessed. Majority of the MH reported that they do not always use soap and disposable towels during hand washing and gloves during meat handling, clean their equipment between carcasses or keep their equipment

away from their protective clothes when not in use. In the final specific-objective, the level of microbial contamination of carcasses, personnel and equipment was assessed in 225 swab samples collected at various slaughter stages. The contamination of carcasses increased from flaying to dispatch. Contamination of personnel was highest at flaying and evisceration. Contamination of knives was highest at flaying. In conclusion, the pre-slaughter and slaughter factors, which may contribute to post slaughter meat quality loss, are prevalent as evident in the study. Measures, such as training, should be put in place to address them.

Dissertation Layout

The study was organized as four sub-studies, which for the purpose of presenting this Dissertation report are organized in seven chapters as follows:

Chapter 1: A general introduction to the study describing the study background, problem statement, justification and objectives

Chapter 2: A review of literature to identify gaps in the study

Chapter 3: An assessment of the design of trucks used to transport cattle in Kenya and deaths of cattle during trucking

Chapter 4: An assessment of animal welfare knowledge, attitudes and practices of stockpeople in Kenyan livestock markets

Chapter 5: An assessment of hygiene practices of meat handlers in SME slaughterhouses in Nairobi County and its environs

Chapter 6: An assessment of the level of contamination of beef, personnel and equipment with hygiene indicator microorganisms in SME slaughterhouses in Nairobi County and its environs

Chapter 7: General discussion on main findings, conclusion and recommendations

Chapter 1. General Introduction

1.1. Background information

According to the 2009 census, Kenya's livestock population comprised over 14, 3, 17, 24 and 3 million of indigenous cattle, exotic cattle, sheep, goats and camels, respectively (GOK, 2009). Although 70-80% of this herd was raised in the pastoral areas (Behnke and Muthami, 2011), less than 20% of the meat produced from the national herd is consumed in the pastoral areas (Aklilu, 2002). Thus, the rest of the livestock have to be transported to their terminal markets for slaughter and further distribution of their meat to far destinations. Nairobi and Mombasa make up the largest of the terminal markets for livestock (Farmer and Mbwika, 2012). As a result, animals have to move considerable distances to reach these markets.

The two methods used for animal transportation, trekking and trucking, contribute to losses of about 5 and 7 Kgs/head, respectively (Aklilu, 2002). The problem associated with long distance moved by the livestock is compounded by poor roads and exposure to numerous stress factors. Long time in transportation and handling during transportation are some of the stress factors that contribute to loss of meat quality primarily due to glycogen depletion in the muscle (Arthington *et al.*, 2003; Hoffman *et al.*, 1998; Honkavaara *et al.*, 2003; Malena *et al.*, 2007; Schaefer *et al.*, 1997). Glycogen depletion causes high ultimate pH (pH_{24}) which in turn results to dark red colour (Bartoš *et al.*, 1993; Kreikemeier *et al.*, 1998a; Mounier *et al.*, 2006), increased tenderness variation and water holding capacity (Apple *et al.*, 2005; Silva *et al.*, 1999; Zhang *et al.*, 2005). High pH_{24}, which is the pH of the meat 24 h after slaughter, promotes the growth of microorganisms to unacceptable levels leading to meat spoilage (Gardner *et al.*, 2001). When these quality losses are translated into quantity losses, it can result in major economic losses for Kenya's livestock sector.

Once in the slaughterhouse, it is expected that the pre-slaughter and slaughter operations will be carried out in accordance to the Kenyan regulations. However, enforcement of these regulations is very weak (Muthee, 2006). Notably, more emphasis is given on post-slaughter inspection compared to pre-slaughter inspection (Farmer and Mbwika, 2012). Handling practices at the slaughterhouse lead to a decrease in early post mortem pH resulting in anaerobic conversion of glycogen and consequently lowers the quality of meat. The way in which the animal is stunned and exsanguinated can also contribute to reduced meat quality (Pipek *et al.*, 2003). After stunning and exsanguination, subsequent slaughter operations expose the once sterile muscle of healthy animals to both spoilage and pathogenic microbial contaminants (Gill, 1998; Sofos *et al.*, 2000). The presence of the latter or their toxins may be the cause of foodborne disease that may lead to loss of human life (Sofos, 1994).

The activities that take place during pre-slaughter and slaughter of livestock are many and complex. Failure in one activity can lead to losses in the meat value chain. Necessary measures should therefore be taken to ensure as minimal losses as possible occur in the chain. This study therefore not only assesses the causes of meat quality losses, but it also aims at providing baseline data for interventions to reduce the resulting losses.

1.2. Problem statement

In Kenya, pre-slaughter and slaughter practices in SME slaughterhouses are short of best practices resulting in poor quality carcasses with short-life, hence high post-slaughter losses. Failure to observe good practices pre-slaughter and care of meat during and after slaughter can lead to losses related to quality loss, condemnation and spoilage. The poor pre-slaughter practices during loading of animals, trucking and/or trekking, offloading and holding of animals results to physiological stress and injuries to the animals. Further stress is induced during trucking and/or trekking over long distances without feeding and watering. Trekking also exposes animals to harsh conditions e.g. running and physical assault. Meat from animals that are stressed or injured during pre-slaughter handling has a low shelf life contributing significantly to post-slaughter losses in meat quality. Poor slaughterhouse and environmental hygiene further leads to these losses. Numerous reports linking poor enforcement of hygiene regulations and poor slaughterhouse and environmental hygiene exist.

Majority of Kenyan meat is supplied by the SME slaughterhouses, however the link between pre-slaughter and slaughter operations and how they affect meat quality and safety is very weak. The risk factors contributing to resultant post-harvest quality losses due to poor pre-slaughter and slaughter handling practices have not been documented adequately. To improve meat yield of Kenya's SMEs slaughterhouses, it is important to identify factors during pre-slaughter and slaughter operations that result in post-harvest losses. Therefore, this study aims at identifying pre-slaughter and slaughter handling practices that affect meat post-harvest losses in the SME slaughterhouses in Kenya.

1.3. Justification

Ideally, interventions that reduce meat quality loss are only effective when the potential sources of quality loss are first identified (Galland, 1997). The slaughterhouse environment and its sanitary conditions are major sources of meat quality loss. Specifically, bacterial contamination of meat originates from a variety of processing and animal sources (Boerema *et al.*, 2003; Gill and Landers, 2004; Gill and McGinnis, 2000). Contamination leads to meat spoilage and should be addressed because, spoilage in itself is wasteful and costly (CAC, 2003). In this case, application of adequate sanitary flaying practices during slaughter can be a major intervention that reduces bacterial contamination of carcasses (Algino *et al.*, 2007). These practices should not be just developed but should be translated into actual and suitable practices.

Losses arising from poor quality meat can negatively affect Kenya's meat value chain and majority of households that depend on livestock meat production. Primary production strategies to improve meat productivity may not be effective because grazing land in Kenya is limited (Muthee, 2006). Therefore, this requires the identification of lost hot spots during pre-slaughter and slaughter operations. This will ensure the process of converting muscle into high quality meat is optimum. Specifically, live animals should be given maximum amount of care to reduce chances of yield loss (Warriss, 1990). When animals for slaughter are properly handled productivity, quality and profitability increase (Smith and Grandin, 1998), while the opposite occurs when animals are given poor care. A study in Canada estimated that poor handling of cattle results in nonconformities that cost the Canadian beef industry about CA $70 per head (Van Donkersgoed *et al.*, 1997). Similar studies have shown that a reduction of non-conformance can save the beef sector a lot of money. One such study in the United States determined that the beef industry could have recaptured about U.S. $13 per head processed by non-conformance (Roeber *et al.*, 2001).

1.4. Study aim

This study addresses pre-slaughter and slaughterer practices that contribute significantly to beef post-harvest quality loss in SME slaughterhouses in Kenya.

1.5. Study purpose

The purpose of this study was to identify the factors contributing significantly to post-harvest beef quality loss in SME slaughterhouses in Kenya

1.6. Study objectives

1.6.1. Main objective

The main objective of this study was to assess pre-slaughter and slaughter factors contributing to post-harvest quality loss of beef in SME slaughterhouses in Kenya.

1.6.2. Specific objectives

1. Evaluate the design of trucks used to transport cattle in Kenya's pastoral areas
2. Assess the animal welfare knowledge, attitude and practices of stockpeople in Kenya's pastoral areas and Nairobi County and its environs
3. Assess the sanitation and hygiene practices in SME Slaughterhouses in Nairobi County and its environs
4. Assess the microbial contamination of carcasses, personnel and equipment in SME slaughterhouses in Nairobi County and its environs

Chapter 2. Literature Review

2.1. Importance of the livestock sector to Kenya's economy

The livestock sector in Kenya contributes about 5.6% (GOK, 2009) to 12.5% (Behnke and Muthami, 2011) to the national Gross Domestic Product (GDP) while estimates of the contribution to agricultural GDP range from 30% (Muthee, 2006) to 47% (FAO, 2005). Livestock production is a major economic and social activity for the communities that live in the high rainfall areas for Intensive livestock dairy production and in the arid and semi-arid areas (ASALS) for meat production (Kiptarus, 2005). The sector employs close to 50 per cent of Kenya's agricultural labour force and is a primary source of livelihoods for the 6 million pastoralists and agro-pastoralists that live in the country's ASALs (Farmer and Mbwika, 2012).

Over 70 per cent of the national livestock herd was raised by pastoralists, and, in 2005, Kenya's livestock in the ASALs was estimated to be worth KES 60 billion (approximately U.S. $800 million), with an internal trade in pastoral areas in the order of KES 6 billion (U.S. $80 million) per year (Farmer and Mbwika, 2012). In pastoral production systems, which are characterized by extensive rangeland grazing systems, communal rangeland and water resources management, and wet and dry season mobility, livestock accounts for 90% of employment and 95% of family incomes (Behnke and Muthami, 2011; Farmer and Mbwika, 2012).

The beef industry has been ranked as one of Kenya's fast rising economic sectors through exports to overseas countries and was projected to hit KES 70 billion in the consequent five years (IFAD, 2012). Beef production was estimated by Ministry of Livestock Development to have grown from 287,000 MT in the year 2001 to about 300,000 MT by year 2008 (IFAD, 2012). Kenya has experienced an important rise in meat exports since 2005, with volumes increasing by a factor of 11 over the five-year period between 2005 and 2010. The 2009-2010 period saw the most dramatic increase, with a doubling of volumes, although the export volumes (2,500 MT in

2010) remained small and accounted for only 1% of Kenya's meat production (Farmer and Mbwika, 2012). The main potential markets for Kenya meat and meat products are other African countries Middle East and Europe (Kiptarus, 2005). Under the Lome and Cotonou Agreements and the European Beef and Veal Protocol, Kenya has been allocated a quota of 142 MT but has not met its quota since 2000 (Muthee, 2006). By exploiting these markets, the livestock market has the potential to further contribute to the economy. Even though this gives Kenya a high potential, exploitation is limited by market accessibility and diseases (Muthee, 2006) which needs addressing.

2.2. Slaughter operations in Kenya and potential impact on meat quality

Kenya's slaughter operations are performed mainly by two formal types of slaughterhouses and abattoirs: those licensed to slaughter for the domestic market (the majority) and those licensed to slaughter for export in addition to the domestic market (Farmer and Mbwika, 2012). The abattoir and slaughter facilities are generally poor from a hygiene and environmental perspective indicating low enforcement of hygiene regulations (IFAD, 2012). Enforcement of other regulations through Veterinary Services Division (DVS) and Public Health is very weak at present (Muthee, 2006). Once in the slaughterhouse, it is expected that the pre-slaughter and slaughter operations will be as provided for in the extensive regulations on meat hygiene rules prepared by DVS (Muthee, 2006). It has however been noted that enforcement of these rules is very weak. Notably, In the SME slaughterhouses, animals are only inspected after slaughter without undergoing pre-slaughter inspection (Farmer and Mbwika, 2012). In contrast, local abattoirs, allow animals a minimum of 24 hours rest period before they are slaughtered; and are inspected for any diseases or physical injury before and after they are slaughtered (Farmer and Mbwika, 2012).

Handling practices at the slaughterhouse have also been shown to affect the quality of meat. Early post mortem pH decrease as result of anaerobic transformation of glycogen to lactic acid is one of these effects. The slaughter technology (the technique of stunning and exsanguination) can also contribute to these factors (Pipek *et al.*, 2003). After stunning and exsanguination, subsequent slaughter operations expose the once sterile muscle of healthy animals to microbial contaminants (Gill, 1998; Sofos *et al.*, 2000). Once in the slaughterhouse, it is expected that the pre-slaughter and slaughter operations will be as provided in the extensive regulations on meat hygiene rules prepared by Kenya Bureau of Standards (Farmer and Mbwika, 2012). It has however been noted that enforcement of these rules is very weak (Muthee, 2006) at present. Notably, animals are only inspected after slaughter without undergoing pre-slaughter inspection (Farmer and Mbwika, 2012). Contamination with spoilage microorganisms may lead to product and economic losses, while presence of pathogens or their toxins may be the cause of foodborne disease that may lead to loss of human life (Sofos, 1994).

It has been demonstrated that the slaughterhouse environment and its sanitary conditions are major factors contributing to bacterial contamination of meat and these contaminants originate from a variety of processing and animal sources (Boerema *et al.*, 2003; Gill and Landers, 2004; Gill and McGinnis, 2000). The processing sources include personnel and equipment. The primary tool in reducing bacterial contamination of beef carcasses is by employing effective sanitary dressing procedures during slaughter (Algino *et al.*, 2007). These procedures should not be just developed but should be translated into working methods suitable for practical use. Contamination leads to meat spoilage and should be addressed because, spoilage in itself is wasteful and costly (CAC, 2003). Losses arising from meat spoilage can have a significant impact on Kenya's main source of red meat as cattle supply 80 per cent of the nation's ruminant off take for slaughter (Behnke and Muthami, 2011). An effective way to increase productivity is to reduce losses during slaughter operations so that as much muscle as possible is converted into safe meat. Loss reduction strategies begin with determining potential sources of loss in quality (Galland, 1997).

2.3. Significance of the design of animal transportation trucks

The condition of trucks can affect the welfare of slaughter animals (Edge and Barnett, 2009). Well-designed trucks can minimize some of the cost associated with unsuccessful adjustment of animals to transportation factors (Miranda-de la Lama *et al.*, 2014). As such, the trucks should have floors with rough surfaces, preferably made of pressed metal, to prevent the animals from falling (Lapworth, 2008). Other materials such as manure, saw dust and sand are not recommended because the absorption of excretions from transported animals by the materials can result in slippery conditions when the materials reach their maximum absorption capacity (Hutchison *et al.*, 2005; Miranda-de la Lama *et al.*, 2014). Slippery conditions may cause falling and trampling of cattle exacerbating the injuries and in extreme cases causing death (Southern *et al.*, 2006). In addition, these materials may impair the cleaning process of the trucks thus making the trucks a host to disease pathogens (Martínez-López *et al.*, 2008).

The nature of the trucks' interior wall is important in preventing bruises. To minimize the prevalence of bruises, hard wood is recommended for use along the body chases (Lapworth, 2008). Another feature of the trucks is ventilation systems (Miranda-de la Lama *et al.*, 2010, 2011). The ventilation system can be either passive or active. Although common, the former does not provide for constant macro-environment condition within the truck because it will depend on shape and speed of the truck as well as wind speed (Norton *et al.*, 2013). The system is especially inadequate when a truck is not moving because temperature and relative humidity inside the truck tend to rise causing cattle to shrink in body weight or become non-ambulatory (Broom, 2005; González *et al.*, 2012a, 2012b).

Compartments within a truck are key design features. They provide livestock with a barrier against shocks they are subjected to during transport. Some of these shocks include sudden brakes or travel on hilly, windy and rough roads (Lapworth, 2008). These compartments will provide sufficient space for each animal to adjust their posture naturally and brace themselves against the movement of the vehicle (Southern *et al.*, 2006). In addition, fighting tends to occur most often when a vehicle stops suddenly and animals are inadvertently 'pushed' into each other (Chambers and Grandin, 2001). Two types of trucks exist in terms of compartments: Those without compartments which are common in countries such as Namibia (Hoffman and Lühl, 2012) and those with specialized individual compartment such as those found in Canada (González *et al.*, 2015).

2.4. Animal welfare knowledge attitude and practices

2.4.1. Animal welfare knowledge

Appropriate knowledge of animal handling among stockpeople is a prerequisite for optimal animal productivity and welfare (Hemsworth and Coleman, 2011). As such, stockpeople should have the knowledge required to interact with animals (Kılıç and Bozkurt, 2013). Education and training are the two most important factors for animal welfare Knowledge (Greger, 2007). Unfortunately, stockpeople have neither basic training nor sufficient knowledge and understanding about the welfare of the animals they handle (Bulitta *et al.*, 2012). The low level of knowledge therefore can be the result of inefficient transfer of a large amount of behavioural knowledge to the livestock industry (Grandin, 2003). In addition, there are no laws that require animal transporters to be trained in animal handling (Schwartzkopf-Genswein *et al.*, 2008).

2.4.2. Animal welfare attitude

Animal welfare attitude influences future behaviour, no matter what is the current knowledge level of an individual; and it also helps explain why an individual adopts one practice and leaves other alternatives (Macias and Glasauer, 2014). During handling, these attitudes may result in differences such as one person causing high levels of stress in the animals while another doing the same with little or no such stress (Broom, 2005). Indeed, the behaviour of stockpeople towards animals is strongly influenced by attitudes (Boivin *et al.*, 2003).

2.4.3. Animal welfare practice

Good animal handling practices result in better animal welfare (Lapworth, 2008). However, animals for slaughter are handled in inhumane manner in developing nations (Rahman, 2004). This hypothesis can be supported by a previous report that there are numerous videos from the developing world which show abusive handling of animals (Koknaroglu and Akunal, 2013). In abattoirs, stockpeople do not think about engaging in better handling practices; this meets with the demands of management that they keep up with the speed of the processing facility (Coleman *et al.*, 2003). The major difference between practices in developing and developed nations is attributed to an increasing interest toward animals and animal product production methods in recent years in developed nations (Koknaroglu and Akunal, 2013). In contrast, requirements from markets of Welfare Friendly Products in developed nations have motivated improvement of animal welfare issues (Paranhos da Costa *et al.*, 2012). Finally, the abundance of scientific information in developed nations focusing on animal welfare (Swanson, 2001) has enabled these countries to establish codes of practice for animal handling.

2.4.4. Importance of personal hygiene practices

Personal hygiene refers to cleanliness of all surfaces of the body likely to come into contact with foods (Nel *et al.*, 2004). Good personal hygiene during food handling is important for food safety programs, while poor personal hygiene can result in foodborne diseases outbreaks (Ansari-Lari *et al.*, 2010; Assefa *et al.*, 2015; Egan *et al.*, 2007; Green *et al.*, 2007; Halim *et al.*, 2015). Annually, poor personal hygiene can contribute to 10-97% of foodborne illness outbreaks, where meat and meat products are particularly important (Assefa *et al.*, 2015; Green *et al.*, 2007; Kahraman *et al.*, 2010). Therefore, all food handlers must ensure high level of personal cleanliness by wearing protective clothing that are suitable and clean (Raspor and Jevšnik, 2009). Protective clothing determine the quality of the working environment (Nel *et al.*, 2004). Attention to personal hygiene has the potential to prevent food cross-contamination, hence foodborne diseases (Nee and Sani, 2011).

Food handlers are not only regarded as potential carriers of pathogens; but their poor hygiene practices may result to contamination of food with these pathogens, which in some cases increase their counts to levels likely to cause foodborne illnesses (Assefa *et al.*, 2015; Opiyo *et al.*, 2013). Normally, humans shed more than $1x10^3$ viable micro-organisms per minute (Frazier and Westhoff, 1988). The food handlers therefore shed some of these pathogens, because the pathogens may be found on their body surface (Sharif *et al.*, 2013). In addition to poor practices, inadequate food hygiene knowledge and attitude have been reported as factors that increase these risks (Halim *et al.*, 2015). Some of the pathogens associated with poor personal hygiene include; *S. aureus*, *E. coli, Salmonella* spp., *Campylobacter* spp, *Shigella* spp., Norovirus and hepatitis A virus (Sharif *et al.*, 2013; Shojaei *et al.*, 2006). Some of these pathogens are able to continue existing on food contact surfaces for several days (Pérez-rodríguez *et al.*, 2013).

2.5. Recommended personnel hygiene practices

2.5.1. Hand washing practices

Hands are a major source of infection from microorganisms, because they are always on the hands' surface and close to 10^7 pathogens are present under the fingernails (Kahraman *et al.*, 2010; Nel *et al.*, 2004; Raspor and Jevšnik, 2009). Therefore, when the level of cleanliness of the hands is not adequate, food handlers should wash their hands so that the quality of food is not affected (Assefa *et al.*, 2015). More so, hands should be washed immediately after visiting the toilet. Neglecting this practice is considered one of the biggest risk factors for food safety (Jevšnik *et al.*, 2008). Proper hand washing practices, which include the application of soap, paper towels can result in a significant reduction of micro-organisms (Montville *et al.*, 2002; Shojaei *et al.*, 2006). In the final step of hand-washing, which is drying, the use of disposable paper towels is highly recommended (Nel *et al.*, 2004).

2.5.2. Protective clothing

Appropriate and clean protective clothing, including aprons, gumboots, hairnets, and beardnets are recommended for food handlers to reduce the risk of food contamination (Assefa *et al.*, 2015; Azmi, 2006; Nel *et al.*, 2004). These protective clothing nonetheless become contaminated with pathogens during working activities (Hayes and Forsythe, 1999). Pathogens that include *Salmonella* spp., *Listeria* spp. and coliforms have been isolated in gloves, aprons and gumboots (Jevšnik *et al.*, 2008; Kahraman *et al.*, 2010). Therefore, the food handlers should wash and disinfect their protective clothing on a regular basis. Gloves are also recommended because they reduce chances of contaminating food with pathogens present on the hands. Although this is a recommended practice, particularly in meat handling, debate among several authors on its relevance exists. It has been suggested that frequent glove use results into poor hand washing practices, but data on this remains scanty (Fendler *et al.*, 1998; Frazier and Westhoff, 1988; Green *et al.*, 2007; Lynch *et al.*, 2005).

2.5.3. Medical care and prohibited habits

In case of illness, the standard protocol is to report the illnesses to the supervisor or management (Nel *et al.*, 2004). However, few food handlers see the need to report illnesses (Jevšnik *et al.*, 2008). Employees are required to undertake regular medical examination, because only healthy employees should be employed in a food establishment (Assefa *et al.*, 2015; Marriott and Gravani, 2006). In addition, they should cover their wounds because these wounds can be contaminated with pathogenic microorganisms from a person's body or the environment promoting growth of biofilms (Miller *et al.*, 2014). Regarding prohibited habits, smoking and eating within a food establishment are discouraged (Assefa *et al.*, 2015). Rings and watches are also discouraged because they increase the bacterial contamination of hands and some have sharp edges that can bruise the wearer (Ingle *et al.*, 2012; White, 2013).

2.6. Personal determinants of food hygiene practices

Identifying differences in hygiene practices across demographic factors can effectively determine suitable interventions that specifically target those who need them most (Mullan *et al.*, 2015). In this regard, an insignificant difference in hygiene practices between males and females has been reported (Jianu and Goleţ, 2014). On the other hand, young adults tend to have poor food handling practices, which is caused by their low food handling knowledge (Byrd-Bredbenner *et al.*, 2007; Carbas *et al.*, 2013). Regarding education level, contradicting results have been reported, where some authors report that it has no influence (Webb and Morancie, 2015) while others report otherwise (Jianu and Goleţ, 2014). Such results may point to the nature of curriculum offered at schools in respective study areas. Normally, a course in home economics can increase the level of knowledge in food handling (Mullan *et al.*, 2015). Daily routine increases the experience of food handlers and over a period of time, food hygiene knowledge also increases (Ajala *et al.*, 2010; Carbas *et al.*, 2013). The positive correlation between food handling knowledge and practices (Jianu and Goleţ, 2014), means that experience and level of education results in good hygiene practices. The same has been reported for food hygiene training (Ababio *et al.*, 2016).

2.7. Personal hygiene training of food handlers

Essentially, training programs in personal hygiene increase the knowledge of food handlers (Ansari-Lari *et al.*, 2010). Training of food handlers on food safety is a prerequisite for positive attitude and good practices of the handlers to ensure that consumers receive safe food products (Nee and Sani, 2011). This training allows for adequate protection of the consumer from foodborne illness (Marais *et al.*, 2008). An effective training program targets behavioural changes that result in a reduction of foodborne diseases (Egan *et al.*, 2007). Indeed, one study found that food handlers trained in proper hand washing practices were less contaminated with *Salmonella* spp. (Kahraman *et al.*, 2010). It is recommended that such training be a clear understanding of principles underlying food hygiene and sanitation and elimination of any pertinent issues that may result in misleading regards to food hygiene issues (Halim *et al.*, 2015; Nel *et al.*, 2004). However, many food industries disregard training despite being a requirement (Ababio and Lovatt, 2015). In addition, there is no law that mandates training of the food handlers and only the food processing management can decide whether to allow or disallow training of the food handlers (Jianu and Goleţ, 2014).

2.8. Microbial contamination of meat during slaughter

Meats and fish normally are free of contamination because the muscle tissues of living animals normally are sterile (Pommerville *et al.*, 2013). In addition, the slaughter process does not cause contamination unless the slaughter equipment come into direct contact with the tissue (Gill, 1995). Other sources of contamination include air, water, soil, faeces, feed, hides, intestines, lymph nodes, processing equipment, utensils and humans (Sheridan, 1998). On flayed carcasses, hides play a significant role in contamination (McEvoy *et al.*, 2000). Bacteria are transferred to the meat from the outer surface of the hide by both direct and indirect contact (Gill, 1995). Carcass flaying and evisceration processes constitute critical points in the microbial contamination of muscle for which corrective measures need to be implemented (Bacon *et al.*, 2000). Faecal matter was a major source of contamination and could reach carcasses through direct deposition, as well as by indirect contact through contaminated and clean carcasses, equipment, workers, installations and air (Borch and Arinder, 2002).

Microbial contamination of animal carcasses during slaughtering has been described as an unavoidable problem in the conversion of live animals to meat for consumption (Dickson and Anderson, 1991). The beef meat contains 70-73% of water, 20-22% of protein and 4.8% of lipids which makes it a good nutrient source for both spoilage and pathogenic microorganisms (Niyonzima *et al.*, 2013). Presence of sufficient nutrient needed to support the growth of microorganisms makes meat one of the most perishable among all important food (Eze and

Ivuoma, 2012). Effective intervention to reduce contamination of beef carcasses begins with determining potential sources of contamination, where the best prevention of contamination is strict and vigilant good sanitation practices (Galland, 1997). However, Kenya like many other developing countries, the absence or non-respect of the existing hygienic practices in slaughtering is one of the major causes of meat contamination by pathogenic and spoilage micro-organisms (Muthee, 2006).

2.9. Small and medium enterprises

2.9.1. Definition of Small and medium enterprises

The term "SME" encompasses a broad spectrum of definitions. Different organizations and countries set their own guidelines for defining SMEs often based on headcount, sales or assets (Bouri *et al.*, 2011). While Egypt defines SMEs as having more than 5 and fewer than 50 employees, Vietnam considers SMEs to have between 10 and 300 employees (Bouri *et al.*, 2011). The World Bank defines SMEs as those enterprises with a maximum of 300 employees, U.S. $15 million in annual revenue, and U.S. $15 million in assets (Bouri *et al.*, 2011). The Inter-American Development Bank, meanwhile, describes SMEs as having a maximum of 100 employees and less than U.S. $3 million in revenue (Scherer *et al.*, 2009). In Tanzania, SMEs are described by as having between 10 to 49 employees (Kussaga *et al.*, 2013). In Kenya, classification of enterprises is primarily by the number of employees engaged by firms whereby SMEs are defined as those firms that engage 5 to 99 workers (Migiro and Wallis, 2006).

2.9.2. Contribution of SMEs to Kenyan Economy

In low-income countries, such as Kenya, the SME sector makes a critical contribution to GDP and employment (Ayyagari *et al.*, 2011) representing a significant segment of the economy with a potential to become the growth engine of the economy. Overall, SMEs create 75% of all new jobs and estimates based on the 1999 baseline survey show that, in the year 2002, the SME sector employed about 5,086,400 people, up from 4,624,400 in 2001 (Ayyagari *et al.*, 2011). There has been a steady increase in the contribution of SMEs in creation of employment opportunities and contribution to the GDP where SMEs employed 74.2% of total national employment but this had increased to 85 per cent of Kenya's employment (African Development Bank, 2011). The World Bank estimates that the contribution of SMEs to the national GDP of developing countries to be 16% (Ayyagari *et al.*, 2011). In Kenya's context, the contribution of SMEs stands at about 20 per cent of the total GDP (Ong'olo and Awino, 2013). This indicates a poor performance of the SMEs despite their large number of Kenya's labour force involved.

2.9.3. Factors responsible for poor implementation of food safety programs in small and medium enterprises

Implementation of food safety programs remains a challenge for most SMEs and at times poses serious practical problems (Marais *et al.*, 2008). Some of the SMEs lack adequate resources and in-house knowledge that are important in the identification of foodborne hazards and correct implement the safety programs (Walker *et al.*, 2003). Given that the performance of an implemented food safety program and the levels of microbial contamination on carcasses are interrelated, poor level of implementation can increase chances of microbial contamination and foodborne illnesses. Some small processors are unable to even meet the minimum hygiene requirements for food handling because they lack proper or adequate sanitation facilities (Opiyo *et al.*, 2013; Raspor and Jevšnik, 2009).

A study in Kenya found that small dairies lack documented procedures for sanitation of equipment and surfaces (Opiyo *et al.*, 2013). SMEs also face other challenges such as lack of funds and experienced trained, motivated, committed and technically qualified personnel (Bertolini *et al.*, 2007; Panisello and Quantick, 2001; Taylor, 2001). Other challenges include lack of legal requirements and poor attitudes (Egan *et al.*, 2007). Normally, the government and other authorities are expected to provide resources to overcome these barriers. These interventions may be in the form of free or subsidized training, developed food safety standards, training manuals and videos on good practices (Ababio and Lovatt, 2015). From these, prerequisite programs for good personal hygiene, cleaning and sanitation programs, proper design and maintenance of facilities and supplier quality assurance can be set up within the SMEs (Hatim *et al.*, 2013).

2.10. Gaps in the study

Although, it has been documented that animals are trucked from the pastoral areas of Kenya to major terminal markets such as Nairobi, the design of the trucks used to transport the animals has not been evaluated. In addition, the personal attributes of people handling the animals have not been assessed.

Majority of the meat consumed in Kenya comes from the SME slaughterhouses. It has been documented that these slaughterhouses operate in poor hygiene and sanitation conditions. Nevertheless, these practices have not been quantified. In addition, the contamination of personnel, beef carcasses and equipment at various points of slaughter has not been adequately documented.

Chapter 3. Design of Trucks used to Transport Cattle in Kenya's Pastoral areas

Abstract

The condition of animal transportation trucks is an important factor for animal welfare and meat quality. These two parameters are particularly compromised over long duration of transportation. Consequently, economic losses along the livestock chain may result. Therefore, the objective of the present study was to assess the design of trucks currently used to transport cattle in Kenya and quantify losses during trucking. A cross-sectional survey was carried out in six purposively sampled livestock markets: Moyale, Marsabit, Isiolo, Maralal, Narok and Kajiado. The markets are located along some of the major livestock routes in Kenya. Direct interviews with truck drivers (*N*=75) and observations were made. Five key design features were assessed; floor design, ventilation system (air vents and roofs), specialized compartments and interior walls. Modified floor was frequent in 95.8% of the trucks. About 80.0% of the trucks had smooth interior walls while 77.1% and 94.3% of the trucks had side vents and open roofs, respectively. None of the trucks was divided into compartments. Presence of vents, floor design and smooth finish of the interior wall were the design features which significantly differed ($p<0.05$) with livestock market. A cattle mortality rate of 6.2% was reported. However, none of the design features significantly caused the deaths. The major cause was injuries from other animals. It was concluded that there are no dedicated trucks for long distance transportation of cattle. Instead, features that are either temporary or not recommended are used to transform locally available trucks into livestock hauliers. In addition, injuries from other cattle being the major cause of deaths are an indication that poor animal handling practices are prevalent pre-slaughter.

Key words: Animal welfare, truck design, cattle transport, meat quality

3.1. Introduction

More than 70% of livestock population in Kenya is raised in the pastoral areas (Farmer and Mbwika, 2012). In these areas, the herd is estimated to be worth KES 60 billion (approximately U.S. $800 million), with an internal trade in the order of KES 6 billion (U.S. $80 million) per year (Muthee, 2006). Much of this trade involves live animals. A constant movement of animals from these areas is very strenuous. For example, animals are trekked 150-200 km before reaching primary markets from where they are further trekked for 14-30 days to secondary markets (Aklilu, 2002; Muthee, 2006). Finally, they are loaded into trucks for transportation to Nairobi, which is about 290 km away (Farmer and Mbwika, 2012).

The demand for meat in Kenya is projected to increase (Muthee, 2006). There will be increased need to transport animals. Animals will have to be moved from farms to slaughterhouses through various channels such as ranches and livestock markets. The intensity at which transportation of these animals has increased is as a result of global marketing systems and structural adjustments and has continued to attract the attention of animal welfare activists and scientists (Frimpong *et al.*, 2012; Gebresenbet and Ljunberg, 2004) and most specifically meat scientists. The main reason for this is that animal transportation is associated with a series of events that subject animals to stressful and unfavourable conditions. This compromises their welfare with a direct consequence on meat quality (Broom, 2003; Ljungberg *et al.*, 2007).

In Kenya, the distances between the livestock production areas and terminal markets are vast and can result in poor animal welfare and meat quality. Various methods such as trucking, trekking and a combination of the two are popular locally. Due to security reasons, trucking is preferred over trekking (Aklilu, 2002). Trucking is particularly important in the pastoral areas because it affects the marketing efficiency of animals in the area (Onono *et al.*, 2015). The condition of trucks transporting animals is therefore important. Poor truck condition can exacerbate the extent of chronic stress in the animal, which in turn increases the frequency of injuries, death and Dark Firm and Dry (DFD) meat. DFD meat has poor quality hence discounted heavily (Kreikemeier *et al.*, 1998b). This type of meat is among the prevalent meat quality problems associated with poor animal handling (Gallo, 2008). These can in turn affect the income of the millions of livelihoods in the pastoral areas who rely either directly or indirectly on livestock marketing.

Few countries in Africa have specialized vehicles for animal transport (Steinfeld *et al.*, 2006). Livestock are therefore transported in ordinary trucks, which are not designed for livestock transport (Bulitta *et al.*, 2012). These trucks result in sub-optimal transport conditions, which highly affects animal welfare and meat quality (Villarroel *et al.*, 2003). The increased emphasis on exploring strategies for mitigating against stress-mediated losses in the livestock sector (Ferguson and Warner, 2008) requires evidence based results to inform relevant stakeholders including the policy makers. The specific objective of present chapter was to evaluate the design of trucks currently used to transport cattle in Kenya and quantify losses during trucking. Such information will bring structural and institutional changes in the animal transport sector that may then improve the welfare of the transported animals and income to the stakeholders.

3.1.1. Main activities

1. Assess the demographic characteristics of truck drivers in Kenya's pastoral areas
2. Assess and compare the design of trucks used to transport cattle in different parts Kenya's pastoral areas
3. Determine the number of cattle that die during trucking
4. Compare cattle mortality rate with truck design feature and different livestock markets

3.2. Materials and methods

3.2.1. Study area

The study was carried out in July 2015 in six livestock markets (Moyale, Marsabit, Isiolo, Maralal, Narok, and Kajiado) along major livestock marketing routes in pastoral areas of Kenya (Figure

3.1). These markets supply approximately 80-90% of the red meat produced and consumed in Kenya (Farmer and Mbwika, 2012). In addition, these markets are the major sources of livestock for SME slaughterhouses located in Nairobi County and its Environs (Farmer and Mbwika, 2012; Muthee, 2006). Hence, the condition of trucks that truck the cattle from these livestock market will have a great impact on meat in the SME slaughterhouses.

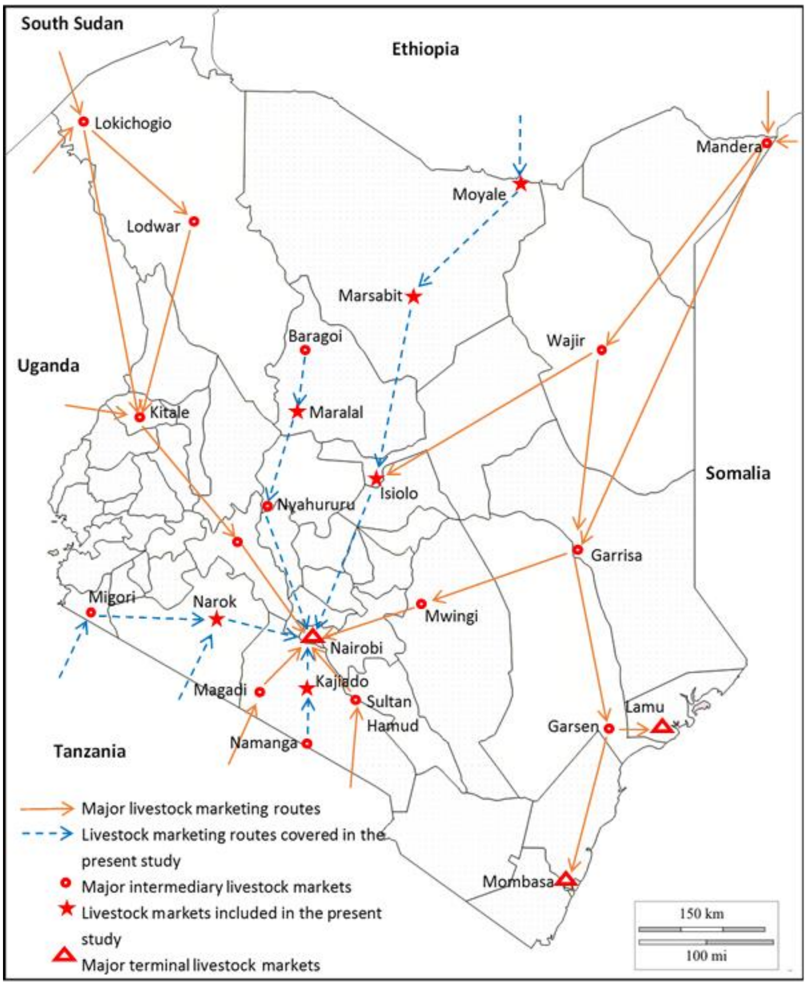

Figure 3.1 Major livestock marketing routes in Kenya

3.2.2. Study design and data collection

A cross-sectional survey was conducted using a semi structured pretested questionnaire (Appendix 1) administered to a cross-section sample of 75 purposively selected truckers transporting live cattle along the selected routes (Appendix 1). The questionnaire contained three sections: - the first section assessed the socio-demographic characteristics of the truckers.

The second section contained six questions on truck design features previously described as fundamental for long distance transportation of livestock (Lapworth, 2008) i.e. if the truck was ventilated on side, had its roof covered, had floor modified to prevent cattle slippage, or had specialized compartments. The third section consisted of five closed and open-ended questions on the number of cattle transported, the number of cattle that died and the cause of cattle death during last day of the cattle trucking. Additionally the truckers were asked to indicate the frequency of cattle death and the measures taken to prevent the deaths. After administering, the questionnaire, Focus Group Discussions comprising of 8-10 respondents were held at each of the markets. Key informant discussions were also held with County Veterinary Officers County Livestock Production Officers and County Officials of Livestock Marketing Council. Direct observations of available trucks were recorded.

3.2.3. Data analysis

Data were statistically analysed using SPSS version 23.0 (IBM Corp., 2015). Descriptive statistics (frequency percentage) of all variables were determined. This was meant to describe the basic features of the data in the present study by providing simple summaries about the sample and the measures. In Section 2, the responses of each questions from each respondent were categorized as either 1=Correctly designed or 0=incorrectly designed. This was meant to simplify the presentation and interpretation of the results. The number of questions with correct designs was divided with total number of design features analysed i.e. five and converted into percentage. Trucks from respondent having a percentage score of ≤ 70% translated to poor truck design, 71–89% the truck design was moderate and with >90% then the truck design was good. Given that the data collected in section 2 non-parametric because it was categorical, Mann Whitney and Kruskal–Wallis one-way ANOVA tests (p=0.05) were used to determine whether the number of cattle that died statistically differed with truck design features and livestock markets, respectively (Appendix 4 and Appendix 5). The Mann Whitney and Kruskal–Wallis tests are nonparametric tests that compare two and three or more independent variables, respectively. They are alternatives to independent t-test and one way ANOVA, which are used when data is normally distributed. Unlike, in independent t-test and one way ANOVA where the means are used to make comparisons, in the Mann Whitney and Kruskal–Wallis tests all the data from the entire grouping variable is ranked together; i.e., rank the data from 1 to N ignoring group membership. The test statistic is then computed from the assigned ranks. Therefore, instead of respective variable means, the Mann Whitney and Kruskal–Wallis tests compute mean ranks.

3.3. Results

3.3.1. Demographic characteristics of truck drivers

From six livestock markets located along major livestock routes, 75 truckers were included in the present study. Out of these, 21.3%, 20.0%, 18.7%, 17.3%, 13.3% and 9.3% were from Kajiado, Marsabit, Isiolo, Moyale, Mararal and Narok, respectively. Trucking was dominated by males (98.7%). Majority of the truckers (44.0%) were in the age group 31-40 while the smallest proportion of the truckers (2.7%) was aged <20. Truckers in the age group 41-50 represented 29.3%. Those in the age groups >50 and 21-30 comprised of 12% of the truckers, each. More than half of the truckers (52.0%) lacked formal education. Truckers with primary and secondary level education included 26.7% and 21.3% of the respondents, respectively. On the other hand, majority of the truckers were employed whereby 69.3% of these were permanent employees while 21.3% were temporary employees. The rest (9.3%) were self-employed. Majority of the truckers (34.7%) had 5-10 years of experience. On one hand, 25.33 and 24.00% of the truckers had 1-5 years of experience and >10 years of experience, respectively. Few truckers (16.0%) had <1 year of experience.

3.3.2. Truck design

Majority of the respondents (95.8%) of reported to have modified the floor of their trucks. The floors were modified using either sawdust, sand or cow-shed manure (Figure 3.2). Eighty percent, 77.2% and 94.26% of respondents had trucks with smooth interior walls, side vents (Figure 3.3) and open roofs, respectively. However, interior walls were made of metal sheets instead of wood and none of the respondents reported that their trucks were divided into individual cattle compartments (Figure 3.4). Based on the number of correct design features per truck, 53.3%, 37.3% and 9.3% of the trucks were categorized as good, moderate and poor design, respectively (Figure 3.5). The distribution of various design features are shown in Table 3.1. Presence of side vents (p=0.027), smooth interior walls (p=0.048) and floor modification (p=0.006), which significantly differed with livestock market (Table 3.2), were ranked highest in trucks in Isiolo, Moyale and Marsabit markets, respectively.

Figure 3.2 Truck floor modified with saw dust

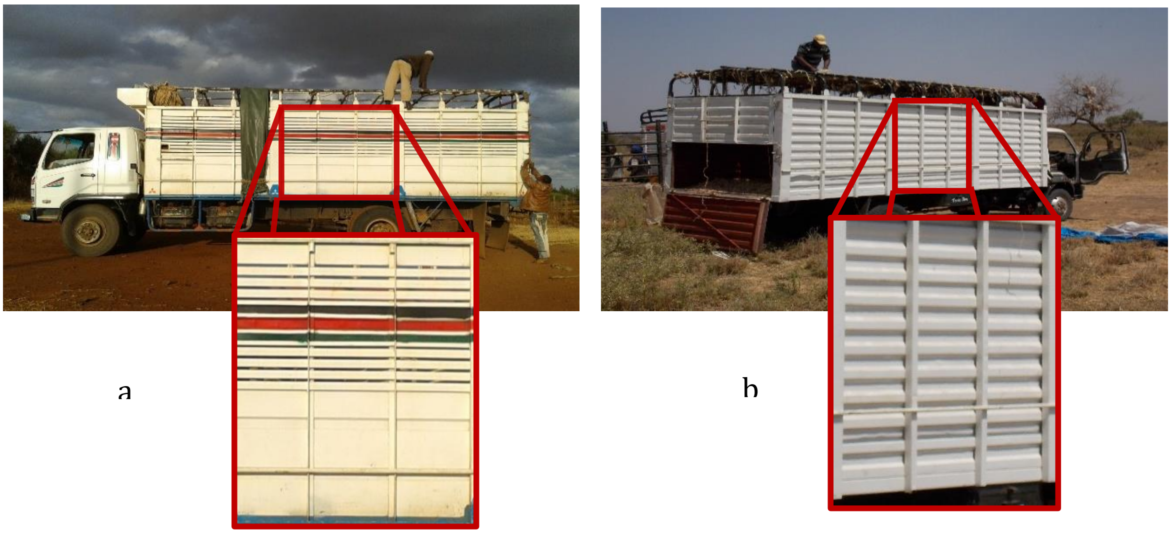

Figure 3.3 (a) Trucks with side vents and (b) trucks without side vents

Figure 3.4 Cattle in a non-compartmentalized with metallic interior walls

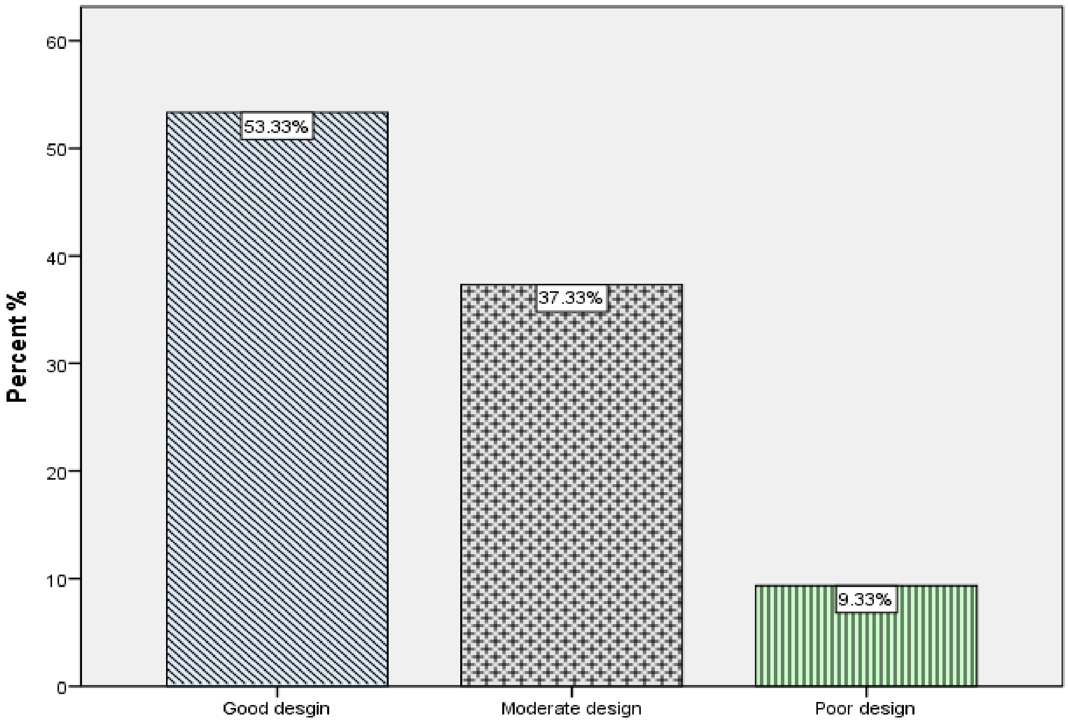

Figure 3.5 Distribution of cattle transportation trucks based on level of design

Table 3.1 Distribution of each of the truck design feature (%) among the studied livestock markets

Market	N	Side vents present		Open roof		Smooth interior wall		Modified floor		Individual compartments present	
		Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Moyale	13	100.0	0.0	25.0	75.0	41.7	58.3	100.0	0.0	0.0	100.0
Isiolo	14	50.0	50.0	0.0	100.0	100.0	0.0	100.0	0.0	0.0	100.0
Marsabit	15	66.7	33.3	0.0	100.0	86.7	13.3	80.0	20.0	0.0	100.0
Maralal	10	100.0	0.0	0.0	100.0	80.0	20.0	100.0	0.0	0.0	100.0
Narok	7	83.3	16.7	0.0	100.0	66.7	33.3	100.0	0.0	0.0	100.0
Kajiado	16	73.3	26.7	6.7	93.3	93.3	6.7	100.0	0.0	0.0	100.0

Table 3.2 The mean ranks of each of the design features trucks with regard to livestock market

Market	N	Side vents present	Open roof	Smooth interior wall	Modified floor	Individual compartments present
Moyale	13	27.5[a]	28.6	48.9[b]	34.0[a]	
Isiolo	14	45.0[b]	37.5	28.5[a]	34.0[ab]	
Marsabit	15	39.2[ab]	37.5	33.2[ab]	41.0[b]	
Maralal	10	27.5[ab]	37.5	35.5[ab]	34.0[ab]	
Narok	7	33.3[ab]	37.5	40.2[ab]	34.0[ab]	
Kajiado	16	36.8[ab]	35.2	30.8[a]	34.0[ab]	
Sig. (p=)		0.027	0.074	0.006	0.048	NC

NC-Not computed

3.3.3. Mortality of cattle during trucking in Kenya's pastoral areas

All the respondents reported that they had transported an average of 1,461 cattle during the last one week, with cattle transported ranging from 10 to 25 per truck. A mortality rate of 6.2% (90 dead cattle out of 1,461 transported cattle) was reported by 70% of respondents, where the deaths ranged from one to seven. The major causes of death were reported as injuries from other animals (34.0%), exhaustion and hunger (30.0%), truck accidents (16.0%) and diseases (14.0%). Injuries due to poor animal handling by animal loaders and off loaders were the least cause of cattle death (6.0%). Measures to prevent these losses were reported to have been put in place by 30.7% of respondents. The main measures included, reduced number of cattle loaded per truck (42.7%), improved veterinary services (33.3%), improved security 14.3%) and training/awareness of the respondents (9.5%). Nonetheless, 58.7% of the respondents reported that no measures have been put in place, while 10.7% did not know if any measure had been put in place.

3.3.4. Comparison of cattle mortality with truck design features and livestock market

The number of cattle reported to have died during transportation were not significantly different among the surveyed markets (p=0.091) and were not no significantly influenced by the truck designs (p>0.05) (Table 3.3).

Table 3.3 Comparison of the number of cattle deaths with either presence or absence of a recommended truck design as given by Mann-Whitney U test

	Mean ranks of number of deaths		
Truck design feature	Yes	No	Sig.(p=)
Side vents present	23.62	23.17	0.929
Open roof	22.60	36.33	0.061
Smooth interior wall	21.78	30.56	0.054
Modified floor	23.27	26.83	0.725
Individual compartments present			NC

NC-Not computed

Trucks with poor design corresponded with the highest number of cattle deaths followed by trucks with moderate design. The least number of deaths was reported in trucks with good design. Nevertheless, these differences were only tendencies and not statistically different (p=0.089).

3.4. Discussion

In the modern era, transportation of animals for slaughter has become a key feature of the livestock sector. The location of prime markets has led to increased distance between production areas and terminal markets. Furthermore, emergence of numerous channels such as intermediary markets, ranches and resting points has intensified the transport process. To ensure good animal welfare and quality meat, considerations have to be made about the current modes of transportation. Several key designs of trucks used to transport animals from the pastoral areas of Kenya were assessed in the present study. In addition, losses of cattle during transportation were quantified. To my best knowledge, this is the first time such a study has been conducted in these areas. The demographic results, showing a wide variety of ages, education level, years of experience, occupation as well as a majority of male participants in all of the surveyed livestock markets, suggests that the sample was indeed diverse.

The condition of trucks affects the welfare of slaughter animals (Edge and Barnett, 2009); hence the quality of meat available in local markets. Well-designed trucks can minimize some of the cost associated with unsuccessful adjustment of animals to transportation factors (Miranda-de la Lama *et al.*, 2014). As such, the trucks should have floors with rough surfaces to prevent the animals from falling (Hutchison *et al.*, 2005). Although the respondents reported that the floors of their trucks were modified, the modification was made using inappropriate materials. Absorption of excretions from transported animals by the sand, cow shed manure and saw dust can result in slippery conditions when the materials reach their maximum absorption capacity (Hutchison *et al.*, 2005; Miranda-de la Lama *et al.*, 2014). Slippery conditions may cause falling and trampling of cattle aggravating the injuries and in extreme cases causing death (Southern *et al.*, 2006). In addition, these materials may impair the cleaning process of the trucks thus making the trucks a host of disease pathogens (Martínez-López *et al.*, 2008).

The nature of the trucks' interior wall is important in preventing bruises. Because of wear and tear, metal used in construction of the body is bound to become rough. In addition, bolts and nuts used to clad the metal sheets together can cause injuries in animals. Such injuries are likely to occur in the present study, which had rough interior walls. To minimize the prevalence of bruises, hard wood is recommended for use on the side of the body of the trucks (Lapworth, 2008). Despite of the recommendation, no truck was reported to have this modification. Another feature of the trucks is ventilation systems (Miranda-de la Lama *et al.*, 2010, 2011). Majority of the local trucks were characterized by side vents and an open roof, which by definition is a passive ventilation system. This system does not provide for constant macro-environment condition within the truck because it will depend on shape and speed of the truck as well as wind speed (Norton *et al.*, 2013). The system is especially inadequate when a truck is not moving because temperature and relative humidity inside the truck tend to rise causing cattle to shrink in body weight or become non-ambulatory (Broom, 2005; González *et al.*, 2012a, 2012b). Given that temperatures in Kenya's pastoral areas are high (Nyberg *et al.*, 2015), this may be a common occurrence.

Compartments within a truck a key design features. They provide livestock with a barrier against shocks they are subjected to during transport. Some of these shocks include sudden brakes or travel on hilly, windy and rough roads (Lapworth, 2008). These compartments will provide sufficient space for each animal to adjust their posture naturally and brace themselves against the movement of the vehicle (Southern *et al.*, 2006). In addition, fighting tends to occur most often when a vehicle stops suddenly and animals are inadvertently 'pushed' into each other (Chambers and Grandin, 2001). The trucks in the present study show similarities with trucks in Namibia (Hoffman and Lühl, 2012), where animals are transported in one compartment. This contrasts countries like Canada, where a recent study showed that compartments were present in all trucks (González *et al.*, 2015). Lack of these compartment subjects cattle to all these conditions, which increases the likelihood of injuries and death during transport.

Significant differences in terms of presence of side vents (Table 3.1) can cause variation in micro-climate within the trucks. In a region like Isiolo where the annual mean temperature is 29°C (Quandt and Kimathi, 2016), truck stopovers can raise the temperature within the truck to above 30°C. Temperature >30°C within trucks increases the likelihood of animals becoming non-ambulatory (González *et al.*, 2015). Similarly, the significant differences in the interior wall and floor modification of the trucks can influence the rate at which injuries in transported animals occur (Lapworth, 2008). As a result, animals carried by trucks with low ranks in each of these two design features may have a higher prevalence of bruises than others may. Given that bruises on carcasses are normally trimmed off, substantial economic losses can occur.

Failure to watch over the welfare of cattle during handling increases their stress levels and may increase mortality rate. Mortality during transportation to slaughter is a good indicator of the level of stress suffered by animals during transportation (Gosálvez *et al.*, 2006). From the present results, it was evident that the animals are subjected to numerous stressors during transportation. Using cattle mortality as an indicator of animal welfare, it was observed that the level of stress in Kenyan cattle during handling is considerably high compared to other animals in such countries as Czech Republic and Canada (Vecerek *et al.*, 2006a, 2006b; Večerek *et al.*, 2006; Vosláŕová *et al.*, 2010; Warren *et al.*, 2010). This contradicts most respondents who reported that the deaths were infrequent.

The present results did not show any significant relation between the truck design and cattle mortality. This can be explained by the fact major cause of deaths was injuries from other animals. Injuries may have been caused by among other factors, mixing of unfamiliar groups of animals (Broom, 2005). This together with the lack of compartments in the trucks may cause fighting, tramping over fallen animas or prodding animals with horns thus causing the injuries. Using recently published data (Onono *et al.*, 2015), where the mean prices per cattle in Kenya livestock markets KES 18, 400 (U.S. $ 184). Death of 90 cattle meant a loss of about KES 1.6 million (U.S. $ 16,560) occurred during the study period. One of the major measures to curb these deaths was reduced number of animals per truck. From the results, an average of 19 animals was reported.

In terms of overall design (Figure 3.1), only about half of the trucks were in good condition to transport livestock. The rest needs either to be considered for improvement or requires urgent improvement. This may be an indication that nearly half of the trucks used to transport cattle in the pastoral areas are a likely cause of poor animal welfare or meat quality.

3.5. Conclusion and recommendations

In the present study, it was observed that there were no trucks dedicated to transport livestock. Locally available trucks are converted into improvised livestock hauliers. Improvements include sand or saw dust that provides a non-slip floor. In addition, the trucks rely on passive ventilation systems. The present design of the trucks is thus not sufficient to guarantee good animal welfare. This has implications on sustainable meat production system in the country. This is clearly indicated by the substantial economic loss through cattle mortality as reported by the respondents. Although none of studied design features significantly contributed to the mortality, injuries were the major cause of cattle deaths. This is an indication that poor animal handling practices are prevalent along the livestock value chain. To understand the underlying cause better, future studies that address other pre-slaughter stressors such as distance travelled by animals, number of unloading and offloading procedures along the routes, feed and water provision or temperature within the trucks. In addition, improvement of animal welfare and reduction of economic losses along these routes will be achieved through policies that address training needs for the truck drivers and development of a standard design for trucks to livestock transport in the country.

Chapter 4. Knowledge, Attitude and Practices of Stockpeople in Kenya in Relation to Animal Welfare

Abstract

Stockpeople play a key role in animal welfare, but they are rarely considered during animal welfare research. A cross-sectional survey was therefore conducted on 266 stockpeople from ten livestock markets located along Kenya's major livestock routes. Out of a high possible score of 100%, the mean percentage scores of knowledge, attitude and practice (KAP), and overall KAP were 78.0 ±14.1%, 75.6 ±16.0% and 64.5 ±17.6%, respectively. The stockpeople scored <70% in knowledge and attitude questions related to animal feeding and watering, and mixing of unfamiliar groups of animals and practices questions related to mixing unfamiliar groups, cooperation with other stakeholders and agitation of animals during handling, an indication that KAP in these animal welfare issues was inadequate. Among the demographic characteristics, female gender, older age, high experience and informal education in stockpeople showed a significantly higher level of animal welfare KAP ($p<0.05$). Further studies that integrate animal welfare KAP and outputs of handling, such as bruises, dark cutting carcasses, and mortality, are needed to verify how the current levels of KAP influence these outputs.

Keywords: animal welfare; knowledge; attitude; practice; stockpeople; animal transport

4.1. Introduction

In nations where livestock production is extensive, such as in most developing countries, animals for slaughter have fewer welfare issues compared to the more intensively raised animals (Grandin, 2014a). This situation is however likely to change in the coming years, and this change will be driven by a thriving demand for livestock products in these nations (McDermott *et al.*, 2010). This occurs especially in places where distant markets offer better prices, which leads to increased transport duration and frequency (Schwartzkopf-Genswein *et al.*, 2012). The lack of animal handling procedures or poor implementation of the existing practices, such as proper feeding and resting and human animal interaction, will further compound on animal welfare.

In developed nations, social concerns about animal welfare issues have resulted in changes in the legislation regarding the livestock industry (María, 2006). This resulted in addressing of the issues in the revised policies (EU, 2016). Other actors also recognized that good animal welfare represents a business opportunity that could be profitable as the meat quality is improved by better animal welfare (Støier *et al.*, 2016; Velarde and Dalmau, 2012). In addition, extensive research has made it easier to assess animal welfare issues at farms and slaughterhouses (Welfare Quality®, 2009). These perceived institutional changes were recognized as the prerequisites for sustainable meat production in the developed nations. Sustainable meat production simply refers to a form of production that is 'ecologically sound, economically viable, socially just, and humane (Appleby, 2004).

Animal welfare issues include the possibilities to experience stress, injury, fatigue, mortality and morbidity that may be due to limited access to food and water during the transportation process, and exposure to adverse climatic conditions, noise, vibrations and toxins, along with poor handling and mixing with unfamiliar animals (Schwartzkopf-Genswein *et al.*, 2012). A system that exposes animals to these factors is not only unsustainable, but is also unacceptable to many people (Broom, 2010). In addition to affecting animals' emotional state, such a system negatively affects the economy of the meat industry (Price, 2008). On the other hand, a sustainable system allows people, specifically the consumers, to perceive this meat as a value for money (Pethick *et al.*, 2011). Therefore, it can be postulated that it would be a good business to improve animal welfare (Smith and Grandin, 2008).

Meat animals move from farms to slaughterhouses and in most cases through various channels such as markets and semi-intensive or intensive feedlots. These channels lengthen the time travelled by animals, increase loading and un-loading procedures, and intensify chances of mixing with unfamiliar animals (Knowles, 1998). All these can be attributed to dynamic marketing systems and may lead to structural adjustments in the meat supply chain (Frimpong *et al.*, 2012; Gebresenbet and Ljunberg, 2004). The pace at which these adjustments occur does not give enough time to the animals to adjust their physiology and behaviour. Thus, animal welfare issues have a direct impact on meat quality (dalla Costa *et al.*, 2007; Ferguson and Warner, 2008; Guàrdia *et al.*, 2010; Hoffman and Lühl, 2012).

In the developing world, thousands of meat animals are transported both formally and informally throughout the length and breadth of these nations, mostly in inhumane manner (Rahman, 2004). To remedy the present situation and adequately prepare for increased animal handling activities arising by an increased demand for meat, there is an urgent need to set up, implement, and enforce proper animal handling procedures (Masiga and Munyua, 2005). In this regard, a prerequisite is exploring the strategies to mitigate the stress-mediated losses in the livestock sector (Ferguson and Warner, 2008). One of the most cost-effective policies to improve animal welfare is to train stockpeople, which in turn, will improve carcasses and meat quality (Velarde *et al.*, 2015). It has been noted that despite of the key role the stockpeople play in animal welfare, it appears they are not appreciated (Hemsworth and Coleman, 2011).

Knowledge, attitude, and practice (KAP) of stockpeople can influence animal welfare (Hemsworth and Coleman, 2011). Knowledge comprises the understanding of any given topic (Sharif *et al.*, 2013). On the other hand, attitude represents those attributes that are modifiable through experience and education (Waiblinger and Spoolder, 2007). These attributes include emotional, motivational, perceptive and cognitive beliefs that positively or negatively influence the behaviour or practice of an individual (Andrien, 1994; Schürch, 1983). Attitude is further influenced by personality. Both attitude and personality in turn affect the behaviour or practice of a stockperson towards the animals they handle (Hemsworth *et al.*, 2002). On the other hand, practice and behaviour are interchangeable terms, although practice has a connotation of long-standing or commonly practiced behaviour (Contento, 2010).

The relationship between each of the three components of KAP and animal welfare issues has been assessed individually (Hemsworth *et al.*, 2002; Miranda-de la Lama *et al.*, 2013; Peeters *et al.*, 2008; Peli *et al.*, 2016). An assessment of all the three aspects of animal handlers can give a comprehensive understanding of an individual's influence on animal welfare. A study of KAP thus would be useful for gaining an insight into the handlers' personal determinants of the handling practices and would identify their educational and training needs. Since their emergence in the 1950s, these types of studies have extensively been used in research covering areas such as nutrition (Macias and Glasauer, 2014) and food safety (Ansari-Lari *et al.*, 2010; Cuprasitrut *et al.*, 2011; Kitagwa and Johan, 2012; Nee and Sani, 2011; Sharif *et al.*, 2013). The specific objective of this chapter was therefore to assess animal welfare knowledge, attitude and practices of stockpeople (transporters, marketers, and loaders/offloaders) in Kenya's pastoral areas and Nairobi County and its environs.

4.1.1. Main activities

1. Assess the demographic characteristics of stockpeople in Kenya's pastoral areas and Nairobi County and its environs
2. Assess the knowledge attitude, and practices of stockpeople in Kenya's pastoral areas and Nairobi County and its environs in relation to animal welfare
3. Compare animal welfare knowledge, attitude and practice of stockpeople in Kenya's pastoral areas and Nairobi County and its environs with their demographic characteristics
4. Determine the level of intervention needs of the stockpeople in Kenya's pastoral areas and Nairobi County and its environs in relation to animal welfare

4.2. Materials and methods

4.2.1. Study area

The study was carried in ten livestock markets located along Kenya's major livestock routes. It is estimated that 80 to 90% of the red meat consumed in Kenya comes from livestock raised in the pastoral areas, which transects through six of the ten markets (Moyale, Marsabit, Isiolo, Maralal, Narok, and Kajiado) to either slaughterhouses in their immediate neighbourhood or other distant terminal markets (Farmer and Mbwika, 2012). The other four markets (Limuru, Kayole, Dagorreti, and Kiserian) are the most important terminal livestock markets in Nairobi County and its environs.

4.2.2. Study design and data collection

A cross-sectional survey was conducted in the ten livestock markets. The stockpeople handling cattle were specifically chosen on the basis of the fact that the beef supply chain employs majority of these Kenyan stockpeople (Farmer and Mbwika, 2012). This population was first classified into three strata (transporters, marketers, and loaders/offloaders). A sample from each strata was purposively sampled.

A structured questionnaire (Appendix 2) containing questions from Kenyan and European Regulations for animal handling (EFSA, 2011; GOK, 2012) was administered to the sampled stockpeople. The questionnaire contained four sections. The first section addressed the socio-demographic characteristics of the respondents and the type of stockpeople. The second and the third sections included seven questions each evaluating the level of animal welfare knowledge and animal welfare attitude, respectively. In both sections, the level of knowledge and attitude were assessed using a five-point ordinal scale (0=Strongly disagree, 1=disagree, 2=not sure, 3=agree to 4=strongly agree). The fourth section included eight questions evaluating the level of animal welfare practices, using a five-point ordinal scale (0=never, 1=rarely, 2=sometimes, 3=most of the times to 4=always).

4.2.3. Data analysis

Data were analysed using SPSS version 23.0 (IBM Corp., 2015). Frequency analysis was used to determine the frequency percentage and mean of each variable. In order to determine the level of KAP, each mean was divided by 4 (the highest possible value), then multiplied by 100 to give an overall percentage. Particular animal welfare issues requiring intervention were identified using a previous threshold level for KAP (Macias and Glasauer, 2014). If the mean score of a particular variable was ≤70 then the issue was considered of high level requiring an urgent intervention. If it was 71–89%, the issue was of moderate level and might be considered for intervention. Finally, if it was >90%, then the issue was low, and was either not requiring or difficult to justify an intervention. The measure of dispersion in each of these three sections was given by mean and standard deviation. Given that the data collected in Section 2-4 were ordinal, non-parametric measurements were preferred (McCrum-Gardner, 2008; Miranda-de la Lama *et al.*, 2013; Mundry and Fischer, 1998). Mann Whitney U-test (p=0.05) was used to compare the means of knowledge, attitude, and practice between educational level and gender (Appendix 6). Kruskal–Wallis one-way ANOVA (p=0.05) was used to compare the means of knowledge, attitude, and practice among stockpeople's age and level of experience (Appendix 7). Finally, the association and correlation of the stockpeople's knowledge, attitude, and practice was determined using Pearson's Chi square and Spearman's correlation tests, respectively (Appendix 8).

4.3. Results

4.3.1. Demographic characteristics of the stockpeople

Characteristics of the stockpeople are presented in Table 4.1. They included transporters (51%), traders (25%), loaders/offloaders (24%). There were more males (95%) than females (5%). Middle aged (31-50 years) stockpeople formed 65% the sample. Those aged above 50 years formed 12.52%. Stockpeople who had formal educated were slightly more (56%) than those with informal education. stockpeople. Highly experienced stockpeople (>10 years of experience) formed 33% of the sample, while the least experienced <5 years of experience formed 26% of the sample.

Table 4.1 Socio-demographic characteristics of the stockpeople

		Number of stockpeople (*N*)	Percentage of stockpeople (%)
Gender	Male	254	95.4
	Female	12	4.6
Age group	<30	67	25.1
	31-50	174	65.4
	>50	25	9.5
Type of education	Informal education	116	43.7
	Formal education	150	56.3
Level of experience	<5 yrs	99	37.4
	5-10 yrs	96	36.2
	>10 yrs	70	26.5
Type of stockpeople	Transporters	135	50.8
	Loaders/Offloaders	64	24.1
	Livestock traders	67	25.2

4.3.2. Knowledge of stockpeople in relation to animal welfare

Table 4.2 gives the frequency percentages of each of the stockpeople's animal welfare knowledge. About half of the stockpeople responded with the correct answers to question on legal requirements during animal handling. On the hand, 36% of the stockpeople responded with the correct answers to question issues related to stress in animals and its effect on meat quality. About a third of the stockpeople responded with the correct answers to question on issues related to animal handling over journeys exceeding 12 hours. Finally, 45% of the stockpeople responded with the correct answers to question on the issue of mixing animals with unfamiliar groups.

4.3.3. Attitude of stockpeople in relation to animal welfare

Table 4.3 gives the frequency percentages of each of the stockpeople's animal welfare attitude questions. Generally, between 40% and 43% of the stockpeople responded with the correct answers to the attitude questions. However, a difference was observed in the attitude towards animal mixing were only about 27% of the stockpeople responded with the correct answer.

Table 4.2 Response to knowledge questions regarding cattle handling practices of cattle handlers at livestock markets in Kenya's pastoral areas

Question	Strongly disagree	Disagree	Not sure	Agree	Strongly agree
1. Only animals accompanied by a legal permit of movement should be handled	6.0	4.9	3.0	36.8	**49.2**
2. A legal permit should accompany animals on transit	1.1	3.4	4.5	37.2	**53.8**
3. Animals suffer from stress when they are grossly mishandled	2.3	2.3	8.3	50.8	**36.5**
4. Stress in animals affects the eating quality of meat	3.0	6.4	12.0	42.5	**36.1**
5. Animals should not be transported for more than 12 hours continuously	7.1	6.4	7.1	47.0	**32.3**
6. Animals should be given feed and water if they have been transported for more than 12 hours	6.4	5.6	4.5	47.7	**35.7**
7. Mixing unfamiliar groups of animals increases the risk of bruises	4.5	4.5	8.3	37.6	**45.1**

Note: Numbers in **bold** indicate correct response

Table 4.3 Response of cattle handlers in livestock markets to attitude questions on animal handling in Kenya's pastoral areas

Question	Strongly disagree	Disagree	Not sure	Agree	Strongly agree
8. Handling animals in a humane manner is an important part of my job	4.9	7.5	4.9	40.2	**42.5**
9. A legal permit should always accompany the animals I am handling	2.3	3.4	3.0	49.1	**42.3**
10. Medical examination of animals before handling is necessary to prevent spread of diseases	2.3	3.4	5.3	45.9	**43.2**
11. Physical inspection of animals before handling ensures only fit animals are handled	3.0	3.4	3.8	49.6	**40.2**
12. It is important to feed and water animals before transporting them on a long journey	6.4	9.0	5.6	39.1	**39.8**
13. It is important that I should be trained on how to handle animals	9.8	1.1	14.3	33.5	**41.4**
14. Animals should not be mixed with other herds in the market place or during transport	10.9	14.3	21.8	25.6	**27.4**

Note: Numbers in **bold** indicate correct response

4.3.4. Practice of stockpeople in relation to animal welfare

Table 4.4 gives the frequency percentages of each of the stockpeople's animal welfare practice questions. Half of the stockpeople responded that they always make special plans before they handle their animals. More than half (55%) of the stockpeople reported that they check the physical conditions of the animal before handling them. However, only 40% of the stockpeople always take into considerations of the weather and feed the animal before long durations of handling. On the hand, 29% of the stockpeople always prevent their animas from mixing with unfamiliar groups while 17% of the stockpeople always allow the animal the animal to move freely without coercion. Finally, only 30% of the stockpeople always engage other stakeholders in case animal welfare issued arise during handling.

Table 4.4 Response of cattle handlers in livestock markets to practice questions on animal handling in Kenya's pastoral areas

Questions	Never	Rarely	Most of the times	Sometimes	Always
15. Do you make any special plans related to animal welfare before you handle animals?	4.1	7.1	12.0	26.7	**50.0**
16. Do you take into considerations the weather conditions before handling animals?	7.2	10.6	20.5	21.2	**40.5**
17. Do you personally check the physical condition of the animals in the market before handling them?	2.3	4.6	12.2	25.5	**55.5**
18. Do you allow animals to feed and take water in case of an extremely long duration of handling?	18.0	6.0	12.4	22.9	**40.6**
19. During handling, do you mix your group of animals with other unfamiliar groups?	**28.9**	20.3	18.8	8.3	23.7
20. Do you force the animal to perform certain activities e.g. movement?	**16.7**	19.7	21.6	16.7	25.4
21. Do you involve other stakeholders in case animal welfare issues arise?	20.1	16.3	18.9	14.4	**30.3**

Note: Numbers in **bold** indicate correct response

4.3.5. Relationship between animal welfare KAP and demographic characteristics

Although males and female had a similar level of animal welfare knowledge (p=0.762), females had significantly higher level of animal welfare attitude (p=0.042) and practice (p=0.047) than males. Stockpeople aged less than 30 years had significantly lower level of animal welfare knowledge (p=0.043), attitude (p=0.041) and practice (p=0.031) than stockpeople aged over 30 years. Level of experience did not influence the level of knowledge or attitude of the stockpeople (p>0.05). However, the level of animal welfare practice increased with increase in the level of experience (p=0.036). Stockpeople with formal education had a similar level of animal welfare knowledge, attitude and with stockpeople with informal education (p>0.05). All the three categories of stockpeople had similar levels of knowledge, attitude and practice (p>0.05).

Table 4.5 Score statistics of overall level of animal welfare knowledge, attitude and practice grouped by demographic characteristics of stockpeople

		Group of questions					
		Knowledge		Attitude		Practice	
		Mean ±SD	Rank	Mean ±SD	Rank	Mean ±SD	Rank
Gender	Male	77.7±14.2	131.7	75.0±16.1	**129.9** [a]	63.9±17.5	**129.8**[a]
	Female	80.1±11.8	138.5	84.5±10.5	**175.4** [b]	71.7±15.0	**166.7**[b]
Education	Formal	79.2±15.1	140.4	77.0±17.0	139.8	65.1±19.1	134.1
	Informal	76.8±13.2	125.5	74.2±15.0	126.0	63.6±16.1	129.5
Age group	<30 yrs	75.4±14.2	**118.9**[a]	72.0±16.0	**118.5**[a]	62.5±16.8	**127.6**[a]
	31-50 yrs	78.2±13.5	**133.7**[b]	76.2±15.3	**133.6**[a]	63.6±17.5	**127.7**[a]
	>50 yrs	81.9±17.0	**155.0**[a]	79.3±19.4	**156.5**[b]	73.3±17.6	**167.8**[b]
Experience level	<5 yrs	76.9±15.1	124.0	74.1±16.5	124.5	61.5±17.6	**117.9**[a]
	5-10 yrs	78.6±12.5	134.7	75.2±13.9	127.4	63.4±17.1	**125.6**[a]
	>10 yrs	77.6±14.7	128.2	77.4±17.9	137.6	68.8±16.6	**147.8**[b]
Profession	Transporters	77.3±15.1	131.7	76.1±15.8	135.3	64.2±18.5	132.9
	Loaders/Offloaders	77.7±14.5	129.8	73.0±18.4	124.1	65.3±16.9	134.3
	Livestock traders	79.5±11.4	140.6	77.3±13.8	138.9	64.5±16.4	132.1

Note: Numbers in **bold** indicate statistically significant mean ranks while the mean ranks with different alphabets per demographic category indicate statistically significant mean ranks

4.3.6. Level of intervention needs for the stockpeople

The mean percentage scores of knowledge, attitude, and practice were 78.0 ±14.1%, 75.6 ±16.0% and 64.5 ±17.6%, respectively. Therefore, there was declining trend: knowledge > attitude > practice. In all the three parameters tested, the percentage of stockpeople who do not need to be considered for an intervention was the least (Figure 4.1). The percentage that need to be considered for intervention decreased from knowledge towards the practice while a reverse trend was observed in the percentage of stockpeople that require urgent intervention.

4.3.7. Association and correlation of animal welfare knowledge, attitude and practice of the stockpeople

The stockpeople's' animal welfare practice was strongly associated with both knowledge and attitude (p<0.001). In addition, there was a direct and positive correlation among knowledge, attitude and practice (p<0.001) (Table 4.6).

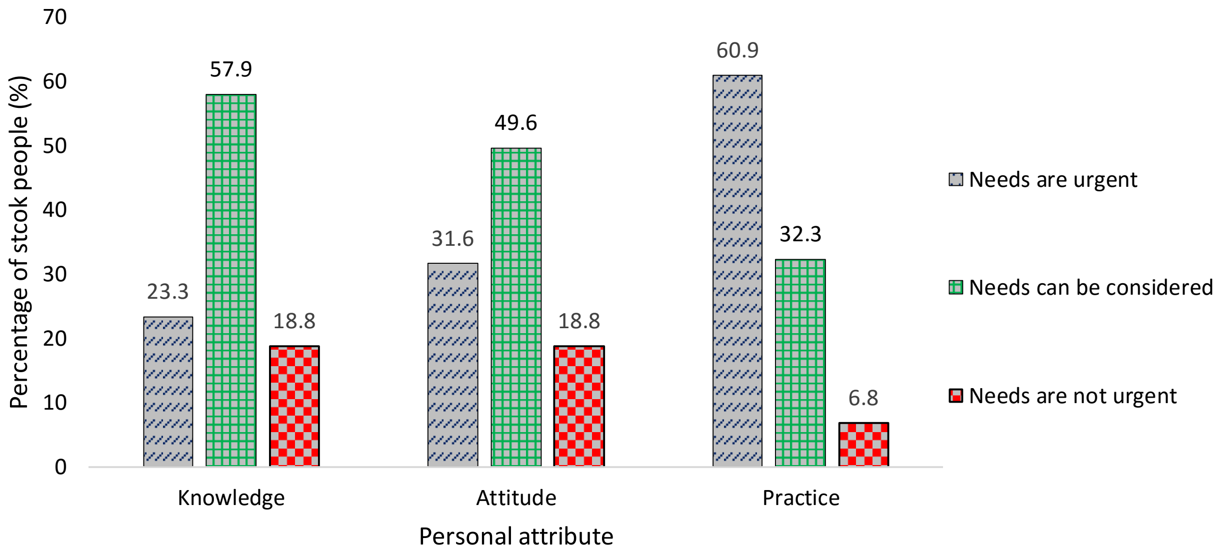

Figure 4.1 The level of intervention needs of the stockpeople

Table 4.6 Correlation coefficient (*p* value) among animal welfare knowledge, attitude and practice of stockpeople

	Knowledge	Attitude	Practice
Knowledge	1	0.632 (<0.001)	0.333 (<0.001)
Attitude	0.632 (<0.001)	1	0.562 (<0.001)
Practice	0.333 (<0.001)	0.562 (<0.001)	1

4.4. Discussion

The welfare of animals during slaughter is important for sustainable meat production. Moving the animals from the farm to slaughterhouses through markets not only increases the frequency of handling, but also the number of risk factors that can affect their welfare and the meat quality. The social aspect of animal welfare has previously been assessed by focusing on farmers, retailers, consumers and the general public (Kupsala *et al.*, 2015; Vanhonacker *et al.*, 2012; Verbeke *et al.*, 2010). The retailers as middle people have not seriously been assessed regarding their attitudes, knowledge and practice to appreciate what they do. The stockpeople who handle animals between the farm and slaughterhouses have rarely been considered for such type of research. This is despite the fact that they play a key role in the delivery of animals for slaughter. Poor animal welfare mediated by personality behaviour can have a profound effect on the concept of sustainable meat production. Therefore, the present study is the first one to address the determinants of stockpeople's personality not only for their attitudes but also knowledge and practices.

The appropriate knowledge of animal handling among stockpeople is a prerequisite for optimal animal productivity and welfare (Hemsworth and Coleman, 2011). Therefore, stockpeople should have the knowledge required to interact with animals (Kılıç and Bozkurt, 2013). Knowledge is affected by education and training, which are the two important factors for animal welfare (Greger, 2007). Unfortunately, stockpeople have neither basic training nor sufficient knowledge and understanding about the welfare of the animals they handle (Bulitta *et al.*, 2012). This can help explain the observations in Table 4.2. The low level of knowledge can be a result of inefficient transfer of a large amount of behavioural knowledge to the livestock industry (Grandin, 2003). In addition, there are no laws that require animal transporters to be trained in animal handling (Schwartzkopf-Genswein *et al.*, 2008). There is also no evidence in literature that marketers required to be trained for the same.

Among the personal determinants of animal welfare, attitude has been the most widely studied. Perhaps this is because, it influences future behaviour, no matter what is the current knowledge level of an individual; and it also helps explain why an individual adopts one practice and leaves other alternatives (Macias and Glasauer, 2014). During handling, these attitudes may result in differences such as one person causing high levels of stress in the animals while another doing the same without little or no such stress (Broom, 2005). Although there has been an increasing interest toward animals and animal product production methods in recent years (Koknaroglu and Akunal, 2013), though this interest may not be as high in developing nations. This can help explain the stockpeople's attitude as shown in Table 4.2. This hypothesis can be supported by a previous report that there are numerous videos from the developing world which show abusive handling of animals (Koknaroglu and Akunal, 2013). Indeed, the behaviour of stockpeople towards animals is strongly influenced by attitudes (Boivin *et al.*, 2003).

Good animal handling practices result in better animal welfare (Lapworth, 2008). The results in Table 4.3 confirm a previous report that animals for slaughter are handled in inhumane manner in developing nations (Rahman, 2004). The low levels of practice can be explained in different ways. Firstly, the stockpeople are not highly motivated. It is well established that animal handling is a very demanding profession (Hemsworth and Coleman, 2011), hence even the following of the existing good animal handling practices requires motivation. Secondly, the pressure from the industry to speed up delivery of animal for slaughter may make the stockpeople disregard animal welfare issues. Although there is no evidence from literature, practices from other stockpeople can be extrapolated. In abattoirs, stockpeople do not think about engaging in better handling practices; this meets with the demands of management that they keep up with the speed of the processing facility (Coleman *et al.*, 2003). Thirdly, there is a little, if any, emphasis on welfare friendly products (WFP) among the meat consumers in developing nations. In contrast, requirements from markets of WFP in developed nations which have motivated improvement of animal welfare issues (Paranhos da Costa *et al.*, 2012). Finally, the abundance of scientific information in developed nations focusing on animal welfare (Swanson, 2001) has enabled these countries to establish codes of practice for animal handling. The lack of such information in developing nations may have slowed down the formulation and adoption of such practices along the meat value chain.

This study identified key animal welfare issues, which, if not addressed, may result in poor animal welfare and meat quality. Knowledge and attitude variables recommended for proper animal transport and feeding were low (Table 4.2 and Table 4.3). In countries where animals are transported over long distances, they are exposed to longer periods of starvation before slaughter (Ferguson and Warner, 2008). Proper feeding and watering are recommended for good animal welfare (OIE, 2015; Welfare Quality®, 2009). During long durations of transport, an animal may suffer from dehydration and hunger which may invoke weight loss (Ferguson and Warner, 2008). Adequate feed and water should therefore be made available for transports lasting over 12 hours (Terlouw *et al.*, 2008). Another issue was negative attitude and a poor practice towards mixing unfamiliar groups (Table 4.3 and 4.4). Mixing of unfamiliar groups of animals increases the level of bruising (Broom, 2005; Rabaste *et al.*, 2007). Specifically in cattle, bruising is an indication of poor animal handling welfare and also causes substantial economic losses (Grandin, 2014b). Mixing also increases the prevalence of dark cutting beef carcasses, which are highly discounted (Kreikemeier *et al.*, 1998b).

The stockpeople in the present study rarely involved other stakeholders when animal welfare issues arise (Table 4.4). It is the joint responsibility of all persons involved to assure appropriate handling of transported animals as the first priority (Southern *et al.*, 2006). An efficient administration of a pre-slaughter logistic chain and handling practices based on animal welfare results in a positive impact (Miranda-de la Lama *et al.*, 2014). Therefore, it is the responsibility of stockpeople to constantly feed animal welfare information to other stakeholders so that poor animal welfare issues can be corrected without significant effect on meat quality. Finally, few stockpeople prevented agitation of the animals during handling (Table 4.3). Consequently, there is increased cattle temperament which in turn increases the incidence and severity of bruising as well as frequency of dark-cutting meat (Southern *et al.*, 2006). Bruises and dark cutting are among the prevalent meat quality problems associated with poor animal handling (Gallo, 2008).

There exists a large difference between genders suggesting that men and women have different emotional and cognitive orientations toward animals (Herzog *et al.*, 1991). The lack of influence of gender on animal welfare knowledge could be due the fact that the information received on animal welfare is accessible to both the genders. Nevertheless, differences observed in the attitude and practices in the present study are consistent with a previous report that there is a widespread gender difference in both attitudes and behaviour toward animals (Herzog *et al.*, 1991). In addition, the present results further confirm that females' attitude towards animals is more positive than males (María, 2006). There is a disposition that females are more empathetic to animals than males (Mestre *et al.*, 2009). In addition, women form a larger part of animal welfare activists than men (Herzog *et al.*, 1991).

Age is one the factors that influence the capacity of stockpeople (Hemsworth and Coleman, 2011). The present results indicated that older stockpeople had a higher animal welfare KAP than younger ones. This observation is in contrast with previous reports that young aged common people (Kupsala *et al.*, 2015) and retailers (Miranda-de la Lama *et al.*, 2013) were more concerned about animal welfare than the older ones. There are only a few studies, to the best of our knowledge, which have analysed how age influences the knowledge, attitude and practices of stockpeople on animal welfare issues. Nevertheless, the differences can be cultural. In developed nations, the younger generations have a better access to information, and might be more aware of animal welfare issues (Grandin, 2014a). On the other hand, majority of livestock in Kenya are owned by pastoralists, (Farmer and Mbwika, 2012) who possess indigenous knowledge about animal welfare and health (Catley, 2006). Since such knowledge is passed from old generations, then animal welfare knowledge is expected to be higher in old stockpeople than the young ones (Table 4.5). On the other hand, there has been a report that younger drivers are more imprudent than older ones (Miranda-de la Lama *et al.*, 2014). This can help explain the lower attitude of the young stockpeople toward animal welfare issues.

Besides socio-demographic background, years of experience while handling animals shapes how humans relate themselves with animals (Kupsala *et al.*, 2015). Experienced stockpeople know about animal behaviour, hence they are able to take advantage of such behaviour to handle the animals well (Broom, 2003) and avoid issues such as bruises, (Strappini *et al.*, 2010) and in extreme cases animal mortality (González *et al.*, 2015; Velarde *et al.*, 2015). Indeed, experience can modify personality factors such as attitudes towards animals (Waiblinger and Spoolder, 2007). These factors explain why the more experienced stockpeople have a positive attitude and better practices (Table 4.5) than the less experienced stockpeople. The present results further emphasize that experience is one of the key competences for stockpeople (OIE, 2015). Nevertheless, the lack of difference in knowledge indicates that the more experienced stockpeople are aware of other animal welfare concepts, which make them to have a more positive attitude towards animals. As a result, they are in a better position to engage in good animal handling practices.

Previous results have shown that there is a modest connection between education level and attitudes toward farm animals (Waiblinger and Spoolder, 2007). Education level also contributes to job commitment (Hemsworth and Coleman, 2011). This is possibly due to reason that education increases animal welfare knowledge and modifies the attitude towards animal welfare issues (Kılıç and Bozkurt, 2013; Kupsala *et al.*, 2015). Indeed, the low level of education in animal welfare issues contributes to animal abuse in Kenya (Mogoa *et al.*, 2007). Nevertheless, results from the present study suggest that the level of education may not be paramount to the content of education when it comes to good animal welfare. To justify this, neither the animal welfare issues are highly considered in majority of the learning institutions in Kenya (Kimwele *et al.*, 2011), nor are these issues taught as a standalone course even in developed nations. Better animal welfare KAP observed by stockpeople with informal education could be the result of passing of indigenous knowledge that is directly relevant to animal welfare issues. On the other hand, formal education increases the level of knowledge and skills in other areas but not those related to animal welfare. Therefore, it is important to realize that training stockpeople to improve human–animal interactions involves behaviour modification rather than mere acquiring skills (Coleman and Hemsworth, 2014).

Improving the capacity of stockpeople can translate into sustainability in meat production. Figure 4.1 clearly shows the need to improve the practice of the stockpeople. The positive correlation between knowledge attitudes and practices point that increasing the knowledge of the stockpeople may have the desired effect on attitude and ultimately their practices. Focusing on the issues that scored low in Tables 4.2–4.4) is one way to improve the KAP levels. Nevertheless, demographic differences as evident in Table 4.5 also need to be considered. Several authors have emphasized on the importance of stockpeople training (Coleman and Hemsworth, 2014; Miranda-de la Lama *et al.*, 2014; Schwartzkopf-Genswein *et al.*, 2008). In the current study, stockpeople with negative attitude to training also had low knowledge and practice score over several issues. Because appropriate training can increase animal welfare knowledge and change stockpeople practices, (Hemsworth and Coleman, 2011) it is important that stockpeople with negative attitude towards training be made aware of potential benefits of training. Indeed, when pig transporters in France were trained on the economic importance of good animal handling practices, there was a decline in bruises that were recorded in slaughterhouses (Chevillon, 1998).

4.5. Conclusion and recommendations

In this study, the stockpeople showed a moderate level of knowledge and attitude about animal welfare issues. The observed particular issues were feeding and watering and mixing of unfamiliar groups of animals. Their animal welfare practices were also generally poor. Of concern were practices regarding mixing unfamiliar groups, low cooperation with other stakeholders and agitation of animals during handling. Although these may be the most serious issues, our results showed that interventions are required for each issue. The results obtained presently reflect the situation in developing countries where animal handling is said to be inhumane. This probably results from inadequate codes of good animal handling practices. In addition, demographic characteristics of the stockpeople such as gender, age and level of experience influenced their KAP. Their current level of KAP can have a serious impact on the sustainable meat production. Further studies that integrate animal welfare KAP and animal welfare outputs such as bruises, dark cutting carcasses, and mortality are needed to verify how the current levels of KAP influence these outputs.

Chapter 5. Personal Hygiene Practices among Meat Handlers at Small and Medium Scale Slaughterhouses in Nairobi County and its Environs

Abstract

Majority of Kenyans consume meat supplied by Small and medium Enterprises slaughterhouses. The aim of this study was therefore to determine the personal hygienic practices, personal determinants of these practices among 207 (meat handlers) MH in Nairobi County and its environs. The hygiene practices assessed were related to hand washing, protective clothing, prohibited practices, medical examination and equipment handling. The score of each category of practices were summed together to determine the overall level of practice. This final level was categorized into either inadequate (<14), moderate (14-17.9) or adequate (>=18) out of a possible high score of 20. Individual assessment of the practices showed that majority of the MH do not always use soap and disposable towels during hand washing, use of gloves, clean their equipment between carcasses or keep the equipment away from their protective clothes when not in use. Overall, the level of hygiene practice among the MH was moderate. Level of education and experience, training, age and profession significantly influenced the MH's hygiene practices ($p<0.05$). There was a significant correlation of the MH's demographic factors among the ($p<0.05$) apart from training and level of education ($p>0.05$). Although the results show a good level of practices among the MH in SME slaughterhouses, some aspects of hand washing and equipment handling are some of the practices that they need to be improved. Improvement can be based on specific tasks, level of experience and training of the MH.

Keywords: meat safety; hygiene; sanitation; meat handling; small and medium enterprise

5.1. Introduction

Personal hygiene is defined as ''as clean as is reasonably practical of hands, forearms, neck, hair and any clothing liable to come into contact with food'' (Nel *et al.*, 2004). All workers in a food-handling area are expected to maintain a high degree of cleanliness of their hand, body and clothing, and wear suitable, clean and, where necessary, protective clothing in order to ensure food safety and public health (Nee and Sani, 2011). The ability of most of these pathogens to survive on hands, mouth, skin, cuts or sores, hair sponges, clothes, coins and other surfaces for hours or days after the initial contact (Pérez-rodríguez *et al.*, 2013), makes good personal hygiene practices essential for public health and consumer protection

Personal hygiene of food workers contribute significantly to outbreak and transmission of foodborne illnesses (Assefa *et al.*, 2015). Globally, several studies have reported the consequence of such negligence. For example, it has been found that annually from 1993 to 1997, poor personal hygiene of food workers was a contributing factor in 27 to 38% of foodborne illness outbreaks (Green *et al.*, 2007). More recently, a study conducted in Malaysia showed that approximately 10-20% of food-borne disease outbreaks are due to contamination by the food handlers (Assefa *et al.*, 2015). In another study in Turkey, improper food handling practices contributed to approximately 97.0% of foodborne illnesses (Kahraman *et al.*, 2010).

Contribution of food handlers to illness comes from the fact that they can be asymptomatic carriers of foodborne disease–causing microorganisms (Opiyo *et al.*, 2013). Frequent outbreaks of food borne illnesses caused by *Staphylococcus aureus* and gram negative bacilli such as *Salmonella* spp., *Shigella* spp., *Campylobacter jejuni*; enterotoxigenic *E. coli* as well as viral agents, i.e., hepatitis A, and Norovirus have been associated with poor personal hygiene by food handlers (Shojaei *et al.*, 2006). Contaminated surfaces of food handlers will play a major role in transmitting these disease–causing microorganisms to foods.

Meat and meat products are of particular importance regarding foodborne illnesses (Ansari-Lari *et al.*, 2010). Personal hygiene practices of meat handlers (MH) are therefore a prerequisite for safe food products (Jianu and Goleţ, 2014). Disregard of hygienic measures, enable pathogens to come into contact with food and, in some cases, to survive and multiply in sufficient numbers to cause illness in consumers (Assefa *et al.*, 2015). In Kenya, a big percentage of consumers consume beef supplied by Small and medium enterprises (SMEs) slaughterhouses, where MH have poor personal practices (Farmer and Mbwika, 2012). As a result, the risk of foodborne illnesses from contaminated meat is considerably high. The factors contributing to the level of hygiene practices have not been identified. In addition, training in hygiene practices have always been recommended after analysis of the Kenyan livestock value chain (Farmer and Mbwika, 2012; Muthee, 2006), but the specific areas of training have not been identified.

Implementation of food safety programs in SMEs poses serious practical problems (Marais *et al.*, 2008). The lack of experienced, and technically qualified personnel, time, training, motivation, commitment, funding, and in-house knowledge to identify foodborne microbial hazards in the SMEs (Bertolini *et al.*, 2007; Panisello and Quantick, 2001; Taylor, 2001), are some of the a potential risk factor for poor hygiene practices. In order to assure safety of meat consumed in Kenya, a thorough understanding of the current level of personal hygienic practices, personal determinants of these practices and other factors that contribute to the practices is needed. This will identify the training needs of the MH and opportunities to overcome particular barriers that may hinder adequate implementation of good personal hygiene practices. As previously cited, similar studies targeting MH have been conducted in other countries including Portugal, Iran and South Africa (Jianu and Goleţ, 2014). The specific objective of this chapter was therefore to assess the personal hygiene practices among meat handlers at SME slaughterhouses in Nairobi County and its environs.

5.1.1. Main activities

1. Assess the demographic characteristics of meat handlers
2. Asses the personal hygiene practices of meat handlers
3. Compare demographic characteristics with the personal practices of the meat handlers
4. Assess the association between demographic characteristics and personal hygiene practices of the meat handlers

5.2. Materials and Methods

5.2.1. Study area

A cross-sectional survey using structured questionnaire-was administered on 207 MHs from five SME slaughterhouses located in Nairobi Country and its environs. Each slaughterhouse had less than 100 employees. About 334,068 cattle are slaughtered annually in these slaughterhouses. Majority of these slaughterhouses serve Nairobi and its environs, which is the largest market for beef in Kenya.

5.2.2. Target population and Sampling Technique

A stratified random sampling technique was used. The population was first classified into five strata according to their area of work (sticking/bleeding, flaying, evisceration, splitting/quartering and green offal section). All the MH in each strata were exhaustively sampled for the interview. The participants included 21 bleeders, 28 flayers, 37 eviscerators, 53 splitters, and 68 offal section workers.

5.2.3. Data collection

A structured questionnaire (Appendix 3) administered through direct interviews with respondents on Socio-demographic characteristics and hygienic practices which were assessed using a five-point ordinal scale (0=never, 1=rarely, 2=sometimes, 3=often to 4=always). The option 'sometimes' was included to ensure the respondents did not pick the correct answer by chance.

5.2.4. Data analysis

Data were analysed using SPSS version 23.0 (IBM Corp., 2015). Descriptive statistics (frequencies) were then obtained to describe each of the practice variable. In order to categorize practices into various levels, the recommended thresholds for knowledge, attitude and practices assessment (Macias and Glasauer, 2014) were used. To get the mean score, each mean was divided by 4 (the highest possible value), then multiplied by N_v; where N_v was the number of variables per section. If the mean score of a particular variable was ≤ 70% N_v, then the practice was poor and required training. If it was 71–89% N_v the level was moderate hence might be considered for training. Finally, if it was >90% N_v, then the practice was good, hence a training was not needed or difficult to justify. Omnibus tests for group differences were tested using Man-Whitney U test for groups with two categories (Appendix 9). Kruskal-Wallis H test was used where the categories were more than two. The stepwise-step down procedure was used to separate statistically significant categories (Kruskal-Wallis, $p<0.05$) (Appendix 10). Significant demographic factors were correlated using Spearman rank correlation coefficient (Appendix 11). Finally, the association and correlation of the MH's practice was determined using Pearson's Chi square and Spearman's correlation tests, respectively (Appendix 12).

5.3. Results

5.3.1. Demographic characteristics

The MH comprised of more male (86%) than female (14%). Majority of the MH were middle aged (31-40 years) representing 41%, with 25% being younger (20-30 years) representing 25%. The rest were above 40 years. Majority of the MH had primary level education (48%) followed by secondary (40%), while 8% lacked formal education and 4% had tertiary level education. Experience varied from 1-5 (38%) years or >10 (35%) years while the rest had less than one of experience. MH trained in hygienic meat handling were fewer (40%) than the untrained (60%).

5.3.2. Meat handlers' hygiene practices

5.3.2.1. Hand washing practices

Table 5.1 gives the frequency percentages of each of the MH's hand washing practices and categorization of the MH based on their score. Majority of the MH (86.4%) reported that they wash their hands before handling meat. On the hand, MH who often wash their hands between carcasses were more (52.7%) than those who always wash their hands (43.5%). After visiting the toilet, majority of the MH (83.5%) always wash their hands. During hand washing, more than half of the MH (58.0%) do not use soap, whereas only 15.0% of the MH always use soap. After hand washing, majority of the MH (49.3%) rarely use a disposable towel. Only 24.6% of the MH use the towels. Majority of the MH (51.7%) scored less than 3.5 out of 5.0 (the highest possible score), while only 8.2% scored >=4.5. The rest scored between 3.5 and 4.5. The mean score of all MH was 3.5.

Table 5.1 Frequency percentages of hand washing practices and categorization based on scores of meat handlers

Question	Never (%)	Rarely (%)	Sometimes (%)	Often (%)	Always (%)
1. Do you wash your hands before you start meat handling?	–	–	–	13.6	**86.4**
2. Do you wash your hands between carcasses?	–	1.9	1.9	52.7	**43.5**
3. Do you wash your hands after visiting the toilet?	–	–	1.0	15.5	**83.5**
4. During hand washing do you use soap?	58.0	1.9	13.0	12.1	**15.0**
5. After hand washing, do you use a disposable towel to dry your hands?	16.4	49.3	5.8	3.9	**24.6**
% of Meat handlers whose score was >=4.50[a]	8.2				
% Meat handlers who scored 3.50-4.49[b]	40.1				
% Meat handlers who scored <3.50[c]	51.7				
Overall score (mean score ±SD)[d]	3.5 ±0.6				

Note: The correct answers appear in **bold**
[a]Meat handlers who answered >=90% of the questions correctly
[b]Meat handlers who answered 70%-89% of the questions correctly
[c]Meat handlers who answered <70% of the questions correctly
[d]The total score of meat handlers ranged from 0.0 to 5.0

5.3.2.2. Protective clothing practices

Table 5.2 gives the frequency percentages of each of the MH's protective clothing practices and categorization of the MH based on their score. MH who reported that they wear an apron and gumboots during meat handling were 93.7 and 99.0%, respectively. On the other hand, majority of the MH (89.9%) sometimes wear gloves during handling meat. At the same time, MH who always wear hair-nets were the majority (77.8%). Concerning washing of aprons and gumboots, 94.5% and 91.8% of the MH reported that they always wash them. Out of possible high score of 6.0, MH whose score was >=5.4 were more (69.9%) than those whose was between 4.2 and 5.3 (30.1%). The mean score of all MH was 5.3 ±0.3.

Table 5.2 Frequency percentages of protective clothing practices and categorization based on scores of meat handlers

Question	Never (%)	Rarely (%)	Sometimes (%)	Often (%)	Always (%)
1. Do you wear an apron during meat handling?	–	2.4	1.0	2.9	**93.7**
2. Do you wear gumboots during meat handling?	–	–	–	1.0	**99.0**
3. Do you wear gloves during meat handling?	–	–	89.9	10.1	–
4. Do you wear a hair-net during meat handling?	–	–	20.3	1.9	**77.8**
5. Is you apron washed daily?	–	–	1.0	4.5	**94.5**
6. Is your pair of gumboots washed daily?	–	–	0.5	7.7	**91.8**
% of Meat handlers whose score was >=5.40[a]	69.9				
% Meat handlers who scored 4.20-5.39[b]	30.1				
% Meat handlers who scored <4.20[c]	–				
Overall score (mean score ±SD)[d]	5.3 ±0.3				

Note: The correct answers appear in **bold**
[a]Meat handlers who answered >=90% of the questions correctly
[b]Meat handlers who answered 70%-89% of the questions correctly
[c]Meat handlers who answered <70% of the questions correctly
[d]The total score of meat handlers ranged from 0.00 to 5.00

5.3.2.3. Practices regarding medical care

Table 5.3 gives the frequency percentages of each of the MH's medical care practices and categorization of the MH based on their score. In case of bruises, 92.5% of the MH (reported that they always covered the bruises. On the other hand, 65.5% of the MH always report their illnesses to the management. In the case of medical examination, 51.2% of the MH always take medical examination as per government regulation. Out of possible high score of 3.0, 61.8% of the MH scored >=2.7 while 34.3% scored between 2.1 and 2.7. The score of the rest was below 2.1. The mean score of all MH was 2.7 ±0.4.

5.3.2.4. Practices regarding prohibited habits

Table 5.4 gives the frequency percentages of each of the MH's practices regarding prohibited habits and categorization of the MH based on their score. In case of eating and smoking while working within the slaughterhouse, majority of the MH (88.4% and 93.3%, respectively) reported that they never engage in the practices. In addition, majority of the MH (87.9%) always remove their jewellery while in the slaughterhouse. Out of possible high score of 3.0, majority of the MH (93.7%) scored >=2.7 while 5.8% scored between 2.1 and 2.7. The score of the rest was below 2.1. The mean score of all MH was 2.9 ±0.3.

Table 5.3 Frequency percentages of medical care practices and categorization based on scores of meat handlers

Question	Never (%)	Rarely (%)	Sometimes (%)	Often (%)	Always (%)
1. In case of bruises or cuts on your hands, do you cover them?	–	–	2.0	5.5	**92.5**
2. In case of an illness, do you report to the management?	–	–	5.9	28.6	**65.5**
3. Do you take medical examination as per the government's regulation?	–	4.4	7.7	29.5	**51.2**
% of Meat handlers whose score was >=2.70[a]	61.8				
% Meat handlers who scored 2.10-2.69[b]	34.3				
% Meat handlers who scored <2.10[c]	3.9				
Overall score (mean score ±SD)[d]	2.7 ±0.4				

Note: The correct answers appear in **bold**

[a]Meat handlers who answered >=90% of the questions correctly

[b]Meat handlers who answered 70%-89% of the questions correctly

[c]Meat handlers who answered <70% of the questions correctly

[d]The total score of meat handlers ranged from 0.0 to 3.0

5.3.2.5. Practices regarding equipment handling

Table 5.5 gives the frequency percentages of each of the MH's equipment handling practices and categorization of the MH based on their score. More than half (55%) of the MH reported that they always clean their equipment between carcasses. Similarly, 50% of the MH reported that they never keep their equipment in their protective clothing when not in use. On the other hand, 79% of the MH remove their equipment when vising the toilet. Out of possible high score of 3.0, 60.4% of the MH (93.3%) scored >=2.7 while 30.9% scored between 2.1 and 2.6. The score of the rest was below 2.1. The mean score of all MH was 2.6 ±0.3.

Table 5.4 Frequency percentages of practices regarding prohibited habits and categorization based on scores of meat handlers

Question	Never	Rarely	Sometimes	Often	Always
1. Do you eat while working in the slaughterhouse?	**88.4**	10.6	1.0	–	–
2. Do you smoke while working in the slaughterhouse?	**93.2**	6.3	0.5	–	–
3. Do you remove your jewellery while working in the slaughterhouse?	–	–	2.9	9.2	**87.9**
% of Meat handlers whose score was >=2.70[a]	93.7				
% Meat handlers who scored 2.10-2.69[b]	5.8				
% Meat handlers who scored <2.10[c]	0.5				
Overall score (mean score ±SD)[d]	2.9 ±0.2				

Note: The correct answers appear in **bold**

[a]Meat handlers who answered >=90% of the questions correctly

[b]Meat handlers who answered 70%-89% of the questions correctly

[c]Meat handlers who answered <70% of the questions correctly

[d]The total score of meat handlers ranged from 0.0 to 3.0

Table 5.5 Frequency percentages of equipment handling practices and categorization based on scores of meat handlers

Question	Never	Rarely	Sometimes	Often	Always
1. Do you clean your equipment between carcasses?	–	–	5.8	39.6	**54.6**
2. Do you keep you equipment in your protective clothing when not in use?	**49.5**	41.3	4.4	2.4	2.4
3. Do you remove your equipment when using the toilet?	–	–	–	21.3	**78.7**
% of Meat handlers whose score was >=2.70[a]	60.4				
% Meat handlers who scored 2.10-2.69[b]	30.9				
% Meat handlers who scored <2.10[c]	8.7				
Overall score (mean score ±SD)[d]	2.6 ±0.3				

Note: The correct answers appear in **bold**

[a]Meat handlers who answered >=90% of the questions correctly

[b]Meat handlers who answered 70%-89% of the questions correctly

[c]Meat handlers who answered <70% of the questions correctly

[d]The total score of meat handlers ranged from 0.0 to 3.0

5.3.2.6. Overall level of hygiene practices

A summary of overall level of MH's hygiene practices is shown in Table 5.6. Out of possible high overall score of 20.0, majority of the MH (82.1%) scored between 14.0 and <18.0. On the other hand, 16.9% of the MH scored >=18.0 while 1.0% scored below 14.0. The overall mean score of all MH was 17.1.

Table 5.6 A summary of overall level of hygiene practices and categorization based on scores of meat handlers

	N	Mean ±SD[d]	Median	Minimum	Maximum
Overall level of hygiene practices	207	17.1 ±0.9	17.1	13.3	19.8
% of Meat handlers whose score was >=18.00[a]	16.9				
% Meat handlers who scored 14.00-17.99[b]	82.1				
% Meat handlers who scored <14.00[c]	1.0				

[a]Meat handlers who answered >=90% of the questions correctly
[b]Meat handlers who answered 70%-89% of the questions correctly
[c]Meat handlers who answered <70% of the questions correctly
[d]The total score of meat handlers ranged from 0.0 to 20.0

5.3.3. Comparison of demographic characteristics and overall level of hygiene practices

The relationship between demographic characteristics and overall level of hygiene practices are shown in Table 5.7. The overall level of hygiene practices of male MH was not statically different from the level of female MH (p=0.534). The MH aged <20 years had the least overall score amongst the age groups (p=0.016). On the other hand, MH with education secondary or tertiary education had higher level of overall score than the others (p=0.028). In terms of experience, MH with 1-5 and >10 years of experience had higher level of overall score than the MH with either <1 or 6-10 years of experience (p=0.001). Trained MH had higher level of overall score than the untrained MH (p=0.015). Finally, flayers had the highest level of overall score while offal section workers had the least level of overall score.

5.3.4. Correlation among demographic characteristics of meat handlers

Profession of the MH was directly correlated with education level (p=0.016), but inversely correlated with age and experience level (p<0.001, respectively). On the other hand, age was directly correlated with experience level (p=0.002), but inversely correlated with education level and training (p<0.05). Education was inversely correlated with experience level (p=0.001). Similarly, experience level was inversely correlated with training (p<0.001). Finally, there no correlation was observed between training and education level (p=0.412). Change colour of table text below

Table 5.7 Score statistics of overall level of hygiene by demographic characteristics of meat handlers

Demography	Sub-group	N	Med	Mean ±SD	Min	Max	Mean Rank
Gender*	Male	177	17.1	17.1 ±0.9	13.3	19.8	105.1
	Female	30	17.1	17.0 ±0.8	15.8	19.2	97.7
Age**	<20	52	16.0	16.1 ±0.6	15.5	17.3	34.2[a]
	20-30	6	17.0	17.1 ±0.7	13.8	19.2	99.2[b]
	31-40	85	17.0	17.1 ±0.9	14.8	19.8	102.2[b]
	41-50	38	17.3	17.2 ±1.0	13.3	19.5	113.3[b]
	>50	26	17.4	17.3 ±1.0	14.3	19.0	122[b]
Education level**	Did not go to school	17	16.8	16.8 ±1.2	14.3	19.0	86.7[a]
	Primary	99	17.0	17.0 ±0.9	13.3	18.5	94.51[a]
	Secondary	83	17.3	17.3 ±0.8	15.3	19.5	118.2[b]
	Tertiary	8	17.1	17.4 ±1.2	16.3	19.8	110.8[a,b]
Experience level**	<1	9	16.1	16.4 ±1.0	14.3	17.3	64.1[a]
	1-5	78	17.0	17.1 ±0.7	15.5	19.5	103.9[b,c]
	6-10	47	17.0	16.8 ±0.9	13.8	18.5	85.1[a,b]
	>10	73	17.3	17.4 ±1.0	13.3	19.8	121.3[c]
Training**	Yes	82	17.3	17.3 ±0.8	14.3	19.8	115.9
	No	125	17.0	17.0 ±0.9	13.3	19.5	95.3
Profession**	Sticking/bleeding	21	17.1	17.3 ±0.8	15.6	18.5	112.9[a,b]
	Flaying	28	17.3	17.3 ±1.0	14.3	19.0	123.8[b]
	Evisceration	37	17.3	17.4 ±0.9	15.5	19.8	121.3[a,b]
	Splitting/quartering	53	17.1	16.9 ±1.0	13.3	19.5	92.81[a,b]
	Green offal section	68	17.0	17.0 ±0.8	15.5	19.2	92.4[a]

Med – Median
Min – Minimum
Max – Maximum
*/** Non-statistically/statistically significant (Kruskal Wallis/Mann-Whitney test at p=0.05)

Table 5.8 Correlation among demographic characteristics of meat handlers

	Profession	Age	Education level	Experience level	Training
Profession	1	-0.353**	0.167**	-0.415**	0.369**
Age	-0.353**	1	-0.215**	0.487**	-0.175**
Education level	0.167**	-0.215**	1	-0.233**	0.057*
Experience level	-0.415**	0.487**	-0.233**	1	-0.301**
Training	0.369**	-0.175**	0.057*	-0.301**	1

*/** Non-statistically/statistically significant (Spearman test at p=0.05)

5.3.4.1. Association between demographic characteristics and overall hygiene practices

There was a strong association between gender, years of experience, designation and training and overall personal hygiene practices of the meat handlers ($p<0.05$). No association was found between education level and overall personal hygiene practices of the meat handlers ($p>0.05$).

5.4. Discussion

The level of personal and hygiene practices of MH may influence the level of microbial contamination of meat. Specifically in SME slaughterhouses where the level of automation is minimal, the increased contact between meat and personnel is unavoidable. Various practices that were considered as risk factors for microbial contamination of meat by MH were assessed. Furthermore, underlying issues that influence these practices were assessed. The demographic results, showing a wide variety of ages, education level, years of experience, occupation and gender in the sample population suggests that the sample was indeed representative if not comprehensive.

Hands are a major source of infection from microorganisms (Kahraman *et al.*, 2010). Up to 10^7 pathogens are present under the fingernails of the food handler (Nel *et al.*, 2004). Food handlers should therefore wash their always as good manufacturing practices (Assefa *et al.*, 2015). The present results (Table 5.1), unlike those reported previously (Nel *et al.*, 2004), showed that not all the MH always washed their hands before starting their work. However, the fact that the practice of hand washing between carcasses was not common among majority of the MH poses the risk of cross-contamination of the meat. Normally, humans shed more than $1x10^3$ viable micro-organisms by per minute (Frazier and Westhoff, 1988). This and regular contact with other contaminated surfaces is a risk to the carcasses.

Compared to a previous study (Jianu and Goleţ, 2014), the proportion of MH in the present study who do not wash their hands after visiting the toilet was low. Neglecting this practice is considered one of the biggest risk factors for food safety (Jevšnik *et al.*, 2008). However, proper hand washing practices, which include the application of soap, paper can result in a significant reduction of micro-organisms (Montville *et al.*, 2002; Shojaei *et al.*, 2006). Nevertheless, soap use was not a common practice among majority of MH in the present study. In the final step of hand-washing, which is drying, the use of disposable paper towels is highly recommended (Nel *et al.*, 2004). However, as observed in the present study, these towels were rarely used. All these factors lower the MH chance to reduce cross-contamination even if they wash their hands. This is reflected by the fact that about half of the MH in the present study scored less than 70% hence requires urgent training in hand washing practices.

The proportion of MH in the present study that wore protective clothing was almost equivalent to what was previously report (Nel *et al.*, 2004). Appropriate and clean clothing help reduce the risk of food contamination (Azmi, 2006). The high proportion of MH with gumboots is of particular importance because the detection rate of *Salmonella* spp. and *L. monocytogenes* from the boots is higher even more than aprons (Kahraman *et al.*, 2010). While wearing protective clothing is important, clothes can become contaminated with pathogens during working activities (Hayes and Forsythe, 1999). For that reason, regular washing of the clothes is important. Indeed, it was reported that coliforms were present on 26% of aprons, of which, 8% exceeded the target value of <2.5 cfu cm^2 (Jevšnik *et al.*, 2008). However, as it was presently observed, such a risk can be considered low because nearly all of MH wore clean clothes and gumboots.

From the present results, a few MH indicated that they wear gloves. This is unlike previous studies (Jianu and Goleţ, 2014; Nel *et al.*, 2004). Proper glove use can decrease the transfer of pathogens from hands to food (Green *et al.*, 2007). Although low level of gloves use by MH can be argued to be a positive practice given that several authors have stated frequent glove use can promote poor hand washing practices (Fendler *et al.*, 1998; Frazier and Westhoff, 1988; Lynch *et al.*, 2005). Although no data is available to support the above statement (Green *et al.*, 2007), it is important that a barrier between the MH's hands and the meat they handle. This may be particular important given the level of hand washing practices reported presently. Other proposed protective clothing to be worn by MH at all times include hair restraints, that is, hairnets (and beardnets if applicable) to cover their hair (Assefa *et al.*, 2015; Nel *et al.*, 2004). Despite of this, only three quarters adhered to this practice compared to 100% reported previously (Nel *et al.*, 2004). Although the present results were low, where only 30% of the MH require to be considered for training in protective clothing practices.

Wounds can be contaminated with pathogenic microorganisms from a person's body or the environment (Miller *et al.*, 2014). To prevent the transfer of these biofilms to the meat during handling, the wounds should be covered. This was observed in majority if MH in the present study. Present results further confirm a previous report that, only a small portion of food handlers identified the need to report illnesses (Jevšnik *et al.*, 2008). In case of illness, the standard protocol is to report the illnesses to the supervisor or management (Nel *et al.*, 2004). Compared to a previous study (Nel *et al.*, 2004), the proportion of MH who adhere to this practice is considerably low. In addition to reporting illnesses, employees are required to undertake regular medical examination, because only healthy employees should be employed in a food establishment (Assefa *et al.*, 2015; Marriott and Gravani, 2006). Nevertheless, only half of the MH took regular medical examination as recommended, which confirms a previous report that, only a small portion of food handlers identify the need to report illnesses (Jevšnik *et al.*, 2008). The risk posed by MH due to poor medical related practices is reflected by the fact that about 35% of the MH in the present study need to be considered for training while 4% need urgent training.

Smoking and eating within a food establishment are discouraged because such practices may lead to contamination of food (Assefa *et al.*, 2015). On the other hand, rings and watches have been shown to increase the frequency of bacterial hand contamination (Ingle *et al.*, 2012), while sharp edges of some jewellery can cause bruises on the skin (White, 2013). Wearing such accessories is thus not recommended. The proportion of MH in the present study who do not engage in these practices was lower than previously reported (Nel *et al.*, 2004; Walker *et al.*, 2003) but higher in other studies (Ansari-Lari *et al.*, 2010; Jianu and Goleţ, 2014). The risk posed by the MH in the present study is nonetheless big by the fact that training for 94% of the MH in these practices is hard to justify.

Many pathogens such as *Escherichia coli*, *Staphylococcus aureus* and *Salmonella* spp. can survive on surfaces for hours or days after the initial contact (Pérez-rodríguez *et al.*, 2013). It is therefore important to prevent formation of biofilms on meat cutting equipment. This will prevent the equipment from becoming media of cross-contamination among carcasses. However, only half of MH cleaned their equipment between carcasses. This therefore increases the risk of biofilm formation on most meat cutting equipment. On the other hand, where the equipment is kept when not in use is important. Given that, gumboots and aprons may be a source of *L. monocytogenes* and *Salmonella* spp. (Kahraman *et al.*, 2010), the equipment should not be kept in the protective clothing. Besides the possible contamination, the equipment can result into cuts on the MH's skin. While using the toilet, work equipment should be removed, because the toilets harbour various pathogens, including *E. coli* (Karibasappa *et al.*, 2011). Nevertheless, the proportion of MH in the present study that practice this was lower than previously reported (Jianu and Goleţ, 2014). This may result in a considerable risk from the fact that this category of practices had the highest number of MH who need urgent training. In addition, 30% of the MH may need to be considered for training.

Training programs improve the knowledge of food handlers (Ansari-Lari *et al.*, 2010). Training of food handlers reduces contamination levels in the food handlers, hence seen as a key to prevent foodborne illnesses (Nel *et al.*, 2004; Shojaei *et al.*, 2006). The proportion of MH in the present study who had attended training was lower than reported by other authors (Ansari-Lari *et al.*, 2010; Nel *et al.*, 2004). This confirms another report that training is one of the requirements that is seriously neglected by the food industry, despite of its importance (Ababio and Lovatt, 2015; Azmi, 2006). Workers in a slaughterhouse are expected to have received training (Nel *et al.*, 2004). In the present study, about the proportion of workers that need training is considerably higher than the one that does not require it. To assure confidence in traded meat, this gap needs to be reduced. However, expected barriers need to be overcome as well. For the SMEs in the present study, these challenges may not only be financial but technical as well. Attending professional training programs is not mandatory in some countries and the completion of such a program remains at the discretion of the operators and employer (Jianu and Goleţ, 2014). In addition, few food companies understand why employee training is important (Jevšnik *et al.*, 2008).

Identifying differences among across demographic factors is seen as a promising, means for more specified food handling interventions that target those who need them most (Mullan *et al.*, 2015). Among the five demographic factors tested, only gender did not influence the overall level of hygiene. Similar results on gender had been reported (Jianu and Goleţ, 2014). Compared to other age groups, young MH in the present study had the least mean ranks of overall level of hygiene practices. These results are in agreement with a previous report that young adults tend to have poor food handling practices (Byrd-Bredbenner *et al.*, 2007), which can be attributed to low food handling knowledge (Carbas *et al.*, 2013). In terms of the significant effect education level had on food handler's level of hygiene practices, the present results disagree with some authors (Webb and Morancie, 2015) but agree with others (Jianu and Goleţ, 2014). Such results may point to the nature of curriculum offered at schools in respective study areas. Courses such as home economics in the education system increases level of knowledge (Mullan *et al.*, 2015) in food handling and hence may be attributed to higher scores in more educated respondents.

Due to daily routine, experienced food handlers have more food hygiene related knowledge (Ajala *et al.*, 2010). As a result, experience results to increased food handling knowledge (Carbas *et al.*, 2013). These factors coupled with a positive correlation between food handling knowledge and practices (Jianu and Goleţ, 2014) explains why more experienced MH had higher scores of hygiene practices. These results also agree with another previous study (Jianu and Goleţ, 2014). Similarly, training has been shown to increase food hygiene knowledge of food handlers (Ababio *et al.*, 2016). This explains why trained MH had significantly higher scores than untrained MH in the present study. Furthermore, these results and previous results (Jianu and Goleţ, 2014) are similar. Although little literature is available on the impact of profession on hygiene practices, the fact that this factor was correlated with all other demographic factors indicate the level of these factors among the MH influences the score of the MH at different sections of the slaughterhouse. Nevertheless, the low scores by offal section workers may justify why meat and offals should be handled separately.

Its acknowledged that SMEs have limited resources (Dora and Gellynck, 2015). This can limit implementation of adequate hygiene programs such as Hazard Analysis Critical Control Point. In addition, it may be difficult to train all the food handlers who require training. From the present study, MH who require training is great and the costs involved may be beyond the reach of the management. To provide a simple solution, the present study formulated a simple equation that can be utilized by the management to identify the MH who are in serious need of training. As a result, the limited resources that are available can be optimally used. From the step-wise regression analysis, designation, level of experience and status of training can be employed for such identification. On a scale ranging 0-20 the management and other supporting stakeholder such as the government can develop a cut-off point for the MH to be trained. Furthermore, this process may encourage the use of documentation in the SMEs. Documentation has been reported to be very low in most countries and hamper effective implementation of food safety programs (Trafialek *et al.*, 2015).

5.5. Conclusion and recommendations

The present study demonstrated a moderate level of hygiene practices among the MH. Gaps were identified in areas such as use of soap and disposable towels during hand washing practices, use of gloves especially, medical examination, cleaning of equipment between carcasses and keeping the equipment in clothes when not in use. These reflect specific practices that require improvement. The study also highlighted the role of level of education and experience, training, age and profession in determining the overall level of MH's hygiene practices in the questions asked. To results further showed that majority of the MH need to be considered for professional training to improve their level of hygiene practices. A simple criterion to identify these MH was developed. Nevertheless, before application, this criterion needs to be validated because the practices were self-reported and this may not always translate to actual practices. Other surveys involving microbial analysis of MH and their clothing, carcasses and equipment can be used to validate the criterion. Furthermore, studies covering SME slaughterhouse in other regions of Kenya are required to give a stronger conclusion of the overall level of hygiene practices of the MH on a nationwide scale.

Chapter 6. Contamination of Carcasses, Personnel and Equipment with Hygiene Indicator Microorganisms in Small and Medium Enterprise Slaughterhouses

Abstract

In Kenya a big percentage of the beef consumed locally is supplied by Small and medium Enterprises (SME) slaughterhouses, where the level of hygiene is unacceptable. In order to analyse the slaughter process and its performance in the SME slaughterhouses, this study aimed at providing a baseline for the level of contamination of carcasses, personnel and mechanical equipment at various slaughter stages of five SME slaughterhouses located within Nairobi County and its environs. A total of 225 swab samples were collected from the slaughterhouses. The microbiological quality of all the samples was evaluated using petri dishes to obtain counts of total aerobes (APC), *S. aureus*, *Enterobacteriaceae* and *Salmonella spp*. The contamination of carcasses in all the five slaughterhouses increased from flaying to dispatch. The prevalence of *Salmonella* spp. on carcasses was 16.67%. In two slaughterhouses, log cfu/cm^2 of *Enterobacteriaceae* were unacceptable. Contamination of personnel was highest at flaying and evisceration. Similarly, APC and *S. aureus* on hands was unacceptable at flaying. On the other hand, contamination of clothes *S. aureus* was only acceptable at flaying in four slaughterhouses. Contamination of knives was highest at flaying. The level of contamination of the equipment in all the slaughterhouses and stages was however within acceptable limits. In conclusion, flaying and evisceration are critical control points for contamination of carcasses, personnel and mechanical equipment in the SME slaughterhouses. Slaughter specific pre-requisite programs targeting these two stages need to be developed and implemented.

Keywords: contamination; carcass; personnel; equipment; hygiene indicator microorganism; small and medium enterprise; slaughterhouse

6.1. Introduction

Over the past two decades, microbiological food safety has received greater attention from regulatory authorities, researchers, public-health officials and consumers (Eifert *et al.*, 2005). Food poisoning and diarrheal illnesses from the microbial contaminants are among the leading causes of morbidity and mortality worldwide (WHO, 2015). Meat and meat products are of particular importance regarding foodborne illnesses (Ansari-Lari *et al.*, 2010). Approximately 12.7% of reported foodborne outbreaks around the globe can be attributable to beef, which makes the meat a more significant source of foodborne diseases than meat from other species (Greig and Ravel, 2009). In Kenya, the per capita beef consumption is 6.5 kg/year, which is twice as much as per capita consumption of meat from the other species combined together (Farmer and Mbwika, 2012; Muthee, 2006). A big percentage of the beef consumed locally is supplied by Small and medium Enterprises (SME) slaughterhouses, where the level of hygiene is inadequate (Farmer and Mbwika, 2012). As a result, the risk of foodborne illnesses from contaminated beef may be considerably high.

Unless in cases of a disease or infection, the muscle tissues of healthy animals and birds, before slaughter, can be considered sterile (Oto *et al.*, 2013). The microbial contamination of carcasses occurs during processing and manipulation such as skinning, and evisceration at slaughterhouses from contact surfaces such as knives and personnel (Gill, 1998; Koutsoumanis *et al.*, 2005). The fundamental principle of controlling microbial contamination during slaughter is thus based on sanitary and hygienic processes (Buncic and Sofos, 2012). This includes good personal hygiene and sanitary handling practices, which are an essential part of any prevention program for food safety at work (Soares *et al.*, 2012). Contaminated slaughterhouse equipment play a more important role in the final carcass contamination level than the slaughterhouse personnel partly due to the possible build-up of bacteria in or on the equipment during working hours (Wong *et al.*, 2002). Meat produced under such conditions will quickly deteriorate, because the nutrient composition and water activity of meat provide excellent growth media for a variety of micro-flora (FAO, 2004; Jay *et al.*, 2005; Rao *et al.*, 2009).

The performance of an implemented food safety program and the levels of microbial contamination on carcasses are interrelated. Analysing the slaughter process is therefore an integral part of assessing the performance of the slaughter process (Zweifel *et al.*, 2014). A 'process-based' microbiological criteria which are based on values of microbiological data measured at abattoir-specific hygienic points of the process, including final carcass values, should be used (Milios *et al.*, 2014). However, provision of suitable information remains a reality in most SMEs, because they lack the in-house knowledge and resources to collect such data (Marais *et al.*, 2008; Walker *et al.*, 2003). It is therefore a practical problem for these SMEs to assess the performance of their own slaughter process. In the end, they are unable to set up prerequisite programs for their slaughter process. Such programs include good personal hygiene, cleaning and sanitation programs, proper facility-design practices and equipment-maintenance (Hatim *et al.*, 2013).

Microbiological limits are widely used in food processing as an aid to reduce the exposure to hazardous microorganisms for the consumers (Bollerslev *et al.*, 2016). The microbiological parameters that have been used as indicators in slaughterhouses are Aerobic Plate Counts and *Enterobacteriaceae* (McEvoy *et al.*, 2004; Ramoneda *et al.*, 2013; Zweifel *et al.*, 2005, 2008, 2014). *Salmonella* spp. have also been recommended and are used as hygiene indicators (Anon, 2005; Delhalle *et al.*, 2008; Nyamakwere *et al.*, 2016). *Staphylococcus aureus*, the third most important cause of food-borne diseases in the world, is as indicator of personal hygiene (Normanno *et al.*, 2005; Osés *et al.*, 2012a; Vázquez-sánchez *et al.*, 2012). It is therefore important to generate information that can be used to develop slaughterhouse specific prerequisite programs for the each slaughterhouses. The specific objective of this chapter was therefore to assess the microbial contamination of carcasses, personnel and mechanical equipment at various slaughter stages in SME slaughterhouses located within Nairobi County and its environs.

6.1.1. Main activities

1. Compare the contamination of carcasses at different slaughter stages in SME slaughterhouses located within Nairobi County and its environs
2. Compare the contamination of personnel hands at different slaughter stages in SME slaughterhouses located within Nairobi County and its environs
3. Compare the contamination of personnel clothes at different slaughter stages in SME slaughterhouses located within Nairobi County and its environs
4. Compare the contamination of cutting equipment at different slaughter stages in SME slaughterhouses located within Nairobi County and its environs
5. Compare the contamination of hooks at different slaughter stages in SME slaughterhouses located within Nairobi County and its environs

6.1. Materials and methods

6.1.1. Description of the SME slaughterhouses and their slaughter processes

This study was carried out in February to March 2016 in five SME slaughterhouses located in Nairobi County and its Environs. Four slaughterhouses (S1-S4) slaughter both cattle and shoats, but on different processing lines that are physically separated. Slaughterhouse S5 slaughters cattle only. On average, carcasses slaughtered in S1, S2, S3, S4 and S5 per day are 70, 100, 80, 20 and 30, while the number of workers who work specifically on the beef were 35, 50, 40, 15 and 25, respectively. In each of the slaughterhouse, slaughter operations are performed on two separated areas where operations are either ground or aerial (Table 6.1). Ground operations are performed in one common area near the stunning box. The aerial operations are performed on two separate lines. Immediately after stunning, the cattle are exsanguinated on the floor for about three minutes, the head and hooves are removed. The cattle are manually pre-skinned whereby incisions are made along the flank, legs, brisket and neck. Hind and fore legs are separated at the tarsal and carpal joints, respectively. On average, the process takes five minutes. The pre-skinned animals are shackled on both hind legs then hoisted onto rails. On the rails, the skin is manually removed using a downward operation. Evisceration, which involves opening of the gut with a knife and brisket with a *panga* (splitting-knife) and removal of gut and thoracic viscera, is the performed. This process takes about five minutes. Carcasses are then split manually with a *panga* into two in about three minutes. Each half of the carcass is washed, trimmed and inspected by a veterinary officer then stamped. The sides are then weighed ready for sale. Only in slaughterhouse S5 are some carcasses chilled for 24 hours before sale. The other slaughterhouses lack chillers hence all carcasses are sold. The flow diagram of the process is shown in Figure 6.1.

Table 6.1 Slaughter stages in Small and Medium Enterprise Slaughterhouses

Type of operations	Processing stage
Ground operations	Lairage
	Captive bolt stunning
	Sticking and bleeding
	Removal of head and legs
	Manual pre-skinning of all legs, flank, neck and rump
Aerial operations	Shackling of hind legs and hoisting
	Manual removal of skin in a downward operation
	Evisceration; opening of the gut with a knife and brisket with a *panga* (machete), freeing of bung, removal of gut and thoracic viscera
	Carcass splitting with a *panga*
	Carcass washing (use of cloth dipped in cold water)
	Trimming
	Meat inspection and stamping
	Carcass weighing and selling

6.1.2. Sampling

Samples were collected from personnel clothes and hands, cutting equipment and carcasses at three potential contamination points (flaying, evisceration, splitting). Carcasses were sampled at an extra potential contamination point (sales area). These potential contamination points were designated PCP1-PCP4 (Table 6.2). At each PCP, three samples per personnel clothes and hands, cutting equipment, hooks and carcasses were sampled. Each of the sample was obtained using sterile cotton swab-sticks pre-moistened with buffered peptone water (Merck, Germany). The sticks swabbed a predetermined surface area (Table 6.2) defined by a sterilized (70% ethanol between uses and air dried) steel template (Opiyo *et al.*, 2013; Pearce and Bolton, 2005). Samples from each area were collected by rolling the cotton 10 times in the horizontal and 10 times in the vertical direction. Per sampling location, a different swab stick was used. Each carcass samples were obtained by swabbing four locations (neck, brisket, flank, and rump) using four different sponge swabs sticks. Knives/*panga* were sampled on each side of the blade using two different swabs sticks. For the personnel hands, each hand was sampled using a different sponge swabs sticks while their clothes were sampled at four sites using four different sponge swabs sticks; the extreme length of left and right sleeves and left and right front parts along the waist. Different swab sticks per sample were pooled together into a bottle containing 10 ml buffered peptone water, placed into a cool box containing ice packs and transported to the laboratory for analysis.

Table 6.2 Sampling protocol in surveyed Small and Medium Enterprise Slaughterhouses

Potential contamination point	**Sampling location**	**Area per sample (cm^2)**	**Samples per PCP (*N*)**
PCP1, PCP2, PCP3, PCP4	Carcass	100	3
PCP1, PCP2, PCP3	Hands	25	3
PCP1, PCP2, PCP3	Clothes	50	3
PCP1, PCP2,	Knives	10	3
PCP3, PCP4	Hooks	10	3
PCP3	*Panga*	25	3

6.1.3. Microbial analysis

Each of the pooled sample was homogenized using a vortex mixer. Suspension were serial diluted in buffered peptone water (Merck, Germany). Samples were analysed for hygiene indicators as shown in Table 6.3. From each of the three highest dilutions, 0.1 ml was spread plated on plate count agar violet red bile dextrose agar and Baird-Parker agar supplemented with 20% sterile egg-yolk tellurite emulsion (Merck, Germany) for aerobic plate counts (APC)

Eteroacteriaceae and *S. aureus*, respectively. Violet red bile dextrose and Baird-Parker agar plates were incubated aerobically for 24 hours at 37 °C while plate count agar plates were incubated for 48 hours at 37 °C. Salmonella *spp*. were analyzed using a chromogenic rapid method (Ossmer, 1992; Rambach, 1990). From the homogenised sample, 1 ml was suspended in 9 ml of Salmosyst® Broth Base (Merck, Germany) and incubated for 8 hours at 35 °C. After incubation, one tablet of Salmosyst® Selective Supplement was added to the 10 ml of the preliminary enrichment culture and left to stand for 30 minutes. The suspension was then mixed using a vortex mixture and then incubated for further 22 hours at 35 °C. *Salmonella* spp. were detected by streaking a sample of the resulting enrichment culture onto Rambach® Agar (Merck, Germany). Resulting red colonies were identified as *Salmonella* spp.

6.1.4. Data analysis and interpretation

Data was analysed using SPSS version 23.0 (IBM Corp., 2015). The counts of all microbial contaminants were transformed to log10 cfu cm^{-2}. Mean logs ($\bar{x}$) and standard deviations (s) of each were calculated per PCP. Statistical difference among the mean level contamination of carcasses, personnel hands and personnel clothes were determined by one-way ANOVA (p=0.05) while statistically significant means were separated using Duncan's means separation technique. Statistical output for the ANOVA analysis of carcasses, personnel hands and personnel clothes are shown in Appendix 13, Appendix 14 and Appendix 15, respectively. Statistical difference among the mean level contamination of knives and hooks were determined by Student T-test (p=0.05). The statistical output for the T-test analysis of the knives and hooks are shown in Appendix 16 and Appendix 17, respectively. The data on each PCP was interpreted using Table 6.3. Microbial contamination of carcasses was interpreted using EU Regulation 2073/2005 (Anon, 2005). The under limit (m) and upper limit (M) for APC were 2.5 log cfu/cm^2 and 5.0 log cfu/cm^2, respectively. The m and M for *Enterobacteriaceae* were 1.5 log cfu/cm^2 and 2.5 log cfu/cm^2, respectively. The criteria for *Salmonella* spp. was absence in the sampled area.

The limit for *S. aureus* on personnel was interpreted using a Standard from Laboratory of Food Microbiology and Food Preservation, Ghent University (Uyttendaele *et al.*, 2010), where the limit was <2.0 log cfu/cm^2. In the case of APC, *Enterobacteriaceae* and *Salmonella* spp. on personnel and equipment, microbial contamination was unacceptable if it was equal or higher as the microbial contamination on beef carcass at the same PCP (Osés *et al.*, 2012b; Uyttendaele *et al.*, 2010). In that case, the limiting criterion was 5.0 log cfu/cm^2 for APC, 2.5 log cfu/cm^2 for *Enterobacteriaceae* and absent for *Salmonella* spp.

Table 6.3 Regulatory criteria and microbiological guidelines for interpretation of results

Sample	Hygiene indicator	Microbiological Criteria	Reference
Carcass	Aerobic plate counts	M=3.5 log cfu/cm^2 M=5.0 log cfu/cm^2	EU* Regulation (Anon, 2005)
	Enterobacteriaceae	m =1.5 log cfu/cm^2 M=2.5 log cfu/cm^2	EU Regulation (Anon, 2005)
	Salmonella spp.	Absent in the area tested	EU Regulation (Anon, 2005)
Personnel	*S. aureus*	<2.0 log cfu/cm^2	(Uyttendaele *et al.*, 2010)
	Aerobic plate counts, *Enterobacteriaceae*	Surfaces whose microbial contamination is equal to or higher than that present in the meat at the same PCP are considered unacceptable	(Osés *et al.*, 2012b)
	Salmonella spp.	Absent in the area tested	(Uyttendaele *et al.*, 2010)
Equipment	Aerobic plate counts, *Enterobacteriaceae*	Surfaces whose microbial contamination is equal to or higher than that present in the meat at the same PCP are considered unacceptable	(Osés *et al.*, 2012b)
	Salmonella spp.	Absent in the area tested	(Uyttendaele *et al.*, 2010)

*European Union

6.2. Results

6.2.1. Contamination of carcasses

The level of contaminants on beef carcasses is shown in Table 6.4. The mean ±SD log cfu/cm^2 values of APC on carcasses ranged from 2.58 ±0.31 to 4.50 ±0.51. In all the slaughterhouses, the values were within marginally acceptable limits but increase from flaying towards dispatch ($p<0.05$). The values of *Enterobacteriaceae* ranged from 0.79 ±0.31 to 2.65 ±0.12. In S1 and S2, the values were statistically similar in all stages ($p>0.05$) but were unacceptable at evisceration. In S3, S4 and S5 the values increased towards the last slaughter stages ($p<0.05$), but the level was within marginally acceptable limits. Similarly, the prevalence of *Salmonella* spp. was highest in S1 and S2 (prevalence =25.00%, each). In S2, the prevalence was 16.67% while no *Salmonella* spp. were detected in S4 and S5.

6.2.2. Contamination of hands

The level of contaminants on personnel hands is shown in Table 6.5. The mean ±SD log cfu/cm^2 values of APC and *S. aureus* on meat handlers at different slaughter stages ranged from 2.75 ±0.39 to 5.26 ±0.35 and 0.59 ±1.03 to 4.06 ±0.26, respectively. The values of *Enterobacteriaceae* ranged from 0.20 ±0.17 to 2.02 ±0.40. The levels of the three contaminants decreased towards splitting (p<0.05). In S4, slaughter stage did not significantly influence the contamination level (p>0.05). At flaying, the values were unacceptable for both APC in S2 and for *S. aureus* in S1 and S2. At evisceration, the values were unacceptable for *S. aureus* in S2. The level of contamination by *Enterobacteriaceae* was acceptable in all slaughterhouses and stages. No *Salmonella* spp. was detected in any of the personnel hands.

Table 6.4 Level of contamination of beef carcasses with hygiene indicators

		Slaughter stage			
Hygiene indicator	Slaughterhouse	Flaying	Evisceration	Splitting	Dispatch
Aerobic plate counts	S1**	2.58 ±0.31^a	4.37 ±0.35^b	3.45 ±0.46^b	4.50 ±0.51^c
	S2**	3.59 ±0.08^a	4.06 ±0.18^c	4.19 ±0.31^b	3.75 ±0.18^a
	S3**	3.27 ±0.45^a	3.07 ±0.37^a	4.21 ±0.37^b	4.01 ±0.22^b
	S4**	2.70 ±0.34^a	3.90 ±0.06^b	4.01 ±0.04^b	3.38 ±0.74^{ab}
	S5**	3.00 ±0.08^a	3.45 ±0.56^{ab}	3.83 ±0.27^b	4.01 ±0.23^b
Enterobacteriaceae	S1*	1.29 ±0.14^a	**2.65 ±0.12^a**	1.62 ±0.97^a	1.74 ±0.77^a
	S2*	1.89 ±0.01^a	**2.64 ±0.24^a**	2.37 ±0.63^a	2.20 ±0.72^a
	S3**	1.30 ±0.11^b	0.79 ±0.31^a	1.64 ±0.13^c	1.00 ±0.07^{ab}
	S4**	0.80 ±0.07^a	1.60 ±0.33^b	1.83 ±0.12^b	1.50 ±0.42^b
	S5**	1.20 ±0.39^a	1.70 ±0.09^b	1.88 ±0.12^{bc}	2.15 ±0.17^c

Note: value in **bold** indicate unacceptable level of contamination.
Values with different alphabets across a row are statistically different at p=0.05
*/** Mean log cfu/cm^2 at different slaughter stages was statically similar/different at p=0.05

Table 6.5 Level of contamination of personnel hands with hygiene indicators

Hygiene indicator	Slaughterhouse	Slaughter stage		
		Evisceration	Flaying	Splitting
Aerobic plate counts	S1**	4.77 ±0.26[c]	3.62 ±0.21[b]	2.75 ±0.39[a]
	S2**	**5.25 ±0.22[b]**	4.84 ±0.28[ab]	4.09 ±0.55[a]
	S3**	**5.26 ±0.35[c]**	4.60 ±0.24[b]	3.70 ±0.32[a]
	S4*	4.34 ±0.38[a]	4.15 ±0.44[a]	3.81 ±0.54[a]
	S5**	4.79 ±0.29[c]	4.11 ±0.22[b]	3.23 ±0.34[a]
S. aureus	S1**	**2.02 ±0.69[b]**	1.26 ±1.10[ab]	0.59 ±0.13[a]
	S2**	**3.06 ±0.26[c]**	**2.40 ±0.17[b]**	1.67 ±0.11[a]
	S3**	1.67 ±0.11[b]	1.64 ±0.11[b]	1.33 ±0.17[a]
	S4*	1.52 ±0.38[a]	1.36 ±0.40[a]	1.33 ±0.06[a]
	S5**	1.60 ±0.02[b]	1.38 ±0.16[b]	0.96 ±0.42[a]
Enterobacteriaceae	S1**	0.87 ±0.14[b]	0.40 ±0.45[ab]	0.20 ±0.17[a]
	S2**	2.02 ±0.40[b]	1.58 ±0.37[ab]	0.97 ±0.36[a]
	S3**	1.37 ±0.19[b]	0.88 ±0.07[ab]	0.57 ±0.01[ab]
	S4**	1.74 ±0.09[b]	1.40 ±0.15[b]	0.68 ±0.03[a]
	S5*	1.80 ±0.08[a]	1.39 ±0.19[a]	1.00 ±0.07[a]

Note: value in **bold** indicate unacceptable level of contamination.
Values with different alphabets across a row are statistically different at p=0.05
*/** Mean log cfu/cm^2 at different slaughter stages was statically similar/different at p=0.05

6.2.3. Contamination of clothes

The level of contaminants on personnel clothes is shown in Table 6.6. The mean ±SD log cfu/cm^2 values of APC on clothes ranged from 3.05 ±0.43 to 5.30 ±0.19 and were within acceptable limits in all slaughterhouses and stages. However, the values in S2 and S4 were significantly higher at evisceration and flaying than at splitting ($p<0.05$). The values of *S. aureus* ranged from 1.00 ±0.63 to 3.43 ±0.69. The values were unacceptable in S2-S5 at flaying and in S3 at evisceration. In these slaughterhouses the values decreased from flaying to splitting ($p<0.05$). The values of *Enterobacteriaceae* ranged from 0.34 ±0.29 to 1.96 ±0.05, did not differ significantly with slaughter stage ($p>0.05$) and were within acceptable limits. *Salmonella* spp. were detected only in S2 (prevalence = 11.11%).

Table 6.6 Level of contamination of personnel clothes with hygiene indicators

Hygiene indicator	Slaughterhouse	Slaughter stage Flaying	Evisceration	Splitting
Aerobic plate counts	S1*	3.23 ±1.29[a]	3.58 ±0.52[a]	4.53 ±0.40[a]
	S2**	4.92 ±0.80[b]	4.00 ±0.44[b]	3.05 ±0.43[a]
	S3*	4.45 ±1.00[a]	5.30 ±0.19[a]	4.77 ±0.69[a]
	S4**	4.40 ±0.55[b]	4.41 ±0.50[b]	3.26 ±0.58[a]
	S5*	4.21 ±0.46[a]	3.43 ±0.72[a]	4.45 ±0.70[a]
S. aureus	S1*	1.00 ±0.63[a]	1.23 ±0.14[a]	1.35 ±0.48[a]
	S2**	**3.43 ±0.69[b]**	1.75 ±0.44[a]	1.88 ±0.27[a]
	S3**	**2.68 ±0.18[b]**	**2.89 ±0.32[b]**	1.93 ±0.06[a]
	S4**	**3.15 ±0.69[b]**	1.95 ±0.06[a]	1.66 ±0.17[a]
	S5**	**3.14 ±0.61[b]**	1.81 ±0.25[a]	1.62 ±0.23[a]
Enterobacteriaceae	S1*	0.34 ±0.29[a]	1.20 ±1.06[a]	1.74 ±1.56[a]
	S2*	1.41 ±1.42[a]	1.34 ±1.17[a]	0.49 ±0.50[a]
	S3*	1.01 ±0.24[a]	0.98 ±0.09[a]	1.23 ±0.26[a]
	S4*	1.90 ±0.02[a]	1.96 ±0.05[a]	1.06 ±0.90[a]
	S5*	1.81 ±0.26[a]	1.89 ±0.07[a]	1.28 ±1.26[a]

Note: value in **bold** indicate unacceptable level of contamination.
Values with different alphabets across a row are statistically different at p=0.05
*/** Mean log cfu/cm^2 at different slaughter stages was statically similar/different at p=0.05

6.2.4. Contamination of cutting equipment

The level of contaminants on cutting equipment is shown in Table 6.7. The mean ±SD log cfu/cm^2 values of APC on knives and *panga* ranged from 2.72±0.56 to 4.76±0.23. In S2 and S3 the values were significantly higher at flaying than at evisceration ($p<0.05$). The values of *Enterobacteriaceae* on the knives ranged from 0.07±0.05 to 1.71±0.33. In S3, the values were significantly higher at flaying than at evisceration ($p<0.05$). The values of APC and *Enterobacteriaceae* on *panga* at splitting ranged from 2.27 ±0.19 to 3.38 ±0.07 and 0.22 ±0.07 to 2.58 ±0.12, respectively. No *Salmonella* spp. were detected in any of the cutting equipment in all the slaughterhouses. The level of contamination by all the three contaminants was also within acceptable limits.

Table 6.7 Level of contamination of cutting equipment with hygiene indicators

			Slaughter stage		
Hygiene indicator		Slaughterhouse	Flaying	Evisceration	Splitting
Aerobic plate counts	Knives	S1*	4.28 ±0.64	3.47 ±0.61	
		S2**	3.81 ±0.31	4.76 ±0.23	
		S3**	4.22 ±0.64	2.72 ±0.56	
		S4*	4.12 ±0.64	3.43 ±0.42	
		S5*	3.54 ±0.37	4.14 ±0.39	
	Panga	S1			2.27 ±0.19
		S2			3.53 ±0.68
		S3			3.38 ±0.07
		S4			3.38 ±0.07
		S5			3.75 ±0.68
Enterobacteriaceae	Knives	S1*	0.17 ±0.09	0.96 ±0.02	
		S2*	1.14 ±1.00	1.71 ±0.33	
		S3**	0.07 ±0.05	0.84 ±0.24	
		S4*	0.71 ±0.07	0.68 ±0.20	
		S5*	0.55 ±0.07	0.98 ±0.02	
	Panga	S1*			1.67 ±0.47
		S2**			1.14 ±0.05
		S3**			1.66 ±0.26
		S4*			1.69 ±0.07
		S5*			1.72 ±0.12

*/** Mean log cfu/cm^2 at different slaughter stages was statistically similar/different at p=0.05

6.2.5. Hooks contamination

The level of contaminants on hooks is shown in Table 6.8. The average contamination of carcasses by APC and *Enterobacteriaceae* at different stages ranged from 2.35 ±0.34 to 4.00 ±0.57 and 0.18 ±0.23 to 1.58 ±0.32, respectively. The level of contamination did not significantly differ with slaughter stage in each of the slaughterhouses (p>0.05). No *Salmonella* spp. were detected in any of the slaughterhouses. The level of contamination by all the three contaminants was within acceptable limits.

Table 6.8 Level of contamination of hooks with hygiene indicators

Hygiene indicator	Slaughterhouse	Slaughter stage	
		Splitting	Dispatch
Aerobic Plate Counts	S1*	2.36 ±0.61	2.35 ±0.34
	S2*	3.35 ±0.36	2.73 ±0.48
	S3*	4.00 ±0.57	3.39 ±0.31
	S4*	3.85 ±0.49	3.67 ±0.52
	S5*	3.67 ±0.55	3.67 ±0.52
Enterobacteriaceae	S1*	0.35 ±0.29	0.18 ±0.23
	S2*	1.58 ±0.32	0.78 ±0.83
	S3*	0.20 ±0.26	0.25 ±0.39
	S4*	0.59 ±0.02	0.36 ±0.18
	S5*	0.38 ±0.11	0.42 ±0.27

* Mean log cfu/cm^2 at different slaughter stages was statistically similar at p=0.05

6.3. Discussion

The microbiological analyses of carcasses showed that contamination at flaying was considerably lower for all hygiene indicators. The low counts at this stage may be expected because meat is initially sterile (Petruzzelli *et al.*, 2016). However, the microbial load observed at this stage was hardly acceptable. Contamination may have come from environmental contaminants including hide, hands and knives (Koutsoumanis *et al.*, 2005; Oto *et al.*, 2013). At evisceration, the microbial load increased significantly and was not within acceptable limits. Together with flaying, evisceration are regarded as critical control points during slaughter, hence require to be monitored (Buncic *et al.*, 2014; Tergney and Bolton, 2006). Increased in microbial load counts may indicate poor evisceration process. Normally, poor incisions leak the intestinal content onto carcasses (Koutsoumanis *et al.*, 2005).

There was hardly a significant increase in microbial load between evisceration and splitting. This is because carcass splitting stage is not considered as a major source of contamination (Wong *et al.*, 2002). The observations may also results from changes during slaughter operations. In the surveyed SME slaughterhouses, carcass were raised onto conveyors for splitting, therefore reducing contact between the floor and the carcass. In addition, carcass splitting unlike the previous operations is done by one person therefore reducing the cross contamination from personnel. At dispatch, different there was no clear pattern of contamination. In all slaughterhouses, cold water was used to clean the carcasses. Cold water, unlike water at 74 °C, is an ineffective medium for reducing microbial loads and yields rather redistributions of contaminants from more highly contaminated areas (Bosilevac *et al.*, 2006; Spescha *et al.*, 2006; Zweifel *et al.*, 2014). This may explain instances where contamination either increased or remained the same as previous stages. Carcass trimming on the other hand can be used to explain decrease in contamination. When correctly done, trimming can remove a substantial amount of contaminants especially the *Enterobacteriaceae* that have been shown to be present on trimmings (Carney *et al.*, 2006).

Results in Table 6.4 show that hands contamination was generally higher at flaying and evisceration than at splitting. This further emphasizes on the significance of flaying and evisceration stages and the low risk posed at splitting stage. The high microbial counts on hands are indicative of poor hand washing practices at the two initial stages. Poor hand washing practices may be supported from observations made in the all the slaughterhouses. Hand washing facilities were located far from these two stages. Even where such facilities were present, they were supplied with cold water and no soap. Substantial reduction of the microbial load on hands requires that the hands are washed with soaps, detergents, and antimicrobial compounds (Todd *et al.*, 2010). This favours dirt accumulation on the hands. In addition, in each of the slaughterhouse, hide removal was done manually and partly on the floor. The flayers' hands are therefore in direct contact with the hide, which have been shown to have high microbial loads (Serraino *et al.*, 2012). This further favours both contamination of the hands and dirt accumulation. Therefore, personnel at flaying and evisceration may be potential carriers of pathogens, and can be a risk factor for cross contamination of beef with the pathogens. Food handlers are regarded as potential carriers of pathogens and shed about more than $1x10^3$ viable micro-organisms per minute (Frazier and Westhoff, 1988; Opiyo *et al.*, 2013).

Similar to hands contamination, APC and *S. aureus* were highest at evisceration and flaying (Table 6.5). Given that a dirty working environment easily contaminates the clothes (Todd *et al.*, 2010), this may indicate that these two stages are performed in a dirty environment. Protective clothing determine the quality of the working environment (Nel *et al.*, 2004), where dirty clothes may be associated with a dirty environment. This would normally be expected given that evisceration and flaying were performed on the ground. Due to the high risk of the slaughterer process, food handlers are required to wear protective clothing (WHO, 2006). It is however evident that the protective clothes worn in the slaughterhouses, especially at the two initial stages may contribute to the risk of microbial contamination, further show the importance of the two stages. It is recommended that when working with raw meat, the clothes be changed at appropriate intervals (Hayes and Forsythe, 1999). Inadequacy in these practices may lead to further accumulation of dirt increasing the risk of cross-contamination of beef.

From Table 6.6 the cutting equipment were identified as another potential source of contamination during slaughter. Where the contamination of knives varied between flaying and evisceration, the latter showed less level of contamination. During flaying, the knife may be passed over faecal matter present on the hide which can be transferred to the carcass beneath the incision (Koutsoumanis *et al.*, 2005; Tergney and Bolton, 2006). In addition, knives have surfaces that are easy to clean (Hutchison *et al.*, 2007), but infrequent sterilization during operations often because of lack of sterilization facilities may results to accumulation of microbial contaminants (Barros *et al.*, 2007; Fasanmi *et al.*, 2010; Niyonzima *et al.*, 2015). Highly contaminated equipment can increase contamination of meat and knives are particularly important (Martínez-Chávez *et al.*, 2015; Metaxopoulos *et al.*, 2003). Hide contamination and carcass contamination may be therefore be a cause of high microbial load during flaying. Equipment used to split carcasses are an important source of *Enterobacteriaceae* (Stiles and Ng, 1981), and this was evident in the microbial contamination of the splitting knife. On the other hand practices such as leaving hooks on the floor may result in high microbial load of the hooks (Barros *et al.*, 2007). However, low microbial contamination of hooks than previously reported (Barros *et al.*, 2007) may indicate that such practices was absent in the slaughterhouses the present study. Nevertheless, hooks contact with carcasses is restricted to the hind quarters (Barros *et al.*, 2007). The observed contamination may pose a risk to these specific parts of the carcass.

One of the entry points for *Salmonella* spp. in the food value chains is the slaughterhouses (Wong *et al.*, 2002). Many sources of contamination have been identified during carcass processing (Delhalle *et al.*, 2008). In the present study, *Salmonella* spp. contamination was primarily on carcasses. Absence of Salmonella from other samples may indicate that the source of contamination originated from the animals themselves. On the other hand, the analysis showed that carcasses that were contaminated with *Salmonella* spp. had relatively high levels of APC and *Enterobacteriaceae*. A positive correlation between these microbial contaminants and Salmonella *spp*. has been reported (Corbellini *et al.*, 2016; Delhalle *et al.*, 2008). Therefore, the presence of the Salmonella can be linked with high microbial load on the carcasses. Out of the 60 carcasses sampled presently, the prevalence of Salmonella spp. was 13.33%. Compared to a prevalence of 42.7% reported in Senegal (Niyonzima *et al.*, 2015), the present prevalence is considerably lower than the 0.20% and 6.00% reported in Australia and Mexico, respectively (Niyonzima *et al.*, 2015). Due to the seriousness of Salmonellosis, this poses a serious food safety concern of the meat supplied by some of the SME slaughterhouses.

6.4. Conclusion and recommendations

Contamination of carcasses, workers and mechanical equipment with hygiene indicators highlights poor hygiene at slaughter of beef in local SME slaughterhouses. Flaying and evisceration are particularly important CCPs for contamination. Unacceptable levels of APC, *Enterobacteriaceae* and *S. aureus* illustrate this. Because of contamination at the various stages, all carcasses dispatched from the slaughterhouses are just but within the marginally acceptable limits. To attain the acceptable limits, development and implementation of standard slaughter operations and slaughterhouses specific prerequisite programs will be critical. These might include, but not limited to use of off-the-ground operations, separation of flaying and evisceration operations and improved hygienic and sanitation practices. Priority should be given to flaying and evisceration stages.

Chapter 7. General Discussion, Conclusion and Recommendations

7.1. Background

This dissertation provided for the first time potential pre-slaughter and slaughter risk factors for beef post-harvest loss. These factors represent the critical control points where if no intervention is made, post-harvest losses of beef may occur with negative spill-over effects for the beef sector in Kenya. These losses may be attributed to quality losses, such as high ultimate pH, DFD meat and meat with blemishes. They may also be attributed to microbial contamination that may result in meat spoilage or foodborne diseases.

The major pre-slaughter practices that may affect post-harvest losses of meat include livestock transportation and marketing while slaughter factors include hygiene and sanitation practices and good manufacturing practices during slaughter. Each of these practices was studied in this dissertation to identify the areas that require intervention and therefore form a basis for future quality protocols. The focus of this dissertation was on the SME slaughterhouses because they supply majority of the meat that is consumed in Kenya. In this chapter, the main findings are discussed with respect to objectives formulated in Chapter 1. The chapter ends with conclusions and recommendations.

7.2. Main findings

7.2.1. Design of trucks used to transport cattle in Kenya's pastoral areas

Trucking is one of the major means of cattle transportation from Kenya's pastoral areas to the main terminal markets. This is attributed to the fact that is fast and overcomes challenges of trekking (the other main means of cattle transportation) such as cattle rustlers and hunger and thirst due to lack of feed and water along the trekking routes. Trucking thus improves the marketing efficiency of the cattle, which makes the design of the trucks important. However, only a few specialized vehicles for animal transportation are generally unavailable in most African countries and animals are therefore transported in ordinary trucks (Steinfeld *et al.*, 2006)(Bulitta *et al.*, 2012). In order to evaluate the design of trucks used to transport cattle in Kenya, truckers in six livestock markets were interviewed and observations of the trucks were made in Chapter 3. Five design features of the trucks based on the responses of the truckers was compared among the markets. Trucks in Isiolo, Moyale and Marsabit markets had better design features than in Kajiado, Narok and Maralal. The main reason could be that they are located along the major livestock route. This can therefore mean that each livestock route is associated with specific design features. The cattle mortality during trucking was reported to be 6.16% and did not differ significantly with individual livestock market. In addition, the mortality did not differ significantly with four of the design features. These results can be attributed to the lack of compartments in all the trucks studied. Compartments, which are a key design feature of animals transport vehicles, protect animals from the movement of the vehicle and prevents fighting among the animals (Lapworth, 2008; Southern *et al.*, 2006). Lack of the compartments may have resulted in a lack of support system for the animals during trucking.

7.2.2. Animal welfare knowledge, attitude and practices of stockpeople

Stockpeople play a key role in animal welfare, hence meat quality. Their interaction with animals can influence animal welfare either negatively or positively. Their personal attributes such as knowledge and attitude will determine their practices. The practices will in turn determine the welfare and/or meat quality of the animal being handled. However as previously stated, the stockpeople are rarely considered for animal welfare research (Hemsworth and Coleman, 2011). In developing countries, where Kenya is also grouped, animals are transported for thousands of kilometres in inhumane conditions (Rahman, 2004). These conditions can be attributed to the human-animals interaction of the stockpeople. However, these interactions have not been adequately investigated in Kenya. In Kenya, inhumane pre-slaughter practices have a major impact on the meat quality in SME slaughterhouses and hence majority of the meat in the country because the SME slaughterhouses supply more than half of the meat consumed locally. In order to assess the knowledge, attitudes and practices of stockpeople in Kenya, stockpeople in six markets in the pastoral areas and four in Nairobi County and its environs were interviewed. Personal determinants of the knowledge, attitudes and practices were also determined. From the study, there was declining trend: knowledge > attitude > practice. Therefore, although the stockpeople were knowledgeable in animal welfare issues, their practices were poor. This could be attributed to fact that their level of attitude was lower than their knowledge. Attitude has a higher influence on personal behaviour that knowledge (Macias and Glasauer, 2014). A comparison between demographic characteristics may also explain the results. For example, about 95% of the stockpeople were males. On gender basis, the males had a negative attitude and poor practices than females even though their level of knowledge was statistically similar. In addition, the proportion of old age stockpeople was lower than the middle aged and young stockpeople despite them having higher level of knowledge, positive attitude and good practices. Therefore, differences in demographic characteristics of Kenyan stockpeople may have a major influence on not only the knowledge and attitude of the stockpeople but also their practices.

7.2.3. Sanitation and hygiene practices in SME Slaughterhouses

All workers in a food-handling area are expected to maintain a high degree of cleanliness of their hand, body and clothing, and wear suitable, clean and, where necessary, protective clothing in order to ensure food safety and public health (Nee and Sani, 2011). Personal hygiene of food workers contribute significantly to outbreak and transmission of foodborne illnesses (Assefa *et al.*, 2015). Meat and meat products are of particular importance regarding foodborne illnesses (Ansari-Lari *et al.*, 2010). Personal hygiene practices of meat handlers (MH) are therefore a prerequisite for safe food products (Jianu and Goleţ, 2014). In Kenya, a big percentage of consumers consume beef supplied by Small and medium enterprises (SMEs) slaughterhouses, where MH have poor hygiene and sanitation practices (Farmer and Mbwika, 2012). As a result, the risk of foodborne illnesses from contaminated meat is considerably high. In order to assess the hygiene and sanitation practices in SME slaughterhouses, MH in five SME slaughterhouses in Nairobi County and its environs were interviewed. The association between the practices and demographic characteristics of the MH was also assessed. From the survey, it was reported than majority of MH wash their hands. However, only a few of them use soap or disposable towels during hand washing. The practice of hand washing maybe attributed to the fact that each of the SME slaughterhouse had at least one tap with running water. However, the lack of soap use can be attributed to other production processes in the slaughterhouses. Some of these include Biogas production where the workers cited that use of soap lowers the efficiency of the biogas production. The MH however had good practices regarding personal clothing, which may be attributed to high surveillance by the veterinary officers in charge. In addition, the high frequency of MH who wore clean protective clothing may be attributed to the high number of women who offer laundry services near the slaughterhouses for a small fee.

7.2.4. Microbial contamination of carcasses, personnel and equipment in SME slaughterhouses

Given that meat and meat products contain most of the nutrients required to support microbial growth, they are of particular important regarding foodborne illnesses and spoilage. It is therefore important to prevent microbial contamination of the meat. The best point of action is during slaughter. The fundamental principle of controlling microbial contamination during slaughter is based on sanitary and hygienic processes (Buncic and Sofos, 2012). This required that the slaughter process be assessed to give an overall performance of the slaughter process. Chapter 6 therefore assessed the microbial contamination of beef carcasses, personnel and equipment at various points of slaughter. The assessment revealed that carcasses contamination increased from flaying to dispatch. This may be attributed to the poor preliminary slaughter operations that take place on the ground operation. Continuous ground operations lead to accumulation of dirt and hence micro-organisms that are then transferred to the carcass. The results further revealed that personnel and cutting equipment were more contaminated at flaying and evisceration, which may also be attributed to ground operations and poor personal hygiene practices.

7.3. Conclusion

From the study, it can be concluded that lack of special compartments in local trucks leads to cattle mortality during transportation. In addition, the practices of the stockpeople with regards to animal welfare are poor. This stems from low knowledge and poor attitude towards animal welfare practices. In the slaughterhouse, poor hand washing practices are rampant and may contribute to contamination of personnel clothes and hands, cutting equipment and hence beef carcasses. These therefore represent major factors that can result to post-slaughter beef quality loss.

7.4. Recommendation

A major training campaign drive is required along the entire cattle value chain. This training should seek to improve the knowledge and attitude of stockpeople with regards to animal welfare and knowledge and attitude of meat handlers in SME slaughterhouses. Improved knowledge and attitude will have a positive impact on the practices of both stockpeople and meat handlers thus prevent quality losses of beef. Furthermore, major design flaws that were identified in the present study need to be converted. These include compartment for the animal transportation trucks in the pre-slaughter stage. In the slaughter stage, the flaying and evisceration process should be physically separated. In addition, mechanism to ensure that these processes are carried out off the ground will reduce microbial contamination of beef carcasses.

References

Ababio, P.F. and Lovatt, P., 2015. A review on food safety and food hygiene studies in Ghana. Food Control 47: 92–97.

Ababio, P.F., Taylor, K.D.A., Swainson, M. and Daramola, B.A., 2016. Effect of good hygiene practices intervention on food safety in senior secondary schools in Ghana. Food Control 60: 18–24.

African Development Bank, 2011. African Economic Outlook 2011 Africa and its Emerging Partners: Africa and its Emerging Partners. 308 pp.

Ajala, A.R., Cruz, A.G., Faria, J.A.F., Walter, E.H.M., Granato, D. and Sant, A.S., 2010. Food allergens : Knowledge and practices of food handlers in restaurants. Food Control 21: 1318–1321.

Aklilu, Y., 2002. An audit of the livestock marketing status in Kenya, Ethiopia and Sudan: Volume II: issues and proposed measures. Available at: http://agris.fao.org/agris-search/search.do?recordID=GB2013202225. Accessed August 14, 2015.

Algino, R.J., Ingham, S.C. and Zhu, J., 2007. Survey of antimicrobial effects of beef carcass intervention treatments in very small state-inspected slaughter plants. Journal of Food Science 72: M173–9.

Andrien, M., 1994. Social Communication in Nutrition: A Methodology for Intervention. Food & Agriculture Org., Rome, Italy, 107 pp.

Anon, 2005. Commission Regulation (EC) No. 2073/2005 of 15 November 2005 on microbiological criteria for foodstuffs. Official Journal of the European Union 1–26.

Ansari-Lari, M., Soodbakhsh, S. and Lakzadeh, L., 2010. Knowledge, attitudes and practices of workers on food hygienic practices in meat processing plants in Fars, Iran. Food Control 21: 260–263.

Apple, J.K., Kegley, E.B., Galloway, D.L., Wistuba, T.J. and Rakes, L.K., 2005. Duration of restraint and isolation stress as a model to study the dark-cutting condition in cattle. Journal of Animal Science 83: 1202–14.

Appleby, M.C., 2004. Alternatives to conventional livestock production methods. In: Benson, G.J. and Rollin, B.E. (eds.) Production animal pain and well-being: Theory and practice. Blackwell, Ames, USA, , pp. 339–350.

Arthington, J.D., Eichert, S.D., Kunkle, W.E. and Martin, F.G., 2003. Effect of transportation and commingling on the acute-phase protein response, growth, and feed intake of newly weaned beef calves. Journal of Animal Science 81: 1120–5.

Assefa, T., Tasew, H., Wondafrash, B. and Beker, J., 2015. Community Medicine & Health Education Assessment of Bacterial Hand Contamination and Associated Factors among Food Handlers Working in the Student Cafeterias of Jimma. Journal of Community Medicine and Health Education 5: 1–8.

Ayyagari, M., Demirguc-Kunt, A. and Maksimovic, V., 2011. Small vs. young firms across the world: contribution to employment, job creation, and growth. World Bank Policy Research Working Paper Series. , 1–57.

Azmi, S., 2006. The evaluation of food hygiene knowledge , attitudes , and practices of food handlers Õ in food businesses in Turkey. 17: 317–322.

Bacon, R.T., Belk, K.E., Sofos, J.N., Clayton, R.P., Reagan, J.O. and Smith, G.C., 2000. Microbial populations on animal hides and beef carcasses at different stages of slaughter in plants employing multiple-sequential interventions for decontamination. Journal of Food Protection 63: 1080–1086.

Barros, A.F., Nero, A., Monteiro, A.A. and Beloti, V., 2007. Identification of main contamination points by hygiene indicator microorganisms in beef processing plants. Food Science and Technology 27: 856–862.

Bartoš, L., Franc, C., Rehák, D. and Stípková, 1993. A practical method to prevent dark-cutting (DFD) in beef. Meat Science 34: 275–82.

Behnke, R. and Muthami, D., 2011. The contribution of livestock to the Kenyan economy. IGAD Livestock Policy Initiative.

Bertolini, M., Rizzi, A. and Bevilacqua, M., 2007. An alternative approach to HACCP system implementation. Journal of Food Engineering 79: 1322–1328.

Boerema, J.A., Broda, D.M. and Bell, R.G., 2003. Abattoir sources of psychrophilic clostridia causing blown pack spoilage of vacuum-packed chilled meats determined by culture-based and molecular detection procedures. Letters in Applied Microbiology 36: 406–11.

Boivin, X., Lensink, J., Tallet, C. and Veissier, I., 2003. Stockmanship and farm animal welfare. Animal Welfare 12: 479–492.

Bollerslev, A.M., Nauta, M., Hansen, T.B. and Aabo, S., 2016. A risk modelling approach for setting microbiological limits using enterococci as indicator for growth potential of Salmonella in pork. International Journal of Food Microbiology , doi:10.1016/j.ijfoodmicro.2016.05.007.

Borch, E. and Arinder, P., 2002. Bacteriological safety issues in red meat and ready-to-eat meat products, as well as control measures. Meat Science 62: 381–390.

Bosilevac, J.M., Nou, X., Barkocy-Gallagher, G. a, Arthur, T.M. and Koohmaraie, M., 2006. Treatments using hot water instead of lactic acid reduce levels of aerobic bacteria and *Enterobacteriaceae* and reduce the prevalence of *Escherichia coil* O157:H7 on preevisceration beef carcasses. Journal of Food Protection 69: 1808–13.

Bouri, A., Breij, M., Diop, M., Kempner, R., Klinger, B. and Stevenson, K., 2011. Report on Support to SMEs in Developing Countries Through Financial Intermediaries. Dalberg Global Development Advisors. , 48.

Broom, D.M., 2003. Transport stress in cattle and sheep with details of physiological, ethological and other indicators. Deutsche Tierarztliche Wochenschrift 110: 83–89.

Broom, D.M., 2005. The effects of land transport on animal welfare. Revue Scientifique et Technique (International Office of Epizootics) 24: 683–691.

Broom, D.M., 2010. Animal welfare: an aspect of care, sustainability, and food quality required by the public. Journal of Veterinary Medical Education 37: 83–88.

Bulitta, F.S., Gebresenbet, G. and Bosona, T., 2012. Animal handling during supply for marketing and operations at an abattoir in developing country: the case of Gudar market and Ambo abattoir, Ethiopia. Journal of Service Science and Management 5: 59–68.

Buncic, S., Nychas, G.J., Lee, M.R.F., Koutsoumanis, K., Hébraud, M., Desvaux, M., Chorianopoulos, N., Bolton, D., Blagojevic, B. and Antic, D., 2014. Microbial pathogen control in the beef chain: Recent research advances. Meat Science 97: 288–297.

Buncic, S. and Sofos, J., 2012. Interventions to control Salmonella contamination during poultry, cattle and pig slaughter. Food Research International 45: 641–655.

Byrd-Bredbenner, C., Maurer, J., Wheatley, V., Schaffner, D., Bruhn, C. and Blalock, L., 2007. Food safety self-reported behaviors and cognitions of young adults: results of a national study. Journal of Food Protection 70: 1917–1926.

CAC, 2003. Recommended International code of practie general principles of food hygiene CAC/RCP 1-1969, Rev. 4-2003. Cac/Rcp 1-1969 1–31.

Carbas, B., Cardoso, L. and Coelho, A.C., 2013. Investigation on the knowledge associated with foodborne diseases in consumers of northeastern Portugal. Food Control 30: 54–57.

Carney, E., O'Brien, S.B., Sheridan, J.J., McDowell, D.A., Blair, I.S. and Duffy, G., 2006. Prevalence and level of Escherichia coli O157 on beef trimmings, carcasses and boned head meat at a beef slaughter plant. Food Microbiology 23: 52–59.

Catley, A., 2006. Use of participatory epidemiology to compare the clinical veterinary knowledge of pastoralists and veterinarians in East Africa. Tropical Animal Health and Production 38: 171–184.

Chambers, P.. P. and Grandin, T., 2001. Guidelines for humane handling, transport and slaughter of livestock. RAP Publication (FAO). Food & Agriculture Organization, Rome, Italy, 1-94 pp.

Chevillon, P., 1998. The training of pig-truck drivers. ISAE-98. Clermont-Ferrand: International Society Applied Ethology.

Coleman, G.J. and Hemsworth, P.H., 2014. Training to improve stockperson beliefs and behaviour towards livestock enhances welfare and productivity. Revue Scientifique et Technique (International Office of Epizootics) 33: 131–137.

Coleman, G.J., McGregor, M., Hemsworth, P.H., Boyce, J. and Dowling, S., 2003. The relationship between beliefs, attitudes and observed behaviours of abattoir personnel in the pig industry. Applied Animal Behaviour Science 82: 189–200.

Contento, I., 2010. Nutrition Education: Linking Research, Theory, and Practice. Jones & Bartlett Learning, 444 pp.

Corbellini, L.G., Júnior, A.B., de Freitas Costa, E., Duarte, A.S.R., Albuquerque, E.R., Kich, J.D., Cardoso, M. and Nauta, M., 2016. Effect of slaughterhouse and day of sample on the probability of a pig carcass being Salmonella-positive according to the Enterobacteriaceae count in the largest Brazilian pork production region. International Journal of Food Microbiology 228: 58–66.

Cuprasitrut, T., Srisorrachatr, S. and Malai, D., 2011. Food safety knowledge, attitude and practice of food handlers and microbiological and chemical food quality assessment of food for making merit for monks in Ratchathewi District, Bangkok. Asia Journal of Public Health 2: 27–34.

dalla Costa, O.A., Faucitano, L., Coldebella, A., Ludke, J.V., Peloso, J.V., dalla Roza, D. and Paranhos da Costa, M.J.R., 2007. Effects of the season of the year, truck type and location on truck on skin bruises and meat quality in pigs. Livestock Science 107: 29–36.

Delhalle, L., De Sadeleer, L., Bollaerts, K., Farnir, F., Saegerman, C., Korsak, N., Dewulf, J., De Zutter, L. and Daube, G., 2008. Risk factors for Salmonella and hygiene indicators in the 10 largest Belgian pig slaughterhouses. Journal of Food Protection 71: 1320–1329.

Dickson, J.S. and Anderson, M.E., 1991. Control of Salmonella on beef tissue surfaces in a model system by pre- and post-evisceration washing and sanitizing, with and without spray chilling. Journal of Food Protection International Association for Food Protection, 54: 514.

Dora, M. and Gellynck, X., 2015. House of lean for food processing SMEs. Trends in Food Science & Technology 44: 272–281.

Edge, M.K. and Barnett, J.L., 2009. Development of animal welfare standards for the livestock transport industry: process, challenges, and implementation. Journal of Veterinary Behavior: Clinical Applications and Research 4: 187–192.

EFSA, 2011. Scientific opinion concerning the welfare of animals during transport. EFSA Journal 9: 1– 44.

Egan, M.B., Raats, M.M., Grubb, S.M., Eves, A., Lumbers, M.L., Dean, M.S. and Adams, M.R., 2007. A review of food safety and food hygiene training studies in the commercial sector. Food Control 18: 1180–1190.

Eifert, J., Arritt III, F. and Kang, D., 2005. Microbiology of Food Systems. In: Hui, Y.H. (ed.) Handbook of food science, technology, and engineering. Tylor & Francis, London, , pp. 50–1–50–12.

EU, 2016. EU strategy on animal welfare. Available at: http://ec.europa.eu/food/animals/welfare/strategy/index_en.htm.

Eze, V.C. and Ivuoma, N., 2012. Evaluation of microbial quality of fresh goat meat sold in Umuahia market, Abia state, Nigeria. Pakistan Journal of Nutrition 11: 782–786.

FAO, 2004. Good Practices for the Meat Industry. Animal production and health.

FAO, 2005. Kenya Livestock Sector Brief. FAO Livestock Information, Sector Analysis and Policy Branch.

Farmer, E. and Mbwika, J., 2012. End market analysis of Kenyan livestock and meat: a desk study. Rep. no. MicroREPORT.

Fasanmi, G.O., Olukole, S.G. and Kehinde, O.O., 2010. Microbial studies of table scrapings from meat stalls in Ibadan Metropolis , Nigeria : Implications on meat hygiene. African Journal of Biotechnology 9: 3158–3162.

Fendler, E.J., Dolan, M.J., Williams, R.A. and Paulson, D.S., 1998. Handwashing and gloving for food protection. Part II. Effectiveness. Dairy Food Environ. Sanit. International Association of Milk, Food and Environmental Sanitarians, 18: 824–829.

Ferguson, D.M. and Warner, R.D., 2008. Have we underestimated the impact of pre-slaughter stress on meat quality in ruminants? Meat Science 80: 12–19.

Frazier, W.C. and Westhoff, D.C., 1988. Food Microbiology. McGraw-Hill, 539 pp.

Frimpong, S., Gebresenbet, G., Bosona, T., Bobobee, E., Aklaku, E. and Hamdu, I., 2012. Animal supply and logistics activities of abattoir chain in developing countries: the case of Kumasi abattoir, Ghana. Journal of Service Science and Management 5: 20–27.

Galland, J.C., 1997. Risks and prevention of contamination of beef carcasses during the slaughter process in the United States of America. Revue Scientifique et Technique (International Office of Epizootics) 16: 395–404.

Gallo, C., 2008. Using scientific evidence to inform public policy on the long distance transportation of animals in South America. Vet Ital 44: 113–120.

Gardner, G.E., McIntyre, B.L., Tudor, G.D. and Pethick, D.W., 2001. The impact of nutrition on bovine muscle glycogen metabolism following exercise. Australian Journal of Agricultural Research 52: 461.

Gebresenbet, G. and Ljunberg, D., 2004. Effective logistics to improve animal welfare in the production chain, with special emphasis on farm-abattoir system. International Society for Animal Hygiene 1: 37–38.

Gill, C.O., 1995. Current and emerging approaches to assuring the hygienic condition of red meats. Canadian Journal of Animal Science 75: 1–13.

Gill, C.O., 1998. Microbiological contamination of meat during slaughter and butchering of cattle, sheep and pigs. In: Davies, A. and Board, R. (eds.) The Microbiology of Meat and Poultry. Blackie Academic & Professional, London, , pp. 118–157.

Gill, C.O. and Landers, C., 2004. Proximate sources of bacteria on boneless loins prepared from routinely processed and detained carcasses at a pork packing plant. International Journal of Food Microbiology 97: 171–178.

Gill, C.O. and McGinnis, J.C., 2000. Contamination of beef trimmings with Escherichia coli during a carcass breaking process. Food Research International 33: 125–130.

GOK, 2009. Population and housing census 2009.

GOK, 2012. Prevention of cruelty to animals (transport of animals) regulations, 1984. Kenya Available at: http://www.kenyalaw.org:8181/exist/kenyalex/sublegview.xql?subleg=CAP. 360. Accessed April 26, 2016.

González, L. a, Schwartzkopf-Genswein, K.S., Bryan, M., Silasi, R. and Brown, F., 2012a. Relationships between transport conditions and welfare outcomes during commercial long haul transport of cattle in North America. Journal of Animal Science 90: 3640–51.

González, L. a, Schwartzkopf-Genswein, K.S., Bryan, M., Silasi, R. and Brown, F., 2012b. Factors affecting body weight loss during commercial long haul transport of cattle in North America. Journal of Animal Science 90: 3630–3639.

González, L.A., Bryan, M., Silasi, R. and Brown, F., 2015. Relationships between transport conditions and welfare outcomes during commercial long haul transport of cattle in North America 1. Journal of Animal Science 90: 3640–3651.

Gosálvez, L.F., Averós, X., Valdelvira, J.J. and Herranz, A., 2006. Influence of season, distance and mixed loads on the physical and carcass integrity of pigs transported to slaughter. Meat Science 73: 553–558.

Grandin, T., 2003. Transferring results of behavioral research to industry to improve animal welfare on the farm, ranch and the slaughter plant. Applied Animal Behaviour Science 81: 215–228.

Grandin, T., 2014a. Animal welfare and society concerns finding the missing link. Meat Science Elsevier B.V., 98: 461–469.

Grandin, T., 2014b. Livestock Handling and Transport: Theories and Applications. CABI Publishing, Wallingford, Oxon, UK, 496 pp.

Green, L.R., Radke, V., Mason, R., Bushnell, L., Reimann, D.W., Mack, J.C., Motsinger, M.D., Stigger, T. and Selman, C.A., 2007. Factors related to food worker hand hygiene practices. Journal of Food Protection 70: 661–666.

Greger, M., 2007. The long haul: risks associated with livestock transport. Biosecurity and Bioterrorism : Biodefense Strategy, Practice, and Science 5: 301–311.

Greig, J.D. and Ravel, A., 2009. Analysis of foodborne outbreak data reported internationally for source attribution. International Journal of Food Microbiology 130: 77–87.

Guàrdia, M.D., Estany, J., Balasch, S., Oliver, M.A., Gispert, M. and Diestre, A., 2010. Risk assessment of DFD meat due to pre-slaughter conditions in pigs. Meat Science 70: 709–716.

Halim, M., Nor, N. and Shazali, M., 2015. A conceptual model of food hygiene and safety : implication for future research. Procedia - Social and Behavioral Sciences 201: 121–127.

Hatim, A., Suliman, S. and Abdalla, M., 2013. Implementation of HACCP and Food Safety Program in Al – Ain City Abu Dabi. Journal of Food & Nutritional Disorders 2: 1–4.

Hayes, P.R. and Forsythe, S.J., 1999. Food Hygiene Microbiology and HACCP. Springer, 449 pp.

Hemsworth, P.H. and Coleman, G.J., 2011. The stockperson and the productivity and welfare of intensively farmed animals. Journal of Chemical Information and Modeling. CAB International, Wallingford, UK.

Hemsworth, P.H., Coleman, G.J., Barnett, J.L., Borg, S. and Dowling, S., 2002. The effects of cognitive behavioral intervention on the attitude and behavior of stockpersons and the behavior and productivity of commercial dairy cows . The online version of this article , along with updated information and services , is located on the. Journal of Animal Science 80: 68–78.

Herzog, H.A., Betchart, N.S. and Pittman, R.B., 1991. Gender, sex role orientation, and attitudes toward animals. Anthrozoos 4: 184–191.

Hoffman, D.E., Spire, M.F., Schwenke, J.R. and Unruh, J.A., 1998. Effect of source of cattle and distance transported to a commercial slaughter facility on carcass bruises in mature beef cows. Journal of the American Veterinary Medical Association 212: 668–72.

Hoffman, L.C. and Lühl, J., 2012. Causes of cattle bruising during handling and transport in Namibia. Meat Science 92: 115–124.

Honkavaara, M., Rintasalo, E., Ylönen, J. and Pudas, T., 2003. Meat quality and transport stress of cattle. Deutsche Tierarztliche Wochenschrift 110: 125–8.

Hutchison, M.L., Thomas, D.J.I., Small, A.H., Buncic, S. and Howell, M., 2007. Implementation of compulsory hazard analysis critical control point system and its effect on concentrations of carcass and environmental surface bacterial indicators in United Kingdom red meat slaughterhouses. Journal of Food Protection 70: 1633–1639.

Hutchison, M.L., Walters, L.D., Avery, S.M., Munro, F. and Moore, A., 2005. Analyses of livestock production, waste storage, and pathogen levels and prevalences in farm manures. Applied and Environmental Microbiology 71: 1231–6.

IBM Corp., 2015. IBM SPSS Statistics 23 Documentation.

IFAD, 2012. An overview of livestock sub-sector in Kenya perspectives, opportunities and innovations for market access for market access for pastoral producers.

Ingle, N.A., Kumar, A.K. and Chaly, P.E., 2012. Contamination of Rings and Watches among Clinical and Non-Clinical Dental staffs. Journal of International Oral Health 4: 39–46.

Jay, J.M., Loessner, M.J. and Golden, D.A., 2005. Modern Food Microbiology. Springer US, Boston, MA, 760 pp , doi:10.1007/b100840.

Jevšnik, M., Hlebec, V. and Raspor, P., 2008. Food safety knowledge and practices among food handlers in Slovenia. Food Control 19: 1107–1118.

Jianu, C. and Goleţ, I., 2014. Knowledge of food safety and hygiene and personal hygiene practices among meat handlers operating in western Romania. Food Control 42: 214–219.

Kahraman, T., Cetin, O., Dumen, E. and Buyukunal, S.K., 2010. Incidence of Salmonella spp. and Listeria monocytogenes on equipment surfaces and personnel hands in meat plants. Revue

De Medecine Veterinaire 161: 108–113.

Karibasappa, G.N., Nagesh, L. and Sujatha, B.K., 2011. Assessment of microbial contamination of toothbrush head: an in vitro study. Indian Journal of Dental Research 22: 2–5.

Kılıç, İ. and Bozkurt, Z., 2013. The relationship between farmers' perceptions and animal welfare standards in sheep farms. Asian-Australasian Journal of Animal Sciences 26: 1329–1338.

Kimwele, C., Matheka, D. and Ferdowsian, H., 2011. A Kenyan perspective on the use of animals in science education and scientific research in Africa and prospects for improvement. The Pan African Medical Journal 9: 45.

Kiptarus, J.K., 2005. Focus on livestock sector: supply policy framework strategies status and links with value addition.

Kitagwa, W.G. and Johan, L., 2012. An assessment of knowledge, attitudes and practices of food handlers in food kiosks in relation to food hygiene in Eldoret, Kenya. International Journal of Current Research 4: 127–138.

Knowles, T.G., 1998. A review of the road transport of slaughter sheep. The Veterinary Record 143: 212–219.

Koknaroglu, H. and Akunal, T., 2013. Animal welfare: An animal science approach. Meat Science 95: 821–827.

Koutsoumanis, K., Geornaras, I. and Sofos, J., 2005. Microbiology of Land Muscle Foods. In: Hui, Y.H. (ed.) Handbook of food science, technology, and engineering. Taylor & Francis, London, , pp. 52–1–52–42.

Kreikemeier, K.K., Unruh, J.A. and Eck, T.P., 1998a. Factors affecting the occurrence of dark-cutting beef and selected carcass traits in finished beef cattle. Journal of Animal Science 76: 388–95.

Kreikemeier, K.K., Unruh, J.A. and Eck, T.P., 1998b. Factors affecting the occurrence of dark-cutting beef and selected carcass traits in finished beef cattle. Journal of Animal Science 76: 468–473.

Kupsala, S., Vinnari, M., Jokinen, P. and Räsänen, P., 2015. Citizen attitudes to farm animals in Finland: a population-based study. Journal of Agricultural and Environmental Ethics 28: 601–620.

Kussaga, J.B., Pieternel, A. and Jacxsens, L., 2013. Diagnosis of food safety management systems performance in food processing sectors for export and domestic markets. African Journal of Food Science and Technology 4: 240–250.

Lapworth, J.W., 2008. Engineering and design of vehicles for long distance road transport of livestock: the example of cattle transport in northern Australia. Veterinaria Italiana 44: 215–222.

Ljungberg, D., Gebresenbet, G. and Aradom, S., 2007. Logistics chain of animal transport and abattoir operations. Biosystems Engineering 96: 267–277.

Lynch, R.A., Phillips, M.L., Elledge, B.L., Hanumanthaiah, S. and Boatright, D.T., 2005. A preliminary evaluation of the effect of glove use by food handlers in fast food restaurants. Journal of Food Protection 68: 187–90.

Macias, Y. and Glasauer, P., 2014. Guidelines for assessing nutrition-related knowledge, attitudes and practices. KAP Manual. Food & Agriculture Organization, Rome, Italy, 180 pp.

Malena, M., Voslářová, E., Kozák, A., Bělobrádek, P., Bedáňová, I., Steinhauser, L. and Večerek, V.,

2007. Comparison of mortality rates in different categories of pigs and cattle during transport for slaughter. Acta Veterinaria Brno 76: 109–116.

Marais, M., Conradie, N. and Labadarios, D., 2008. Small and micro enterprises – aspects of knowledge, attitudes and practices of managers’ and food handlers' knowledge of food safety in the proximity of Tygerberg Academic Hospital, Western Cape. South African Journal of Clinical Nutrition 20: 50–61.

María, G.A., 2006. Public perception of farm animal welfare in Spain. Livestock Science 103: 250–256.

Marriott, N.G. and Gravani, R.B., 2006. Principles of Food Sanitation. Springer, US, New York, 401 pp.

Martínez-Chávez, L., Cabrera-Diaz, E., Pérez-Montaño, J.A., Garay-Martínez, L.E., Varela-Hernández, J.J., Castillo, A., Lucia, L., Ávila-Novoa, M.G., Cardona-López, M.A., Gutiérrez-Gonz??lez, P. and Martínez-Gonzáles, N.E., 2015. Quantitative distribution of Salmonella spp. and Escherichia coli on beef carcasses and raw beef at retail establishments. International Journal of Food Microbiology 210: 149–155.

Martínez-López, B., Perez, A.M., De la Torre, A. and Rodriguez, J.M.S.-V., 2008. Quantitative risk assessment of foot-and-mouth disease introduction into Spain via importation of live animals. Preventive Veterinary Medicine 86: 43–56.

Masiga, W.N. and Munyua, S.J.M., 2005. Global perspectives on animal welfare : Africa A working definition of animal welfare and their influence on animal. International Office of Epizootics 24: 579–586.

McCrum-Gardner, E., 2008. Which is the correct statistical test to use? The British Journal of Oral and Maxillofacial Surgery 46: 38–41.

McDermott, J.J., Staal, S.J., Freeman, H.A., Herrero, M. and Van de Steeg, J.A., 2010. Sustaining intensification of smallholder livestock systems in the tropics. Livestock Science 130: 95–109.

McEvoy, J.M., Doherty, A.M., Finnerty, M., Sheridan, J.J., McGuire, L., Blair, I.S., McDowell, D.A. and Harrington, D., 2000. The relationship between hide cleanliness and bacterial numbers on beef carcasses at a commercial abattoir. Letters in Applied Microbiology 30: 390–395.

McEvoy, J.M., Sheridan, J.J., Blair, I.S. and McDowell, D.A., 2004. Microbial contamination on beef in relation to hygiene assessment based on criteria used in EU Decision 2001/471/EC. International Journal of Food Microbiology 92: 217–225.

Mestre, M.V., Samper, P., Frías, M.D. and Tur, A.M., 2009. Are women more empathetic than men? A longitudinal study in adolescence. The Spanish Journal of Psychology 12: 76–83.

Metaxopoulos, J., Kritikos, D. and Drosinos, E.H., 2003. Examination of microbiological parameters relevant to the implementation of GHP and HACCP system in Greek meat industry in the production of cooked sausages and cooked cured meat products. Food Control 14: 323–332.

Migiro, S.O. and Wallis, M., 2006. Relating Kenyan manufacturing SMEs ’ finance needs to information on alternative sources of finance. South African Journal of Information Managemment 8: 1–14.

Milios, K.T., Drosinos, E.H. and Zoiopoulos, P.E., 2014. Food Safety Management System validation and verification in meat industry: Carcass sampling methods for microbiological hygiene criteria – A review. Food Control 43: 74–81.

Miller, K.G., Tran, P.L., Haley, C.L., Kruzek, C., Colmer-Hamood, J.A., Myntti, M. and Hamood, A.N., 2014. Next science wound gel technology, a novel agent that inhibits biofilm development by gram-positive and gram-negative wound pathogens. Antimicrobial Agents and Chemotherapy 58: 3060–3072.

Miranda-de la Lama, G.C., Sepúlveda, W.S., Villarroel, M. and María, G. a, 2011. Livestock vehicle accidents in Spain: causes, consequences, and effects on animal welfare. Journal of applied animal welfare science : JAAWS 14: 109–123.

Miranda-de la Lama, G.C., Sepulveda, W.S., Villarroel, M. and Maria, G.A., 2013. Attitudes of meat retailers to animal welfare in Spain. Meat Science 95: 569–575.

Miranda-de la Lama, G.C., Villarroel, M., Liste, G., Escós, J. and María, G. a., 2010. Critical points in the pre-slaughter logistic chain of lambs in Spain that may compromise the animal's welfare. Small Ruminant Research 90: 174–178.

Miranda-de la Lama, G.C., Villarroel, M. and María, G.A.A., 2014. Livestock transport from the perspective of the pre-slaughter logistic chain: a review. Meat Science 98: 9–20.

Mogoa, E.G., Wabacha, J.K., Mbithi, P.M. and Kiama, S.G., 2007. An Overview of Animal Welfare Issues in Kenya. Kenya Veterinarian The Kenya Veterinary Association, 29: 48–52.

Montville, R., Chen, Y. and Schaffner, D.W., 2002. Risk assessment of hand washing efficacy using literature and experimental data. International journal of food microbiology 73: 305–13.

Mounier, L., Dubroeucq, H., Andanson, S. and Veissier, I., 2006. Variations in meat pH of beef bulls in relation to conditions of transfer to slaughter and previous history of the animals. Journal of Animal Science 84: 1567–76.

Mullan, B., Wong, C., Todd, J., Davis, E. and Kothe, E.J., 2015. Food hygiene knowledge in adolescents and young adults. British Food Journal 117: 50.

Mundry, R. and Fischer, J., 1998. Use of statistical programs for nonparametric tests of small samples often leads to incorrect P values: examples fromAnimal Behaviour. Animal Behaviour 56: 256–259.

Muthee, A., 2006. Kenya livestock sector study: An analysis of pastoralist livestock products market value chains and potential external markets for live animals and meat. Available at: http://pdf.usaid.gov/pdf_docs/pnady825.pdf. Accessed March 26, 2016.

Nee, S.O. and Sani, N.A., 2011. Assessment of Knowledge, Attitudes and Practices (KAP) among food handlers at residential colleges and canteen regarding food safety. Sains Malaysiana 40: 403–410.

Nel, S., Lues, J.F.R., Buys, E.M. and Venter, P., 2004. The personal and general hygiene practices in the deboning room of a high throughput red meat abattoir. Food Control 15: 571–578.

Niyonzima, E., Bora, D. and Ongol, M.P., 2013. Assessment of beef meat microbial contamination during skinning , dressing , transportation and marketing at a commercial abattoir in Kigali city , Rwanda. Pakistan Journal of Food Science 23: 133–138.

Niyonzima, E., Ongol, M.P., Kimonyo, A. and Sindic, M., 2015. Risk factors and control measures for bacterial contamination in the bovine meat chain : a review on Salmonella and pathogenic E . coli. Journal of Food Research 4: 98–121.

Normanno, G., Firinu, A., Virgilio, S., Mula, G., Dambrosio, A., Poggiu, A., Decastelli, L., Mioni, R., Scuota, S., Bolzoni, G., Di Giannatale, E., Salinetti, A.P., La Salandra, G., Bartoli, M., Zuccon, F., Pirino, T., Sias, S., Parisi, A., Quaglia, N.C. and Celano, G. V., 2005. Coagulase-positive Staphylococci and Staphylococcus aureus in food products marketed in Italy. International

Journal of Food Microbiology 98: 73–79.

Norton, T., Kettlewell, P. and Mitchell, M., 2013. A computational analysis of a fully-stocked dual-mode ventilated livestock vehicle during ferry transportation. Computers and Electronics in Agriculture 93: 217–228.

Nyamakwere, F., Muchenje, V., Mushonga, B., Makepe, M. and Mutero, G., 2016. Assessment of Salmonella, Escherichia Coli, Enterobacteriaceae and Aerobic Colony Counts Contamination Levels During the Beef Slaughter Process. Journal of Food Safety Article in Press.

Nyberg, G., Knutsson, P., Ostwald, M., Öborn, I., Wredle, E., Otieno, D.J., Mureithi, S., Mwangi, P., Said, M.Y., Jirström, M., Grönvall, A., Wernersson, J., Svanlund, S., Saxer, L., Geutjes, L., Karmebäck, V., Wairore, J.N., Wambui, R., De Leeuw, J. and Malmer, A., 2015. Enclosures in West Pokot, Kenya: Transforming land, livestock and livelihoods in drylands. Pastoralism Springer Berlin Heidelberg, 5: 25.

OIE, 2015. World Organisation for Animal Health Terrestrial Animal Health Code: Chapter 7.2.4 Transport of Animals by Sea. Available at: http://www.oie.int/index.php?id=169&L=0&htmfile=chapitre_aw_sea_transpt.htm.

Ong'olo, D. and Awino, S., 2013. Integrating SMEs in the devolved government system; policy options for institutional and regulatory framework in Kenya data collection and analysis.

Onono, J.O., Amimo, J.O. and Rushton, J., 2015. Constraints and efficiency of cattle marketing in semiarid pastoral system in Kenya. Tropical Animal Health and Production 47: 691–697.

Opiyo, B.A., Wangoh, J. and Njage, P.M.K., 2013. Microbiological performance of dairy processing plants is influenced by scale of production and the implemented food safety management system: a case study. Journal of Food Protection 76: 975–83.

Osés, S., Luning, P., Jacxsens, L., Santillana, S., Jaime, I. and Rovira, J., 2012a. Food safety management system performance in the lamb chain. Food Control 25: 493–500.

Osés, S., Luning, P., Jacxsens, L., Santillana, S., Jaime, I. and Rovira, J., 2012b. Microbial performance of food safety management systems implemented in the lamb production chain. Journal of Food Protection 75: 95–103.

Ossmer, R., 1992. Salmosyst and Rambach - agar. A rapid alternative for the detection of Salmonella. Congress - Poster - Salmonella and Salmonellosis. Ploufragan/Saint - Brieux - France.

Oto, N., Oshita, S., Makino, Y., Kawagoe, Y., Sugiyama, J. and Yoshimura, M., 2013. Non-destructive evaluation of ATP content and plate count on pork meat surface by fluorescence spectroscopy. Meat Science Elsevier Ltd, 93: 579–585.

Panisello, P.J. and Quantick, P.C., 2001. Technical barriers to Hazard Analysis Critical Control Point (HACCP). Food Control 12: 165–173.

Paranhos da Costa, M.J.R., Huertas, S.M., Gallo, C. and Dalla Costa, O. a., 2012. Strategies to promote farm animal welfare in Latin America and their effects on carcass and meat quality traits. Meat Science 92: 221–226.

Pearce, R.A. and Bolton, D.J., 2005. Excision vs sponge swabbing - A comparison of methods for the microbiological sampling of beef, pork and lamb carcasses. Journal of Applied Microbiology 98: 896–900.

Peeters, E., Deprez, K., Beckers, F., De Baerdemaeker, J., Auben, a. E. and Geers, R., 2008. Effect of driver and driving style on the stress responses of pigs during a short journey by trailer. Animal Welfare 17: 189–196.

Peli, A., Pietra, M., Giacometti, F., Mazzi, A., Scacco, G., Serraino, A. and Scagliarini, L., 2016. Survey on animal welfare in nine hundred and forty three Italian dairy farms. Italian Journal of Food Safety 5: 50–56.

Pérez-rodríguez, F., Garcia-gimeno, R.M. and Zurera-cosano, G., 2013. Modelling survival kinetics of Staphylococcus aureus and Escherichia coli O157 : H7 on stainless steel surfaces soiled with different substrates under static conditions of temperature and relative humidity. Food Microbiology 33: 197–204.

Pethick, D.W., Ball, A.J., Banks, R.G. and Hocquette, J.F., 2011. Current and future issues facing red meat quality in a competitive market and how to manage continuous improvement. Animal Production Science 51: 1–13.

Petruzzelli, A., Osimani, A., Pasquini, M., Clementi, F., Vetrano, V., Paolini, F., Foglini, M., Micci, E., Paoloni, A. and Tonucci, F., 2016. Trends in the microbial contamination of bovine, ovine and swine carcasses in three small-scale abattoirs in central Italy: A four-year monitoring. Meat Science 111: 53–59.

Pipek, P., Haberl, A. and Jeleníková, J., 2003. Influence of slaughterhouse handling on the quality of beef carcasses. Czech Journal of Animal Science 9: 371–378.

Pommerville, J.C., Alcamo, I.E. and Alcamo, I.E., 2013. Alcamo's fundamentals of microbiology. Body systems edition. Jones & Bartlett Learning, Burlington, MA, 854 pp.

Price, E.O., 2008. Animal handling and movement. Principles and Applications of Domestic Animal Behavior An Introductory Text. CABI, Oxfordshire, UK, , pp. 247–271.

Quandt, A. and Kimathi, Y.A., 2016. Adapting livelihoods to floods and droughts in arid Kenya : Local perspectives and insights. African Journal of Rural Development 1: 51–60.

Rabaste, C., Faucitano, L., Saucier, L., Mormede, P., Correa, J.A., Giguere, A. and Bergeron, R., 2007. The effects of handling and group size on welfare of pigs in lairage and their influence on stomach weight, carcass microbial contamination and meat quality. Canadian Journal of Animal Science 87: 3–12.

Rahman, S., 2004. Animal welfare: a developing country perspective. Proceedings of the global conference on animal welfare: an OIE initiative. Paris, France, , pp. 101–112.

Rambach, A., 1990. New plate medium for facilitated differentiation of Salmonella spp. from Proteus spp. and other enteric bacteria. Applied and Environmental Microbiology 56: 301–303.

Ramoneda, M., Foncuberta, M., Simón, M., Sabaté, S., Ferrer, M.D., Herrera, S., Landa, B., Musté, N., Martí, R., Trabado, V., Carbonell, O., Vila, M., Espelt, M., Ramírez, B. and Durán, J., 2013. Prevalence of verotoxigenic Escherichia coli O157 (VTEC O157) and compliance with microbiological safety standards in bovine carcasses from an industrial beef slaughter plant. Letters in Applied Microbiology 56: 408–413.

Rao, V.A., Thulasi, G. and Ruban, S.W., 2009. Meat quality characteristics of non-descript buffalo as affected by age and sex. World Applied Sciences Journal 6: 1058–1065.

Raspor, P. and Jevšnik, M., 2009. Novel food safety concepts for safe food: case meat processing industry. Tehnologija Mesa 50: 1–10.

Roeber, D.L., Mies, P.D., Smith, C.D., Belk, K.E., Field, T.G., Tatum, J.D., Scanga, J.A. and Smith, G.C., 2001. National market cow and bull beef quality audit-1999: a survey of producer-related defects in market cows and bulls. Journal of Animal Science 79: 658–65.

Schaefer, A.L., Jones, S.D. and Stanley, R.W., 1997. The use of electrolyte solutions for reducing transport stress. Journal of Animal Science 75: 258–65.

Scherer, J., Zeidman, B. and Yago, G., 2009. Stimulating Investment in Emerging-Market SMEs. Milken Institute. , 1–42.

Schürch, B., 1983. Evaluation of nutrition education in Third World communities: a Nestlé Foundation workshop, Lutry/Lausanne, September 16th and 17th, 1982. Hans Huber, 235 pp.

Schwartzkopf-Genswein, K.S., Faucitano, L., Dadgar, S., Shand, P., González, L.A. and Crowe, T.G., 2012. Road transport of cattle, swine and poultry in North America and its impact on animal welfare, carcass and meat quality: A review. Meat Science 92: 227–243.

Schwartzkopf-Genswein, K.S., Haley, D.B., Church, S., Woods, J. and O'Byrne, T., 2008. An education and training programme for livestock transporters in Canada. Veterinaria Italiana 44: 273–283.

Serraino, A., Bardasi, L., Riu, R., Pizzamiglio, V., Liuzzo, G., Galletti, G., Giacometti, F. and Merialdi, G., 2012. Visual evaluation of cattle cleanliness and correlation to carcass microbial contamination during slaughtering. Meat Science. 502-506 pp , doi:10.1016/j.meatsci.2011.08.001.

Sharif, L., Obaidat, M.M. and Al-Dalalah, M.-R., 2013. Food hygiene knowledge, attitudes and practices of the food handlers in the military hospitals. Food and Nutrition Sciences 4: 245–251.

Sheridan, J.J., 1998. Sources of contamination during slaughter and measures for control. Journal of Food Safety 18: 321–339.

Shojaei, H., Shooshtaripoor, J. and Amiri, M., 2006. Efficacy of simple hand-washing in reduction of microbial hand contamination of Iranian food handlers. Food Research International 39: 525–529.

Silva, J.A., Patarata, L. and Martins, C., 1999. Influence of ultimate pH on bovine meat tenderness during ageing. Meat Science 52: 453–459.

Smith, G.C. and Grandin, T., 1998. Animal handling for productivity, quality and profitability. Annual Convention of the American Meat Institute. Philadelphia, USA, , pp. 1–12.

Smith, G.C. and Grandin, T., 2008. Animal handling for productivity, quality and profitability. Annual Convention of the American Meat Institute. Philadelphia, USA, , pp. 1–12.

Soares, L.S., Almeida, R.C.C., Cerqueira, E.S., Carvalho, J.S. and Nunes, I.L., 2012. Knowledge, attitudes and practices in food safety and the presence of coagulase-positive staphylococci on hands of food handlers in the schools of Camaçari, Brazil. Food Control 27: 206–213.

Sofos, J.N., 1994. Microbial growth and its control in meat, poultry and fish. In: Pearson, A.M. and Dutson, T.R. (eds.) Quality Attributes and Their Measurement in Meat, Poultry, and Fish Products. Blackie Academic and Professional, Glasgow, UK, , pp. 359–403.

Sofos, J.N., Cabedo, L., Zerby, H., Belk, K.E. and Smith, G.C., 2000. Potential interactions between antioxidants and microbial meat quality. In: Decker, E., Faustman, C. and Lopez-Bote, C.J. (eds.) Antioxidants in muscle foods : nutritional strategies to improve quality. John Wiley & Sons, Inc., New York, , pp. 427–453.

Southern, K.J., Rasekh, J.G., Hemphill, F.E. and Thaler, A.M., 2006. Conditions of transfer and quality of food. Revue De Medecine Veterinaire 25: 675–684.

Spescha, C., Stephan, R. and Zweifel, C., 2006. Microbiological contamination of pig carcasses at different stages of slaughter in two European Union-approved abattoirs. Journal of Food Protection 69: 2568–2575.

Steinfeld, H., Wassenaar, T. and Jutzi, S., 2006. Livestock production systems in developing countries : status , drivers , trends. Revue Scientifique et Technique (International Office of Epizootics) 25: 505–516.

Stiles, M.E. and Ng, L., 1981. Enterobacteriaceae Associated with Meats and Meat Handling. 41: 867–872.

Støier, S., Larsen, H.D., Aaslyng, M.D. and Lykke, L., 2016. Improved animal welfare, the right technology and increased business. Meat Science 120: 71–77.

Strappini, A.C., Frankena, K., Metz, J.H.M., Gallo, B. and Kemp, B., 2010. Prevalence and risk factors for bruises in Chilean bovine carcasses. Meat Science 86: 859–864.

Swanson, J.C., 2001. Cattle transport : Historical , research , and future perspectives 1. Animal Science 79: 102–109.

Taylor, E., 2001. HACCP in small companies: benefit or burden? Food Control 12: 217–222.

Tergney, A. and Bolton, D.J., 2006. Validation studies on an online monitoring system for reducing faecal and microbial contamination on beef carcasses. Food Control 17: 378–382.

Terlouw, E.M.C., Arnould, C., Auperin, B., Berri, C., Le Bihan-Duval, E., Deiss, V., Lefèvre, F., Lensink, B.J. and Mounier, L., 2008. Pre-slaughter conditions, animal stress and welfare: current status and possible future research. Animal 2: 1501–1517.

Todd, E.C.D., Michaels, B.S., Greig, J.D., Smith, D., Holah, J. and Bartleson, C.A., 2010. Outbreaks Where Food Workers Have Been Implicated in the Spread of Foodborne Disease. Part 2. Description of Outbreaks by Size, Severity, and Settings. Journal of Food Protection 73: 1552–1565.

Trafialek, J., Laskowski, W. and Kolanowski, W., 2015. The use of Kohonen's artificial neural networks for analyzing the results of HACCP system declarative survey. Food Control 51: 263–269.

Uyttendaele, M., Jacxsens, L., De Loy-Hendrickx, A., Devlieghere, F. and Debevere, J., 2010. Microbiologische richtwaarden & wettelijke microbiologische criteria. Laboratory of food Microbiology and Food Preservation, Department of Food Safety and Food Quality, Ghent University, Ghent, Belgium, 123 pp.

Van Donkersgoed, J., Jewison, G., Mann, M., Cherry, B., Altwasser, B., Lower, R., Wiggins, K., Dejonge, R., Thorlakson, B., Moss, E., Mills, C. and Grogan, H., 1997. Canadian beef quality audit. The Canadian Veterinary Journal 38: 217–25.

Vanhonacker, F., Verbeke, W., van Poucke, E., Pieniak, Z., Nijs, G. and Tuyttens, F., 2012. The concept of farm animal welfare: citizen perceptions and stakeholder opinion in Flanders, Belgium. Journal of Agricultural and Environmental Ethics 25: 79–101.

Vázquez-sánchez, D., López-cabo, M., Saá-ibusquiza, P. and Rodríguez-herrera, J.J., 2012. Incidence and characterization of Staphylococcus aureus in fishery products marketed in Galicia (Northwest Spain). International Journal of Food Microbiology 157: 286–296.

Vecerek, V., Grbalova, S., Voslarova, E., Janackova, B. and Malena, M., 2006a. Effects of travel distance and the season of the year on death rates of broilers transported to poultry processing plants. Poultry Science 85: 1881–1884.

Vecerek, V., Malena, M., Malena, M., Voslarova, E. and Chloupek, P., 2006b. The impact of the transport distance and season on losses of fattened pigs during transport to the slaughterhouse in the Czech Republic in the period from 1997 to 2004. Veterinarni Medicina 51: 21–28.

Večerek, V., Malena, M., Voslářová, E. and Bedáňová, I., 2006. Mortality in dairy cows transported to slaughter as affected by travel distance and seasonality. Acta Veterinaria Brno 75: 449–454.

Velarde, A. and Dalmau, A., 2012. Animal welfare assessment at slaughter in Europe: moving from inputs to outputs. Meat Science 92: 244–251.

Velarde, A., Fàbrega, E., Blanco-Penedo, I. and Dalmau, A., 2015. Animal welfare towards sustainability in pork meat production. Meat Science 109: 13–17.

Verbeke, W., Pérez-Cueto, F.J.A., Barcellos, M.D. de, Krystallis, A. and Grunert, K.G., 2010. European citizen and consumer attitudes and preferences regarding beef and pork. Meat Science 84: 284–292.

Villarroel, M., Maria, G.A., Sanudo, C., Olleta, J.L. and Gebresenbet, G., 2003. Effect of transport time on sensorial aspects of beef meat quality. Meat Science 63: 353–357.

Voslářová, E., Chloupek, P., Steinhauser, L., Havlíček, J. and Večerek, V., 2010. Influence of housing system and number of transported animals on transport-induced mortality in slaughter pigs. Acta Veterinaria Brno 79: S79–S84.

Waiblinger, S. and Spoolder, H., 2007. Quality of stockpersonship. In: Velarde, A. and Geers, R. (eds.) On farm monitoring of pig welfare. Wageningen Academic Publishers, Wageningen, , pp. 159–166.

Walker, E., Pritchard, C. and Forsythe, S., 2003. Food handlers' hygiene knowledge in small food businesses. Food Control 14: 339–343.

Warren, L.A., Mandell, I.B. and Bateman, K.G., 2010. An audit of transport conditions and arrival status of slaughter cattle shipped by road at an Ontario processor. Canadian Journal of Animal Science 90: 159–167.

Warriss, P.D., 1990. The handling of cattle pre-slaughter and its effects on carcass and meat quality. Applied Animal Behaviour Science 28: 171–186.

Webb, M. and Morancie, A., 2015. Food safety knowledge of foodservice workers at a university campus by education level, experience, and food safety training. Food Control 50: 259–264.

Welfare Quality®, 2009. Welfare Quality® applied to growing and finishing pigs. In: Dalmau, A., Velarde, A., Scott, K., Edwards, S., Veissier, I., Keeling, L. and Butterworth, A. (eds.) Welfare Quality® assessment protocol for pigs. Welfare Quality® Consortium, Netherlands.

White, J., 2013. Jewelry and artificial fingernails in the health care environment: infection risk or urban legend? Clinical Microbiology Newsletter 35: 61–67.

WHO, 2006. Five keys to safer food manual. WHO Press, Geneva, Switzerland, 28 pp.

WHO, 2015. WHO estimates of the global burden of foodborne diseases. WHO. World Health Organization, Rome, Italy, 255 pp.

Wong, L.F., Hald, T., Van Der Wolf, P.J. and Swanenburg, M., 2002. Epidemiology and control measures for Salmonella in pigs and pork. Livestock Production Science 76: 215–222.

Zhang, S.X., Farouk, M.M., Young, O.A., Wieliczko, K.J. and Podmore, C., 2005. Functional stability of frozen normal and high pH beef. Meat Science 69: 765–772.

Zweifel, C., Baltzer, D. and Stephan, R., 2005. Microbiological contamination of cattle and pig carcasses at five abattoirs determined by swab sampling in accordance with EU Decision 2001/471/EC. Meat Science 69: 559–566.

Zweifel, C., Capek, M. and Stephan, R., 2014. Microbiological contamination of cattle carcasses at different stages of slaughter in two abattoirs. Meat Science 98: 198–202.

Zweifel, C., Fischer, R. and Stephan, R., 2008. Microbiological contamination of pig and cattle carcasses in different small-scale Swiss abattoirs. Meat Science 78: 225–231.

Appendix 1 Questionnaire

Characteristics of Trucks used to Transport Cattle in Kenya's Pastoral areas

Questionnaire number.. Date of interview…./……/20……

Name of interviewer ....

Introduction

This is to introduce you to a study on pre-slaughter Good Livestock Handling Practices (GLHPs) in Kenya's Cattle Value Chain that have an impact on beef quality. The study is being conducted in Nairobi, Marsabit, Isiolo, Samburu, Narok, and Kajiado Counties. The aim of this study is to assess the current situation of pre-slaughter GLHPs in these counties. This information will be used to design beef quality assurance protocols along the value chain to reduce losses that result from poor pre-slaughter GLHPs. By reducing losses, the profit margins of you and other stakeholders along the chain will increase. You are therefore being requested, as a key stakeholder, 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 [ ]

Personal Identification

Respondent's name:..

Name of livestock market ....

County ....

Sub-county: ....

Division: ....

Location: ....

Sub-location: ....

Section A: Demographic Characteristics

Gender	Age	Highest Level of education reached	Form of employment	Years of animal trucking
[.......]	[.......]	[.......]	[.......]	[.......]
1=Male 2=Female	1=<20 2=20-30 3=31-40 4=41-50 5=>50	1=Did not go to school 2=Primary 3=Secondary 4=Tertiary 5=University	1=Self employment 2=Salaried employee (permanent) 3=Salaried employee (temporary) 4=Other	1=<1 2=1-5 3=6-10 4=>10

Section B: Truck Characteristics

1. Side vents present	2. Roof covered by canvas	3. Smooth finish of the interior wall	4. Floor designed to prevent slippage	5. Truck divided into Specialised compartments
[.......]	[.......]	[....]	[....]	[.......]
1=Yes 2=No	1=Yes 2=No	1=Yes 2=No	1=Yes 2=No	1=Yes 2=No

Section D: Cattle deaths during trucking

1. In the last trip how many did you truck?
   ....
2. How many animals died during you trucking?
   ....
3. What would you term as the major cause of these deaths?
   a. Diseases [ ] **b.** Injury resulting from other animals **c.** [ ] injuries resulting from animals handlers **d.** Exhaustion and hunger [ ] **e.** other specify [ ]
4. Have measures been put in place to prevent losses of cattle during trucking?
   a. Yes [ ] **b.** No [ ] **c.** Don't know [ ]
5. If yes, what are some of the measures?
   ....
   ....

Appendix 2 Questionnaire

Animal Welfare Knowledge Attitude and Practices of Stockpeople

Questionnaire number.. Date of interview..../....../20......

Name of interviewer..

Introduction

This is to introduce you to a study on pre-slaughter Good Livestock Handling Practices (GLHPs) in Kenya's Cattle Value Chain that have an impact on beef quality. The study is being conducted in Nairobi, Marsabit, Isiolo, Samburu, Narok, Kajiado, Nairobi and Kiambu Counties. The aim of this study is to assess the current situation of pre-slaughter GLHPs in these counties. This information will be used to design beef quality assurance protocols along the value chain to reduce losses that result from poor pre-slaughter GLHPs. By reducing losses, the profit margins of you and other stakeholders along the chain will increase. You are therefore being requested, as a key stakeholder, 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 [ ]

Personal Identification

Respondent's name:..

Name of livestock market..

County..

Sub-county:..

Division:..

Location:..

Sub-location:..

Section A: Demographic Characteristics

Gender	Age	Form of education	Years of animal handling	Type of stockperson
[.......]	[.......]	[.......]	[.......]	[.......]
1=Male 2=Female	1=<20 2=20-50 3=>50	1=Informal education 2=Formal education	1=<1 2=1-10 3=>10	1=Transporter 2=Loader/off-loader 3=Livestock Marketer

Section C. Animal welfare Knowledge, Attitude and Practices of Stockpeople

Q. no.	Question	Tick the correct numerical response against each question whereby

		4=Strongly agree, 3=Agree, 2=Not sure, 1=Disagree 0=Strongly disagree				
		4	**3**	**2**	**1**	**0**
Part One: Animal welfare Knowledge of Stockpeople						
1.	Only animals accompanied by a legal permit of movement should be handled					
2.	Handling animals prior to inspection by veterinary officers is against the law					
3.	Animals suffer from stress when they are grossly mishandled					
4.	Stress in animals affects the eating quality of meat					
5.	Animals should be given feed and water if they have been transported for more than 12 hours					
6.	Animals should not be transported for more than 12 hours continuously					
7.	Mixing unfamiliar groups of animals increases the risk of bruises					
Part Two: Animal welfare Attitude of Stockpeople						
8.	Medical examination of animals before handling is necessary to prevent spread of diseases					
9.	Physical inspection of animals before handling ensures only fit animals are handled					
10.	It is important that I should be trained on how to handle animals					
11.	Handling animals in a humane manner is an important part of my job					
12.	A legal permit should always accompany the animals I am handling					
13.	It is important to feed and water animals before transporting them on a long journey					
14.	Animals should not be mixed with other herds in the market place or during transport					
Part Three: Animal welfare practices of Stockpeople						
15.	Do you make any special plans related to animal welfare before you handle animals?					
16.	Do you personally check the physical condition of the animals in the market before handling them?					
17.	Do you take into considerations the weather conditions while handling animals?					
18.	Do you allow animals to feed and take water in case of an extremely long duration of handling?					
19.	During handling, do you prevent the mixing of your animals with other unfamiliar animals?					
20.	Do you involve other stakeholders in case animal welfare issues arise?					
21.	Do you by any means agitate the animals during handling?					

Appendix 3 Questionnaire

Personal and General Hygiene Practices in Small and Medium Enterprise Slaughterhouses in Kenya

Questionnaire number.. Date of interview..../....../20......

Name of interviewer..

Introduction

This is to introduce you to a study on the personal and general hygiene practices in Kenya's SME slaughterhouses that have an impact on the microbial quality of beef in Kenya. The aim of this study is to identify the current status of personal and general hygiene practices in the slaughterhouses. You are therefore being requested, as a key stakeholder, to spare some of your time to answer questions in this questionnaire. Information generated from this study will be used to develop a hygiene protocol that can easily be adopted in your slaughterhouse. 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.

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

Personal Identification

Respondent's name:..

Name of livestock market ....

County ....

Sub-county: ....

Division: ....

Location: ....

Sub-location: ....

Section A: Demographic Characteristics

Gender	**Age**	**Education level**	**Work experience**	**Training**	**Designation in th Slaughterhouse**
[.......]	[.......]	[.......]	[.......]	[.......]	[.......]
1=Male **2**=Female	**1**=<20 **2**=20-30 **3**=31-40 **4**=41-50 **5**=>50	**1**=Did not go to school **2**=Primary **3**=Secondary **4**=Tertiary **5**=University	**1**=<1 **2**=1-5 **3**=5-10 **4**=>10	**1**=Yes **2**=No	**1**= Sticking/Bleeding **2**= Flaying **3**= Evisceration **4**= Splitting/quartering **5**= Green offals section

Section B: Personal Hygiene Practices

Hand washing practices	
1.	How often do you wash your hands before you start work? **i.** Always [ ] **ii.** Most of the time [ ] **iii.** Sometimes [ ] **iv**. Rarely [ ] **v.** Never [ ]
2.	During operations, how frequently do you wash your hands? **i.** Always [ ] **ii.** Most of the time [ ] **iii.** Sometimes [ ] **iv**. Rarely [ ] **v.** Never [ ]
3.	How often do you wash your hands after visiting the washrooms? **i.** Always [ ] **ii.** Most of the time [ ] **iii.** Sometimes [ ] **iv**. Rarely [ ] **v.** Never [ ]
4.	How would you often do you use soap to wash your hands? **i.** Always [ ] **ii.** Most of the time [ ] **iii.** Sometimes [ ] **iv**. Rarely [ ] **v.** Never [ ]
5.	After washing, how often do you use a disposable towel to dry your hands? **i.** Always [ ] **ii.** Most of the time [ ] **iii.** Sometimes [ ] **iv**. Rarely [ ] **v.** Never [ ]
Practices regarding personnel clothing	
6.	How frequently do you wear an apron during operations? **i.** Always [ ] **ii.** Most of the time [ ] **iii.** Sometimes [ ] **iv**. Rarely [ ] **v.** Never [ ]
7.	How frequently do you wear gumboots during operations? **i.** Always [ ] **ii.** Most of the time [ ] **iii.** Sometimes [ ] **iv**. Rarely [ ] **v.** Never [ ]
8.	How frequently do you wash your apron? **i.** Always [ ] **ii.** Most of the time [ ] **iii.** Sometimes [ ] **iv**. Rarely [ ] **v.** Never [ ]
9.	How frequently do you clean your gumboots? **i.** Always [ ] **ii.** Most of the time [ ] **iii.** Sometimes [ ] **iv**. Rarely [ ] **v.** Never [ ]
10.	How frequently do you wear gloves during slaughterhouse operations? **i.** Always [ ] **ii.** Most of the time [ ] **iii.** Sometimes [ ] **iv**. Rarely [ ] **v.** Never [ ]
11.	How frequently do you wear hair nets during slaughterhouse operations? **i.** Always [ ] **ii.** Most of the time [ ] **iii.** Sometimes [ ] **iv**. Rarely [ ] **v.** Never [ ]
Practices regarding medical care	
12.	In case of bruises or cuts on your hands, how often do you cover them? **i.** Always [ ] **ii.** Most of the time [ ] **iii.** Sometimes [ ] **iv**. Rarely [ ] **v.** Never [ ]
13.	In case of an illness, how often do you report to the management? **i.** Always [ ] **ii.** Most of the time [ ] **iii.** Sometimes [ ] **iv**. Rarely [ ] **v.** Never [ ]
14.	How often do you undertake medical examination as per the government regulations? **i.** Always [ ] **ii.** Most of the time [ ] **iii.** Sometimes [ ] **iv**. Rarely [ ] **v.** Never [ ]
The practices regarding prohibited habits	
15.	How often do avoid eating while working in the slaughterhouse? **i.** Always [ ] **ii.** Most of the time [ ] **iii.** Sometimes [ ] **iv**. Rarely [ ] **v.** Never [ ]
16.	How often do you avoid smoking while working in the slaughterhouse? **i.** Always [ ] **ii.** Most of the time [ ] **iii.** Sometimes [ ] **iv**. Rarely [ ] **v.** Never [ ]

17.	Do often do you avoid wearing jewellery while working in the slaughterhouse? **i.** Always [ ] **ii.** Most of the time [ ] **iii.** Sometimes [ ] **iv**. Rarely [ ] **v.** Never [ ]
Practices regarding the disinfection of equipment	
18.	How frequently do you disinfect your knives between carcasses? **i.** Always [ ] **ii.** Often [ ] **iii.** Sometimes [ ] **iv**. Rarely [ ] **v.** Never [ ]
19.	How frequently are hooks disinfected between carcasses? **i.** Always [ ] **ii.** Most of the time [ ] **iii.** Sometimes [ ] **iv**. Rarely [ ] **v.** Never [ ]
20.	How frequently is the floor cleaned before work? **i.** Always [ ] **ii.** Most of the time [ ] **iii.** Sometimes [ ] **iv**. Rarely [ ] **v.** Never [ ]
21.	How frequently are meat contact surfaces cleaned before work? **i.** Always [ ] **ii.** Most of the time [ ] **iii.** Sometimes [ ] **iv**. Rarely [ ] **v.** Never [ ]
Practices regarding the disinfection of equipment	
22.	How frequently do you disinfect your knives between carcasses? **i.** Always [ ] **ii.** Most of the time [ ] **iii.** Sometimes [ ] **iv**. Rarely [ ] **v.** Never [ ]
23.	How frequently are hooks disinfected between carcasses? **i.** Always [ ] **ii.** Most of the time [ ] **iii.** Sometimes [ ] **iv**. Rarely [ ] **v.** Never [ ]
24.	How frequently is the floor cleaned before work? **i.** Always [ ] **ii.** Most of the time [ ] **iii.** Sometimes [ ] **iv**. Rarely [ ] **v.** Never [ ]
25.	How frequently are meat contact surfaces cleaned before work? **i.** Always [ ] **ii.** Most of the time [ ] **iii.** Sometimes [ ] **iv**. Rarely [ ] **v.** Never [ ]

Appendix 4 Statistical output

1) Kruskal-Wallis Test (Difference of truck design with livestock market)

Ranks

	Name of livestock market	N	Mean Rank
Side vents present	Moyale	13	27.50
	Isiolo	14	45.00
	Marsabit	15	39.17
	Maralal	10	27.50
	Narok	7	33.33
	Kajiado	16	36.83
	Total	70	
Open roof	Moyale	13	28.75
	Isiolo	14	37.50
	Marsabit	15	37.50
	Maralal	10	37.50
	Narok	7	37.50
	Kajiado	16	35.17
	Total	70	
Smooth interior wall	Moyale	13	48.92
	Isiolo	14	28.50
	Marsabit	15	33.17
	Maralal	10	35.50
	Narok	7	40.17
	Kajiado	16	30.83
	Total	70	
Modified floor	Moyale	13	34.00
	Isiolo	14	34.00
	Marsabit	15	41.00
	Maralal	10	34.00
	Narok	7	34.00
	Kajiado	16	34.00
	Total	70	
Individual compartments present	Moyale	13	34.50
	Isiolo	14	34.50
	Marsabit	15	34.50
	Maralal	10	34.50
	Narok	7	34.50
	Kajiado	16	34.50
	Total	68	

Test Statistics[a,b]

			Side vents present	Open roof	Smooth interior wall	Modified floor	Individual compartments present
Chi-Square			12.538	10.759	16.531	11.328	.000
df			5	5	5	5	5
Asymp. Sig.			.028	.056	.005	.045	1.000
Monte Carlo Sig.	Sig.		.027[c]	.074[c]	.006[c]	.048[c]	
	95% Confidence Interval	Lower Bound	.024	.069	.004	.044	
		Upper Bound	.030	.079	.007	.052	

a. Kruskal Wallis Test
b. Grouping Variable: Name of Sampling Point
c. Based on 10000 sampled tables with starting seed 299883525.
d. Exact results are provided instead of Monte Carlo for this test.

2) Kruskal-Wallis Test (difference of number of cattle that died with overall design feature of trucks during trucking)

Ranks

	Overall design feature of trucks	N	Mean Rank
How many animals died in the last one week as you trucked them?	Good design	39	35.68
	Moderate design	27	34.80
	Poor design	7	52.86
	Total	73	

Test Statistics[a,b]

			How many animals died in the last one week as you trucked them?
Chi-Square			4.750
df			2
Asymp. Sig.			.093
Monte Carlo Sig.	Sig.		.089[c]
	95% Confidence Interval	Lower Bound	.083
		Upper Bound	.094

a. Kruskal Wallis Test
b. Grouping Variable: Design status
c. Based on 10000 sampled tables with starting seed 957002199.

3) Kruskal-Wallis Test (difference of number of cattle that died with livestock market)

Ranks

	Name of Sampling Point	N	Mean Rank
How many animals died in the last one week as you trucked them?	Moyale	6	29.58
	Isiolo	14	17.68
	Marsabit	11	28.45
	Maralal	7	23.43
	Narok	5	35.70
	Kajiado	7	27.79
	Total	50	

Test Statistics[a,b]

			How many animals died in the last one week as you trucked them?
Chi-Square			9.224
df			5
Asymp. Sig.			.100
Monte Carlo Sig.	Sig.		.091[c]
	95% Confidence Interval	Lower Bound	.085
		Upper Bound	.096

a. Kruskal Wallis Test
b. Grouping Variable: Name of Sampling Point
c. Based on 10000 sampled tables with starting seed 2000000.

Appendix 5 Statistical output

1) Mann-Whitney Test (difference in the number of cattle that died with specific design feature during trucking)

a. Vents

Ranks

	Side vents present	N	Mean Rank	Sum of Ranks
How many animals died in the last one week as you trucked them?	Yes	34	23.62	803.00
	No	12	23.17	278.00
	Total	46		

Test Statistics[a]

			How many animals died in the last one week as you trucked them?
Mann-Whitney U			200.000
Wilcoxon W			278.000
Z			-.108
Asymp. Sig. (2-tailed)			.914
Monte Carlo Sig. (2-tailed)	Sig.		.929[b]
	95% Confidence Interval	Lower Bound	.924
		Upper Bound	.934
Monte Carlo Sig. (1-tailed)	Sig.		.469[b]
	95% Confidence Interval	Lower Bound	.459
		Upper Bound	.479

a. Grouping Variable: Side vents present
b. Based on 10000 sampled tables with starting seed 299883525.

b. Roof

Ranks

	Open roof	N	Mean Rank	Sum of Ranks
How many animals died in the last one week as you trucked them?	Yes	3	36.33	109.00
	No	43	22.60	972.00
	Total	46		

Test Statistics[a]

			How many animals died in the last one week as you trucked them?
Mann-Whitney U			26.000
Wilcoxon W			972.000
Z			-1.846
Asymp. Sig. (2-tailed)			.065
Exact Sig. [2*(1-tailed Sig.)]			.094[b]
Monte Carlo Sig. (2-tailed)	Sig.		.061[c]
	95% Confidence Interval	Lower Bound	.056
		Upper Bound	.065
Monte Carlo Sig. (1-tailed)	Sig.		.061[c]
	95% Confidence Interval	Lower Bound	.056
		Upper Bound	.065

a. Grouping Variable: Open roof
b. Not corrected for ties.
c. Based on 10000 sampled tables with starting seed 926214481.

c. Interior wall

Ranks

	Smooth interior wall	N	Mean Rank	Sum of Ranks
How many animals died in the last one week as you trucked them?	Yes	37	21.78	806.00
	No	9	30.56	275.00
	Total	46		

Test Statistics[a]

			How many animals died in the last one week as you trucked them?
Mann-Whitney U			103.000
Wilcoxon W			806.000
Z			-1.895
Asymp. Sig. (2-tailed)			.058
Exact Sig. [2*(1-tailed Sig.)]			.081[b]
Monte Carlo Sig. (2-tailed)	Sig.		.054[c]
	95% Confidence Interval	Lower Bound	.049
		Upper Bound	.058
Monte Carlo Sig. (1-tailed)	Sig.		.035[c]
	95% Confidence Interval	Lower Bound	.031
		Upper Bound	.038

a. Grouping Variable: Smooth interior wall
b. Not corrected for ties.
c. Based on 10000 sampled tables with starting seed 1314643744.

d. Floor

Ranks

	Modified floor	N	Mean Rank	Sum of Ranks
How many animals died in the last one week as you trucked them?	Yes	43	23.27	1000.50
	No	3	26.83	80.50
	Total	46		

Test Statistics[a]

			How many animals died in the last one week as you trucked them?
Mann-Whitney U			54.500
Wilcoxon W			1000.500
Z			-.479
Asymp. Sig. (2-tailed)			.632
Exact Sig. [2*(1-tailed Sig.)]			.674[b]
Monte Carlo Sig. (2-tailed)	Sig.		.725[c]
	95% Confidence Interval	Lower Bound	.716
		Upper Bound	.733
Monte Carlo Sig. (1-tailed)	Sig.		.420[c]
	95% Confidence Interval	Lower Bound	.411
		Upper Bound	.430

a. Grouping Variable: Modified floor
b. Not corrected for ties.
c. Based on 10000 sampled tables with starting seed 624387341.

e. Compartments

Ranks

	Individual compartments present	N	Mean Rank	Sum of Ranks
How many animals died in the last one week as you trucked them?	Yes	0[a]	.00	.00
	No	46	23.50	1081.00
	Total	46		

a. Mann-Whitney Test cannot be performed on empty groups.

Appendix 6 Statistical output

Mann-Whitney Test (Difference of Kenya's stockpeople KAP with demographic characteristics)

a. Gender

Ranks

	Gender	N	Mean Rank	Sum of Ranks
Level of Knowledge	Male	251	131.69	33054.50
	Female	12	138.46	1661.50
	Total	263		
Level of Attitude	Male	251	129.92	32611.00
	Female	12	175.42	2105.00
	Total	263		
Level of Practice	Male	250	129.81	32453.00
	Female	12	166.67	2000.00
	Total	262		

Test Statistics[a]

	Level of Knowledge	Level of Attitude	Level of Practice
Mann-Whitney U	1428.500	985.000	1078.000
Wilcoxon W	33054.500	32611.000	32453.000
Z	-.302	-2.030	-1.649
Asymp. Sig. (2-tailed)	.762	.042	.047

a. Grouping Variable: Gender

b. Form of education

Ranks

	Form of education	N	Mean Rank	Sum of Ranks
Form of Knowledge	Formal education	115	140.40	16146.50
	Informal education	148	125.47	18569.50
	Total	263		
Form of Attitude	Formal education	115	139.79	16075.50
	Informal education	148	125.95	18640.50
	Total	263		
Form of Practice	Formal education	115	134.12	15423.50
	Informal education	147	129.45	19029.50
	Total	262		

Test Statistics[a]

	Level of Knowledge	Level of Attitude	Level of Practice
Mann-Whitney U	7543.500	7614.500	8151.500
Wilcoxon W	18569.500	18640.500	19029.500
Z	-1.586	-1.468	-.496
Asymp. Sig. (2-tailed)	.113	.142	.620

a. Grouping Variable: Form of education

Appendix 7 Statistical output

Kruskal-Wallis Test (Difference of Kenya's stockpeople KAP with demographic characteristics)

a. Age of stockpeople

Ranks

	Age	N	Mean Rank
Level of Knowledge	<30	66	118.92
	31-50	172	133.67
	>50	25	155.00
	Total	263	
Level of Attitude	<30	66	118.45
	31-50	172	133.63
	>50	25	156.54
	Total	263	
Level of Practice	<30	66	127.55
	31-50	171	127.72
	>50	25	167.80
	Total	262	

Test Statistics[a,b]

	Level of knowledge	Level of Attitude	Level of Practice
Chi-Square	4.358	4.805	6.369
df	2	2	2
Asymp. Sig.	.113	.041	.031

a. Kruskal Wallis Test
b. Grouping Variable: Age

b. Level of experience

Ranks

	Level of experience	N	Mean Rank
Level of knowledge	<5 yrs	96	124.04
	5-10 yrs	93	134.68
	>10 yrs	68	128.24
	Total	257	
Level of Attitude	<5 yrs	96	124.48
	5-10 yrs	93	127.36
	>10 yrs	68	137.62
	Total	257	
Level of Practice	<5 yrs	96	117.92
	5-10 yrs	93	125.55
	>10 yrs	67	147.75
	Total	256	

Test Statistics[a,b]

	Level of knowledge	Level of Attitude	Level of Practice
Chi-Square	.987	1.322	6.668
df	2	2	2
Asymp. Sig.	.610	.516	.036

a. Kruskal Wallis Test
b. Grouping Variable: Level of experience

c. Type of stockpeople

Ranks

	Stockperson type	N	Mean Rank
Level of knowledge	Transporters	135	131.72
	Loaders/Offloaders	64	129.80
	Livestock traders	67	140.62
	Total	266	
Level of Attitude	Transporters	135	135.28
	Loaders/Offloaders	64	124.13
	Livestock traders	67	138.87
	Total	266	
Level of Practice	Transporters	135	132.87
	Loaders/Offloaders	63	134.28
	Livestock traders	67	132.06
	Total	265	

Test Statistics[a,b]

	Level of knowledge	Level of Attitude	Level of Practice
Chi-Square	.801	1.358	.028
df	2	2	2
Asymp. Sig.	.670	.507	.986

a. Kruskal Wallis Test

b. Grouping Variable: Stockperson type

Appendix 8 Statistical output

Spearman's correlation matrix of the Kenyan stockpeople's knowledge, attitude, and practice

Correlations

			Level of knowledge	Level of Attitude	Level of Practice
Spearman's rho	Level of knowledge	Correlation Coefficient	1.000	.632**	.333**
		Sig. (2-tailed)	.	.000	.000
		N	266	266	265
	Level of Attitude	Correlation Coefficient	.632**	1.000	.562**
		Sig. (2-tailed)	.000	.	.000
		N	266	266	265
	Level of Practice	Correlation Coefficient	.333**	.562**	1.000
		Sig. (2-tailed)	.000	.000	.
		N	265	265	265

**. Correlation is significant at the 0.01 level (2-tailed).

Appendix 9 Statistical output

Mann-Whitney Test (Differences among meat handlers overall hygiene practises with demographic characteristics)

a. Gender

Ranks

	Gender	N	Mean Rank	Sum of Ranks
Overall hygiene practices	Male	177	105.08	18598.50
	Female	30	97.65	2929.50
	Total	207		

Test Statistics[a]

			Overall hygiene practices
Mann-Whitney U			2464.500
Wilcoxon W			2929.500
Z			-.630
Asymp. Sig. (2-tailed)			.529
Monte Carlo Sig. (2-tailed)	Sig.		.534[b]
	95% Confidence Interval	Lower Bound	.524
		Upper Bound	.544
Monte Carlo Sig. (1-tailed)	Sig.		.278[b]
	95% Confidence Interval	Lower Bound	.269
		Upper Bound	.286

a. Grouping Variable: Gender
b. Based on 10000 sampled tables with starting seed 624387341.

b. Training in hygienic handling of meat

Ranks

	Training on hygienic handling of meat	N	Mean Rank	Sum of Ranks
Overall hygiene practices	Yes	82	115.87	9501.50
	No	124	95.32	11819.50
	Total	206		

Test Statistics[a]

			Overall hygiene practices
Mann-Whitney U			4069.500
Wilcoxon W			11819.500
Z			-2.430
Asymp. Sig. (2-tailed)			.015
Monte Carlo Sig. (2-tailed)	Sig.		.015[b]
	95% Confidence Interval	Lower Bound	.013
		Upper Bound	.017
Monte Carlo Sig. (1-tailed)	Sig.		.007[b]
	95% Confidence Interval	Lower Bound	.005
		Upper Bound	.009

a. Grouping Variable: Training on hygienic handling of meat
b. Based on 10000 sampled tables with starting seed 334431365.

Appendix 10 Statistical output

Kruskal-Wallis Test (Differences among meat handlers overall hygiene practises with demographic characteristics)

a. Age

Ranks

	Age	N	Mean Rank
Overall hygiene practices	<20	6	34.17
	20-30	52	99.17
	31-40	85	102.22
	41-50	38	113.30
	50	26	122.00
	Total	207	

Test Statistics[a,b]

			Overall hygiene practices
Chi-Square			11.910
df			4
Asymp. Sig.			.018
Monte Carlo Sig.	Sig.		.014[c]
	95% Confidence Interval	Lower Bound	.012
		Upper Bound	.017

a. Kruskal Wallis Test
b. Grouping Variable: Age
c. Based on 10000 sampled tables with starting seed 957002199.

b. Education level

Ranks

	Highest level of education	N	Mean Rank
Overall hygiene practices	Did not go to school	17	86.65
	Primary	99	94.51
	Secondary	83	118.22
	Tertiary	8	110.75
	Total	207	

Test Statistics[a,b]

			Overall hygiene practices
Chi-Square			8.750
df			3
Asymp. Sig.			.033
Monte Carlo Sig.	Sig.		.028[c]
	95% Confidence Interval	Lower Bound	.025
		Upper Bound	.032

a. Kruskal Wallis Test
b. Grouping Variable: Highest level of education
c. Based on 10000 sampled tables with starting seed 112562564.

c. Experience level

Ranks

	Years of work experience	N	Mean Rank
Overall hygiene practices	<1	9	64.11
	1-5	78	103.85
	6-10	47	85.10
	>10	73	121.25
	Total	207	

Test Statistics[a,b]

			Overall hygiene practices
Chi-Square			14.826
df			3
Asymp. Sig.			.002
Monte Carlo Sig.	Sig.		.001[c]
	95% Confidence Interval	Lower Bound	.000
		Upper Bound	.002

a. Kruskal Wallis Test
b. Grouping Variable: Years of work experience
c. Based on 10000 sampled tables with starting seed 221623949.

d. Profession

Ranks

	Profession of respondent	N	Mean Rank
Overall hygiene practices	Sticking/bleeding	21	112.88
	Flaying	28	123.77
	Evisceration	37	121.30
	Splitting/quartering	53	92.81
	Green offal section	68	92.43
	Total	207	

Test Statistics[a,b]

			Overall hygiene practices
Chi-Square			11.056
df			4
Asymp. Sig.			.026
Monte Carlo Sig.	Sig.		.026[c]
	95% Confidence Interval	Lower Bound	.023
		Upper Bound	.029

a. Kruskal Wallis Test
b. Grouping Variable: Profession of respondent
c. Based on 10000 sampled tables with starting seed 303130861.

Appendix 11 Statistical output

Nonparametric Correlations (Demographic characteristics of meat handlers)

Correlations

			Profession of respondent	Gender	Age	Highest level of education	Years of work experience	Training on hygienic handling of meat
Spearman's rho	Profession of respondent	Correlation Coefficient	1.000	.494**	-.353**	.168*	-.415**	.369**
		Sig. (2-tailed)	.	.000	.000	.016	.000	.000
		N	207	207	207	207	207	206
	Gender	Correlation Coefficient	.494**	1.000	-.155*	.050	-.230**	.139*
		Sig. (2-tailed)	.000	.	.026	.476	.001	.046
		N	207	207	207	207	207	206
	Age	Correlation Coefficient	-.353**	-.155*	1.000	-.216**	.487**	-.175*
		Sig. (2-tailed)	.000	.026	.	.002	.000	.012
		N	207	207	207	207	207	206
	Highest level of education	Correlation Coefficient	.168*	.050	-.216**	1.000	-.233**	.058
		Sig. (2-tailed)	.016	.476	.002	.	.001	.411
		N	207	207	207	207	207	206
	Years of work experience	Correlation Coefficient	-.415**	-.230**	.487**	-.233**	1.000	-.301**
		Sig. (2-tailed)	.000	.001	.000	.001	.	.000
		N	207	207	207	207	207	206
	Training on hygienic handling of meat	Correlation Coefficient	.369**	.139*	-.175*	.058	-.301**	1.000
		Sig. (2-tailed)	.000	.046	.012	.411	.000	.
		N	206	206	206	206	206	206

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Appendix 12 Statistical output

Prediction equation for the overall level of hygiene practices using regression analysis (a step-wise regression analysis)

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Profession of respondent	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	Years of work experience	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
3	Training on hygienic handling of meat	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: Overall hygiene practices

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	Age	-.023[b]	-.321	.748	-.023	.876
	Highest level of education	.121[b]	1.751	.082	.122	.971
	Years of work experience	-.216[b]	-2.956	.003	-.203	.838
	Training on hygienic handling of meat	-.131[b]	-1.788	.075	-.125	.857
2	Age	.068[c]	.875	.383	.061	.747
	Highest level of education	.088[c]	1.283	.201	.090	.942
	Training on hygienic handling of meat	-.174[c]	-2.392	.018	-.166	.831
3	Age	.067[d]	.874	.383	.062	.747
	Highest level of education	.078[d]	1.140	.255	.080	.938

a. Dependent Variable: Overall hygiene practices
b. Predictors in the Model: (Constant), Profession of respondent
c. Predictors in the Model: (Constant), Profession of respondent, Years of work experience
d. Predictors in the Model: (Constant), Profession of respondent, Years of work experience, Training on hygienic handling of meat

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.225[a]	.050	.046	.88002	.050	10.838	1	204	.001
2	.299[b]	.090	.081	.86378	.039	8.740	1	203	.003
3	.339[c]	.115	.102	.85391	.025	5.719	1	202	.018

a. Predictors: (Constant), Profession of respondent
b. Predictors: (Constant), Profession of respondent, Years of work experience
c. Predictors: (Constant), Profession of respondent, Years of work experience, Training on hygienic handling of meat

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8.393	1	8.393	10.838	.001[b]
	Residual	157.984	204	.774		
	Total	166.377	205			
2	Regression	14.914	2	7.457	9.994	.000[c]
	Residual	151.463	203	.746		
	Total	166.377	205			
3	Regression	19.085	3	6.362	8.724	.000[d]
	Residual	147.292	202	.729		
	Total	166.377	205			

a. Dependent Variable: Overall hygiene practices
b. Predictors: (Constant), Profession of respondent
c. Predictors: (Constant), Profession of respondent, Years of work experience
d. Predictors: (Constant), Profession of respondent, Years of work experience, Training on hygienic handling of meat

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations		
		B	Std. Error	Beta			Zero-order	Partial	Part
1	(Constant)	17.631	.175		100.801	.000			
	Profession of respondent	-.151	.046	-.225	-3.292	.001	-.225	-.225	-.225
2	(Constant)	18.441	.323		57.015	.000			
	Profession of respondent	-.209	.049	-.312	-4.261	.000	-.225	-.287	-.285
	Years of work experience	-.207	.070	-.216	-2.956	.003	-.091	-.203	-.198
3	(Constant)	18.909	.375		50.439	.000			
	Profession of respondent	-.174	.051	-.258	-3.415	.001	-.225	-.234	-.226
	Years of work experience	-.237	.070	-.247	-3.362	.001	-.091	-.230	-.223
	Training on hygienic handling of meat	-.319	.133	-.174	-2.392	.018	-.197	-.166	-.158

a. Dependent Variable: Overall hygiene practices

Appendix 13 Statistical output

1) ANOVA output for contamination of carcasses at various slaughter stages with hygiene indicators

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Aerobic plate counts (S1)-Carcass	Between Groups	7.172	3	2.391	13.765	.002
	Within Groups	1.389	8	.174		
	Total	8.561	11			
Enterobacteriaceae (S1)-Carcass	Between Groups	2.856	3	.952	3.857	.056
	Within Groups	1.974	8	.247		
	Total	4.830	11			
Aerobic plate counts (S2)-Carcass	Between Groups	.694	3	.231	5.607	.023
	Within Groups	.330	8	.041		
	Total	1.024	11			
Enterobacteriaceae (S2)-Carcass	Between Groups	.896	3	.299	1.210	.367
	Within Groups	1.975	8	.247		
	Total	2.871	11			
Aerobic plate counts (S3)-Carcass	Between Groups	2.745	3	.915	6.874	.013
	Within Groups	1.065	8	.133		
	Total	3.809	11			
Enterobacteriaceae (S3)-Carcass	Between Groups	1.225	3	.408	12.920	.002
	Within Groups	.253	8	.032		
	Total	1.478	11			
Aerobic plate counts (S4)-Carcass	Between Groups	3.232	3	1.077	6.461	.016
	Within Groups	1.334	8	.167		
	Total	4.565	11			
Enterobacteriaceae (S4)-Carcass	Between Groups	1.766	3	.589	7.847	.009
	Within Groups	.600	8	.075		
	Total	2.366	11			
Aerobic plate counts (S5)-Carcass	Between Groups	1.793	3	.598	5.345	.026
	Within Groups	.895	8	.112		
	Total	2.688	11			
Enterobacteriaceae (S5)-Carcass	Between Groups	1.456	3	.485	9.516	.005
	Within Groups	.408	8	.051		
	Total	1.864	11			

2) Separation of statistically significant means using Duncan's means separation technique

a. Aerobic plate counts in slaughterhouse 1

Aerobic plate counts (S1)-Carcass

Duncan[a]

Potential Contamination Point	N	Subset for alpha = 0.05		
		1	2	3
Flaying	3	2.5833		
Evisceration	3		3.4500	
Dispatch	3			4.3700
Splitting	3			4.4967
Sig.		1.000	1.000	.719

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

b. *Enterobacteriaceae* in slaughterhouse 2

Enterobacteriaceae **(S1)-Carcass**

Duncan[a]

Potential Contamination Point	N	Subset for alpha = 0.05	
		1	2
Flaying	3	1.3567	
Splitting	3	1.6233	
Dispatch	3	1.7400	1.7400
Evisceration	3		2.6533
Sig.		.391	.054

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

c. Aerobic plate count is slaughterhouse 2

Aerobic plate counts (S2)-Carcass

Duncan[a]

Potential Contamination Point	N	Subset for alpha = 0.05		
		1	2	3
Flaying	3	3.5833		
Dispatch	3	3.7467	3.7467	
Evisceration	3		4.0600	4.0600
Splitting	3			4.1867
Sig.		.354	.096	.467

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

d. Aerobic plate counts in slaughterhouse 3

Aerobic plate counts (S3)-Carcass

Duncan[a]

Potential Contamination Point	N	Subset for alpha = 0.05	
		1	2
Evisceration	3	3.0733	
Flaying	3	3.2733	
Dispatch	3		4.0067
Splitting	3		4.2100
Sig.		.521	.514

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

e. *Enterobacteriaceae* in slaughterhouse 3

Enterobacteriaceae **(S3)-Carcass**

Duncan[a]

Potential Contamination Point	N	Subset for alpha = 0.05		
		1	2	3
Evisceration	3	.7900		
Dispatch	3	1.0033	1.0033	
Flaying	3		1.2967	
Splitting	3			1.6400
Sig.		.180	.078	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

f. Aerobic plate counts in slaughterhouse 4

Aerobic plate counts (S4)-Carcass

Duncan[a]

Potential Contamination Point	N	Subset for alpha = 0.05	
		1	2
Flaying	3	2.7000	
Dispatch	3	3.3800	3.3800
Evisceration	3		3.9033
Splitting	3		4.0100
Sig.		.076	.107

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

g. *Enterobacteriaceae* in slaughterhouse 4

***Enterobacteriaceae* (S4)-Carcass**

Duncan[a]

Potential Contamination Point	N	Subset for alpha = 0.05	
		1	2
Flaying	3	.8000	
Dispatch	3		1.4967
Evisceration	3		1.6033
Splitting	3		1.8267
Sig.		1.000	.195

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

h. Aerobic plate counts in slaughterhouse 5

Aerobic plate counts (S5)-Carcass

Duncan[a]

Potential Contamination Point	N	Subset for alpha = 0.05	
		1	2
Flaying	3	3.0000	
Evisceration	3	3.4567	3.4567
Splitting	3		3.8333
Dispatch	3		4.0067
Sig.		.133	.089

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

Appendix 14 Statistical output

1) ANOVA-Contamination of personnel hands at various slaughter stages with hygiene indicators

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Aerobic plate counts (S1)-Hand	Between Groups	6.158	2	3.079	34.957	.000
	Within Groups	.528	6	.088		
	Total	6.686	8			
S. aureus (S1)-Hand	Between Groups	3.043	2	1.521	2.685	.047
	Within Groups	3.400	6	.567		
	Total	6.443	8			
Enterobacteriaceae (S1)-Hand	Between Groups	.712	2	.356	4.172	.043
	Within Groups	.512	6	.085		
	Total	1.223	8			
Aerobic plate counts (S2)-Hand	Between Groups	2.068	2	1.034	7.252	.025
	Within Groups	.856	6	.143		
	Total	2.924	8			
S. aureus (S2)-Hand	Between Groups	1.688	2	.844	2.060	.028
	Within Groups	2.458	6	.410		
	Total	4.147	8			
Enterobacteriaceae (S2)-Hand	Between Groups	1.668	2	.834	5.902	.038
	Within Groups	.848	6	.141		
	Total	2.516	8			
Aerobic plate counts (S3)-Hand	Between Groups	2.275	2	1.138	7.782	.022
	Within Groups	.877	6	.146		
	Total	3.153	8			
S. aureus (S3)-Hand	Between Groups	.216	2	.108	5.913	.038
	Within Groups	.110	6	.018		
	Total	.326	8			
Enterobacteriaceae (S3)-Hand	Between Groups	.975	2	.488	4.459	.045
	Within Groups	.656	6	.109		
	Total	1.631	8			
Aerobic plate counts (S4)-Hand	Between Groups	.421	2	.211	.999	.422
	Within Groups	1.264	6	.211		
	Total	1.685	8			
S. aureus (S4)-Hand	Between Groups	.063	2	.031	.567	.595
	Within Groups	.331	6	.055		
	Total	.394	8			
Enterobacteriaceae (S4)-Hand	Between Groups	1.748	2	.874	4.668	.040
	Within Groups	1.124	6	.187		
	Total	2.872	8			
Aerobic plate counts (S5)-Hand	Between Groups	3.653	2	1.826	22.561	.002
	Within Groups	.486	6	.081		
	Total	4.139	8			
S. aureus (S5)-Hand	Between Groups	.622	2	.311	4.579	.042
	Within Groups	.407	6	.068		
	Total	1.029	8			
Enterobacteriaceae (S5)-Hand	Between Groups	.960	2	.480	1.794	.245
	Within Groups	1.606	6	.268		
	Total	2.566	8			

2) Separation of statistically significant means using Duncan's means separation technique

a. Aerobic plate counts in slaughterhouse 1

Aerobic plate counts (S1)-Hand

Duncan[a]

Potential Contamination Point	N	Subset for alpha = 0.05		
		1	2	3
Splitting	3	2.7500		
Evisceration	3		3.6233	
Flaying	3			4.7700
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

b. *Staphylococcus aureus* in slaughterhouse 1

***S. aureus* (S1)-Hand**

Duncan[a]

Potential Contamination Point	N	Subset for alpha = 0.05		
		1	2	3
Splitting	3	.5933		
Evisceration	3		1.2600	
Flaying	3			2.0167
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

c. *Enterobacteriaceae* in slaughterhouse 1

***Enterobacteriaceae* (S1)-Hand**

Duncan[a]

Potential Contamination Point	N	Subset for alpha = 0.05	
		1	2
Splitting	3	.2000	
Evisceration	3	.3967	.3967
Flaying	3		.8700
Sig.		.441	.094

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

d. Aerobic plate counts in slaughterhouse 2

Aerobic plate counts (S2)-Hand

Duncan[a]

Potential Contamination Point	N	Subset for alpha = 0.05	
		1	2
Splitting	3	4.0900	
Evisceration	3	4.8433	4.8433
Flaying	3		5.2467
Sig.		.050	.239

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

e. *Staphylococcus aureus* in slaughterhouse 2

***S. aureus* (S2)-Hand**

Duncan[a]

Potential Contamination Point	N	Subset for alpha = 0.05		
		1	2	3
Splitting	3	1.6733		
Evisceration	3		2.4000	
Flaying	3			3.0567
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

f. *Enterobacteriaceae* in slaughterhouse 2

***Enterobacteriaceae* (S2)-Hand**

Duncan[a]

Potential Contamination Point	N	Subset for alpha = 0.05	
		1	2
Splitting	3	.9733	
Evisceration	3	1.5833	1.5833
Flaying	3		2.0233
Sig.		.094	.202

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

g. Aerobic plate counts in slaughterhouse 3

Aerobic plate counts (S3)-Hand

Duncan[a]

Potential Contamination Point	N	Subset for alpha = 0.05	
		1	2
Splitting	3	4.0367	
Evisceration	3	4.5967	4.5967
Flaying	3		5.2567
Sig.		.123	.076

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

h. *Staphylococcus aureus* in slaughterhouse 3

***S. aureus* (S3)-Hand**

Duncan[a]

Potential Contamination Point	N	Subset for alpha = 0.05	
		1	2
Splitting	3	1.3267	
Evisceration	3		1.6433
Flaying	3		1.6667
Sig.		1.000	.840

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

i. *Enterobacteriaceae* in slaughterhouse 3

***Enterobacteriaceae* (S3)-Hand**

Duncan[a]

Potential Contamination Point	N	Subset for alpha = 0.05	
		1	2
Splitting	3	.5667	
Evisceration	3	.8800	.8800
Flaying	3		1.3667
Sig.		.290	.121

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

j. *Enterobacteriaceae* in slaughterhouse 4

***Enterobacteriaceae* (S4)-Hand**

Duncan[a]

Potential Contamination Point	N	Subset for alpha = 0.05	
		1	2
Splitting	3	.6833	
Evisceration	3	1.4033	1.4033
Flaying	3		1.7400
Sig.		.088	.377

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

k. Aerobic plate counts in slaughterhouse 5

Aerobic plate counts (S5)-Hand

Duncan[a]

Potential Contamination Point	N	Subset for alpha = 0.05		
		1	2	3
Splitting	3	3.2333		
Evisceration	3		4.1067	
Flaying	3			4.7900
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

l. *Staphylococcus aureus* in slaughterhouse 5

***S. aureus* (S5)-Hand**

Duncan[a]

Potential Contamination Point	N	Subset for alpha = 0.05	
		1	2
Splitting	3	.9633	
Evisceration	3	1.3800	1.3800
Flaying	3		1.5967
Sig.		.098	.348

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

Appendix 15 Statistical output

1) ANOVA-Contamination of personnel clothes at various slaughter stages with hygiene indicators

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Aerobic plate counts (S1)-Clothes	Between Groups	2.700	2	1.350	1.920	.227
	Within Groups	4.219	6	.703		
	Total	6.919	8			
S. aureus (S1)-Clothes	Between Groups	.187	2	.093	.431	.668
	Within Groups	1.299	6	.216		
	Total	1.485	8			
Enterobacteriaceae (S1)-Clothes	Between Groups	3.021	2	1.511	1.246	.353
	Within Groups	7.275	6	1.213		
	Total	10.297	8			
Aerobic plate counts (S2)-Clothes	Between Groups	5.264	2	2.632	7.834	.021
	Within Groups	2.016	6	.336		
	Total	7.280	8			
S. aureus (S2)-Clothes	Between Groups	3.345	2	1.672	12.033	.008
	Within Groups	.834	6	.139		
	Total	4.179	8			
Enterobacteriaceae (S2)-Clothes	Between Groups	1.557	2	.778	.646	.557
	Within Groups	7.227	6	1.204		
	Total	8.784	8			
Aerobic plate counts (S3)-Clothes	Between Groups	.538	2	.269	.436	.666
	Within Groups	3.704	6	.617		
	Total	4.242	8			
S. aureus (S3)-Clothes	Between Groups	1.521	2	.761	16.498	.004
	Within Groups	.277	6	.046		
	Total	1.798	8			
Enterobacteriaceae (S3)-Clothes	Between Groups	.112	2	.056	1.266	.348
	Within Groups	.267	6	.044		
	Total	.379	8			
Aerobic plate counts (S4)-Clothes	Between Groups	2.614	2	1.307	9.378	.014
	Within Groups	.836	6	.139		
	Total	3.451	8			
S. aureus (S4)-Clothes	Between Groups	3.768	2	1.884	11.163	.010
	Within Groups	1.013	6	.169		
	Total	4.781	8			
Enterobacteriaceae (S4)-Clothes	Between Groups	1.526	2	.763	5.736	.060
	Within Groups	.798	6	.133		
	Total	2.324	8			
Aerobic plate counts (S5)-Clothes	Between Groups	1.706	2	.853	2.065	.208
	Within Groups	2.479	6	.413		
	Total	4.185	8			
S. aureus (S5)-Clothes	Between Groups	4.085	2	2.043	12.481	.007
	Within Groups	.982	6	.164		
	Total	5.067	8			
Enterobacteriaceae (S5)-Clothes	Between Groups	.659	2	.330	.596	.581
	Within Groups	3.318	6	.553		
	Total	3.977	8			

2) Separation of statistically significant means using Duncan's means separation technique

a. Aerobic plate counts in slaughterhouse 2

Aerobic plate counts (S2)-Clothes

Duncan[a]

Potential Contamination Point	N	Subset for alpha = 0.05	
		1	2
Splitting	3	3.0500	
Evisceration	3	3.9967	3.9967
Flaying	3		4.9233
Sig.		.092	.098

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

b. *Staphylococcus aureus* in slaughterhouse 2

***S. aureus* (S2)-Clothes**

Duncan[a]

Potential Contamination Point	N	Subset for alpha = 0.05	
		1	2
Evisceration	3	1.7467	
Splitting	3	1.8767	
Flaying	3		3.4300
Sig.		.684	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

c. *Staphylococcus aureus* in slaughterhouse 3

***S. aureus* (S3)-Clothes**

Duncan[a]

Potential Contamination Point	N	Subset for alpha = 0.05	
		1	2
Splitting	3	1.9333	
Evisceration	3		2.6767
Flaying	3		2.8933
Sig.		1.000	.263

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

d. Aerobic plate counts in slaughterhouse 4

Aerobic plate counts (S4)-Clothes

Duncan[a]

Potential Contamination Point	N	Subset for alpha = 0.05	
		1	2
Splitting	3	3.2633	
Flaying	3		4.4033
Evisceration	3		4.4100
Sig.		1.000	.983

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

e. *Staphylococcus aureus* in slaughterhouse 4

S. aureus **(S4)-Clothes**

Duncan[a]

Potential Contamination Point	N	Subset for alpha = 0.05	
		1	2
Splitting	3	1.6600	
Evisceration	3	1.9467	
Flaying	3		3.1533
Sig.		.426	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

f. *Staphylococcus aureus* in slaughterhouse 5

S. aureus **(S5)-Clothes**

Duncan[a]

Potential Contamination Point	N	Subset for alpha = 0.05	
		1	2
Splitting	3	1.6233	
Evisceration	3	1.8100	
Flaying	3		3.1367
Sig.		.592	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

Appendix 16 Statistical output

Independent t-Test -Contamination of knives at flaying and evisceration with hygiene indicators

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Aerobic plate counts (S1)-Knives	Equal variances assumed	.021	.891	1.564	4	.193	.81000	.51806	-.62837	2.24837
	Equal variances not assumed			1.564	3.981	.193	.81000	.51806	-.63105	2.25105
Enterobacteriaceae (S1)-Knives	Equal variances assumed	4.292	.107	-1.182	4	.303	-.79000	.66827	-2.64542	1.06542
	Equal variances not assumed			-1.182	2.264	.346	-.79000	.66827	-3.36665	1.78665
Aerobic plate counts (S2)-Knives	Equal variances assumed	.201	.677	-4.112	4	.015	-.94000	.22862	-1.57475	-.30525
	Equal variances not assumed			-4.112	3.649	.018	-.94000	.22862	-1.59954	-.28046
Enterobacteriaceae (S2)-Knives	Equal variances assumed	5.352	.082	-.931	4	.404	-.56667	.60848	-2.25607	1.12274
	Equal variances not assumed			-.931	2.431	.435	-.56667	.60848	-2.78628	1.65295
Aerobic plate counts (S3)-Knives	Equal variances assumed	.162	.707	3.068	4	.037	1.49667	.48788	.14211	2.85123
	Equal variances not assumed			3.068	3.923	.038	1.49667	.48788	.13157	2.86177
Enterobacteriaceae (S3)-Knives	Equal variances assumed	5.742	.075	-5.520	4	.005	-.77000	.13948	-1.15727	-.38273
	Equal variances not assumed			-5.520	2.152	.027	-.77000	.13948	-1.33141	-.20859
Aerobic plate counts (S4)-Knives	Equal variances assumed	2.243	.209	.630	4	.563	.35667	.56611	-1.21510	1.92843
	Equal variances not assumed			.630	2.876	.575	.35667	.56611	-1.48982	2.20315
Enterobacteriaceae (S4)-Knives	Equal variances assumed	2.112	.220	.066	4	.950	.02667	.40222	-1.09006	1.14340
	Equal variances not assumed			.066	2.368	.952	.02667	.40222	-1.47001	1.52334
Aerobic plate counts (S5)-Knives	Equal variances assumed	.005	.948	-1.981	4	.119	-.61000	.30788	-1.46481	.24481
	Equal variances not assumed			-1.981	3.994	.119	-.61000	.30788	-1.46532	.24532
Enterobacteriaceae (S5)-Knives	Equal variances assumed	9.578	.036	-1.561	4	.194	-.42667	.27333	-1.18556	.33223
	Equal variances not assumed			-1.561	2.004	.259	-.42667	.27333	-1.60038	.74705

Appendix 17 Statistical output

Independent t-Test -Contamination of hooks at splitting and dispatch with hygiene indicators

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Aerobic plate counts (S1)-Hooks	Equal variances assumed	.641	.468	.041	4	.969	.01667	.40712	-1.11367	1.14701
	Equal variances not assumed			.041	3.298	.970	.01667	.40712	-1.21521	1.24855
Enterobacteriaceae (S1)-Hooks	Equal variances assumed	.367	.578	.789	4	.474	.17000	.21554	-.42842	.76842
	Equal variances not assumed			.789	3.769	.477	.17000	.21554	-.44317	.78317
Aerobic plate counts (S2)-Hooks	Equal variances assumed	.262	.636	1.800	4	.146	.62333	.34638	-.33837	1.58503
	Equal variances not assumed			1.800	3.684	.152	.62333	.34638	-.37174	1.61840
Enterobacteriaceae (S2)-Hooks	Equal variances assumed	1.742	.257	1.556	4	.195	.79667	.51210	-.62515	2.21848
	Equal variances not assumed			1.556	2.576	.232	.79667	.51210	-.99583	2.58917
Aerobic plate counts (S3)-Hooks	Equal variances assumed	1.537	.283	1.624	4	.180	.61333	.37764	-.43516	1.66183
	Equal variances not assumed			1.624	3.056	.201	.61333	.37764	-.57610	1.80276
Enterobacteriaceae (S3)-Hooks	Equal variances assumed	1.255	.325	-.184	4	.863	-.05000	.27176	-.80454	.70454
	Equal variances not assumed			-.184	3.460	.864	-.05000	.27176	-.85329	.75329
Aerobic plate counts (S4)-Hooks	Equal variances assumed	2.852	.167	1.234	4	.285	.84000	.68069	-1.04989	2.72989
	Equal variances not assumed			1.234	2.915	.307	.84000	.68069	-1.36257	3.04257
Enterobacteriaceae (S4)-Hooks	Equal variances assumed	10.341	.032	2.217	4	.091	.23333	.10525	-.05889	.52556
	Equal variances not assumed			2.217	2.036	.155	.23333	.10525	-.21185	.67852
Aerobic plate counts (S5)-Hooks	Equal variances assumed	.028	.876	-.008	4	.994	-.00333	.43785	-1.21900	1.21233
	Equal variances not assumed			-.008	3.987	.994	-.00333	.43785	-1.22061	1.21394
Enterobacteriaceae (S5)-Hooks	Equal variances assumed	1.343	.311	-.263	4	.806	-.04333	.16486	-.50105	.41438
	Equal variances not assumed			-.263	2.623	.812	-.04333	.16486	-.61329	.52663