oA STUDY OF CONDITIONS CAUSING CARCASS AND ORGAN CONDEMNATION DURING MEAT INSPECTION AND THEIR FINANCIAL IMPLICATIONS IN KISII COUNTY, KENYA

A thesis submitted in partial fulfillment of Master of Veterinary Public Health, University of Nairobi

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DECLARATION

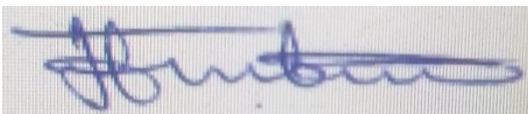This thesis is my original work and has not been presented for award of any degree in any other University.

Signature_____ Date **16TH February 2023**

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This thesis has been submitted to the University of Nairobi with our approval as supervisors,

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DEDICATION

I dedicate the works of this thesis to my wife Charity and our Children who supported me at every stage and gave me ample time to be able to concentrate on my studies and research.

ACKNOWLEDGEMENTS

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ABSTRACT

Meat inspection is an important activity along the value chain that not only guarantee food safety but equally plays an important role in safeguarding public health. The overall goal of meat inspection is to provide risk free meat products to the society. These risks include diseases and contaminants that make animal products unfit for human consumption. Kisii County is an important source of red meat in Kenya but the type and prevalence of conditions causing carcass/organ condemnation and their financial implication remains unknown.

The aim of this study was to determine the incidence and financial implication attributed to conditions causing carcass/organ condemnation in Kisii county and further evaluate knowledge and practices of meat inspectors and meat/livestock traders regarding conditions associated with condemnation of carcass/organs. The County meat inspection records from January 2004 to December 2014 were scrutinized and data related to species slaughtered, carcass/organ condemned and conditions causing carcass/organ condemnation were extracted and recorded. A questionnaire was administered to meat inspector and traders to collect data regarding their knowledge and practices on conditions causing condemnation of carcasses and organs. Financial losses attributed to carcass and organ condemnation was estimated using previously described tools.

In the period between 2004-2014, a total of 108,622 animals were slaughtered in abattoirs within Kisii County. Out of the 108,622 animals, 45.6% (49,481) were cattle, 43.1% (46,802) were goats and 11.4% (12,339) were sheep. A total of 3,245 whole carcasses condemned in the study period out of which 1,478 were from cattle, 1,399 from goats and 369 were sheep. With regards to specific organs that were condemned, 43.5% (19,317) were lungs, 33.1% (14,697) were livers, 9.7% (4,315) were kidneys, 8.8% (3,919) were intestines and stomach, 3.7% (1,643) were hearts and 1.1% (480) heads and tongues. Incomplete bleeding was the

major cause of whole carcass condemnation. Liver cirrhosis and degeneration accounted for 48.1% of causes of liver condemnation across the three species. Abscesses (32.5%), pleurisy (22.5%) and pneumonia (15.2%) accounted for the major reasons for condemnation of lungs. While the main reasons for condemnation of kidneys in bovine and shoats in Kisii County were hydronephrosis 34.1% (1471/4315), nephritis 26.1% (1124/4315) and inflammation of capsule 24.4% (1053/4315).

A total of 87 randomly selected respondents participated in this a questionnaire survey. Out of the 87 respondents, 11.5% (10/87) were meat inspectors, 72.4% (63/87) were meat traders and 16.1% (14/87) were live animal trader. About 10.0% of meat inspectors and 4.7% of traders demonstrated knowledge of zoonosis. The criteria used to select animals for slaughter according to respondents were healthy animals, animals at prime age of reproduction and male ones. The total estimated financial loss attributed to carcass/organ condemnation in Kisii County between 2004 and 2014 was KES 57,121,157.22 (571211.57USD) which translated to approximate loss of KES 476,009.64 per month.

It was concluded that incomplete bleeding was the main cause of whole carcass condemnation while liver cirrhosis and lung abscess were leading cause of organ condemnation in Kisii County. Although a high number of meat inspectors and meat/livestock traders could identify conditions responsible for condemnation of carcass/organs in abattoirs, their knowledge on zoonotic conditions was inadequate. Condemnation of carcasses and organs in abattoirs in Kisii County was associated with high economic losses, which was estimated to be around 571,211.57 USD annually.

In order to guarantee food safety and safeguard public health, this study recommends further training and continuous education of meat inspectors working in Kisii County. This would heighten their ability to recognize conditions that require condemnation of organs, more so

zoonotic diseases that pose a greater threat to public health. Additionally, it will be imperative for Kisii County Government to invest more in infrastructure of slaughter houses in addition to employing more meat inspectors.

CHAPTER ONE: Introduction

The increase the in global human population has increased demand for food of animal origin (Gutema *et al.,* 2021). Ensuring safe meat supply to the population has proved to be a challenge in resource limited countries due lack of recommended slaughter facilities and substandard slaughtering techniques which have contributed to meat contamination and therefore causing food poisoning in humans (Joshi *et al.*, 2003). Food can be contaminated by parasites, viruses, bacteria or chemicals. Foodborne diseases are estimated to cause 600 million cases and 420,000 deaths each year worldwide (WHO, 2022). These diseases also account for most diarrheal cases in low- and middle-income countries (Grace, 2015). They have also contributed significantly to the global burden of disease and mortality thus lowering productivity, which have put a strain on health-care systems and harm on tourism and trade (WHO, 2022). Lack of regulations governing the meat inspection and lack of implementation to the existing laws in developing countries is also a major challenge which have exposed consumers to zoonotic parasites (Joshi *et al.,* 2003).

In Kenya, the meat industry is regulated by the meat control act (CAP, 356). The law provides guidelines on inspection and licensing of slaughter facilities, hygiene practices to be observed during slaughtering process, meat inspection and transportation of meat and meat products. Ensuring quality meat inspection and hygiene practices are followed during slaughter is therefore important to protect public health by providing risk free products to the

society (Denbarga, 2011). Also, meat inspection provides information that can be utilized for control of notifiable animal diseases which have a zoonotic potential (Gracy, 1999). Abattoir data is an excellent option for detecting diseases of both economic and public health importance (Arbabi, 2006, Abunna, 2010), especially in ascertaining the extent to which man is exposed to certain zoonotic diseases in addition to estimating the financial implications of carcass condemnations (Jobre, 1996). Meat inspection and hygiene is also important in monitoring of Transboundary animal disease transmission within the country.

The Kenyan population presently stands at 47 million and it is projected to grow to 96 million by 2050. Consequently, the demand for animal-source food supplies has been on the increase (KNBS, 2019). Kisii county is among the highest populated counties in Kenya with a population of 1,266,860 occupying 1,323.0 square kilometers (KNBS, 2019). The national livestock population comprises 18.8 million cattle, 26.7 million goats, 18.9 million sheep, 3.2 million camels, 44.6 44.6 million poultry, 1.9 million donkeys, o.5 million pigs and an undetermined number of companion game and aquatic animals. Red meat comprises 80 % of the meat that is consumed in the country averaging to 15.5kg per capita consumption with an annual production of about 600,000 metric tons (Muhoro, 2014). The highest percent of these animals (65-70%) are sourced from the Kenyan Pastoral communities and the rest from informal cross border trade with neighboring counties which include mainly Tanzania, South Sudan, Ethiopia and Somalia (Kenya Market Trust, 2019). Rabbit keeping and pig farming is also gaining momentum among farmers in the county. The market for livestock supplies is increasingly expanding both locally and globally hence necessitating proper meat inspection in control of animal and zoonotic diseases in Kenya. According to Evelyn and Waithaka (2005), nearly all the cattle sourced at Moyale and some of the cattle and goats purchased at

Mandera market originate from the Borana and Somali regions of Ethiopia. Small numbers of cattle originating from Eastern South Sudan and the South-western part of Ethiopia are routed to Eldoret and Nairobi through Lokichogio and Lodwar. A significant proportion of the cattle in Garissa market come from Somalia. Similarly, livestock from Tanzania are routed to Kuria in Migori County through Kisii County and then to the terminal markets in Nairobi.

There is a great demand for slaughter services in Kisii County given the increasing meat consumption and animal traffic to Nairobi and neighboring markets. Currently there are 7 main slaughterhouses which include (Riosiri, Suneka, Kisii Municipal, Keroka, Ogembo and Marani) which not only serves Kisii but also export their products to Nairobi County. There are also 36 slaughter slabs distributed evenly within the county. These slaughter facilities are overwhelmed and do not meet the required hygiene standards (www.kisii.go.ke-invest in livestock). A study done by Nyarango *et al.*, (2008) concluded that there was a high risk of infection with intestinal parasites in Kisii municipal markets. About 65.5% of meat sold at the Kisii Municipal market was found to be contaminated with parasites hence the need to the stakeholders on food safety and good distribution practices.

It is therefore significant to conduct this study in Kisii County as it is one of the recognized livestock meat terminal markets and transit route in Kenya. In addition, it is important in disease monitoring as some livestock slaughtered in this region are from Tanzania and may have found their way into Kenya through informal routes which are a threat to disease spread.

1.1 Problem statement

Most slaughterhouses in Kisii do not meet the expected standards. They have poor meat inspection facilities and a shortage of qualified and certified meat and abattoir inspectors. Zoonotic diseases especially tuberculosis and brucellosis, both of which are transmissible through meat, have been seen to be on the increase based on unpublished hospital records in Kisii County. With increasing beef consumption in and out of Kisii County and the increasing livestock movement through Kisii County for slaughter and transportation to terminal markets in other urban centres, it was prudent to investigate conditions of economic and public health importance that are commonly encountered in slaughterhouses and slabs within the borders of Kisii.

1.2   Justification

The few studies done in Kisii on conditions of public health importance have indicated that there is a relatively high occurrence of zoonotic conditions with a high risk of infection to humans. In addition, these studies have indicated that hygiene levels in slaughterhouses in Kisii County are substandard. This situation notwithstanding, few studies have been documented with regards to causes of condemnation of organs and carcasses in slaughterhouses in the county and the economic implication of these conditions. This study identifies the occurrence of these conditions and their economic significance to the stakeholders.

1.2 Hypothesis

Conditions responsible for condemnation of carcasses and organs during meat inspection are of great economic and public health significance in Kisii County.

1.4   Overall objective

To identify the conditions causing condemnation of carcasses and organs during meat inspection in Kisii County from 2004-2014, and assess their financial and public health significance.

1.4.1 Specific objectives

1.   To identify conditions causing carcass and organ condemnations during meat inspection in Kisii County from 2004 - 2014.

2.   To estimate the financial losses attributed to carcass and organ condemnation in Kisii County from 2004-2014.

3.   To determine knowledge and practices of meat inspectors and trader on carcass and organ condemnation in Kisii County.

CHAPTER TWO: LITERATURE REVIEW

2.1 General introduction

Red meat represents 80% of domestic meat consumption in Kenya, and cattle are Kenya's main source of red meat (EPZA, 2005). In 2009, cattle meat accounted for 73% of the total meat consumed by Kenyans (FAOSTAT Food Balance Sheet, 2012). A bulk of the cattle meat supply in Kenya comes from the country's ASALs, while only a small portion comes from dairy herds (EPZA, 2005). Geographically, meat consumption in Kenya is highest in Mombasa and Nairobi, where annual per capita beef consumption is estimated at 15 and 18.25 kg, respectively. (Deloitte, 2006). In Kisii County where the current study was carried out, the annual beef consumption is estimated to be 3.25 kg per capita (Deloitte, 2006).

In Kenya, terminal markets for livestock meat are located close to large urban areas. These terminal markets include Nairobi, Nyahururu, Isiolo, Meru and Nyeri for the North-central axis; Kisumu, Kisii, Eldoret, Nakuru, Naivasha and Nairobi for the North- western axis; and Nairobi and Machakos on the Southern axis. The coastal terminal markets are on the North-western and North-central axis and to a minor extent on the Southern axis; Kajiado (Muthee, 2006).

2.2 General conditions that cause carcass or organ condemnation

Organs and carcasses in slaughterhouses are condemned for various reasons. In Iraq, about, 2,741 large animals (cattle and camels) and 77,515 small animals (sheep and goats) were slaughtered between June 2011 and March 2012. Of all animals slaughtered 0.21% of the large animals and 0.02% of the small animals were condemned. Organs such as liver, lungs and kidneys for the large animals were condemned at a rate of 5.36%, 21.23% and 3.68% respectively for the large animals and 4.37%, 5.46% and 0.51% respectively for the small animals. The main reasons for carcass condemnations in both large and small animals were icterus and cachexia while organ condemnations were attributed to parasitic infection specially metacestodes (Hajimohammadi *et al.,* 2014).

In Ethiopia, *Stelesia hepatica*, pneumonia, pericarditis and nephritis were found to be the main conditions that caused condemnation of carcasses and organs (Mandefro *et al.,* 2015). Abunna and Hordofa, (2013) reported fasciolosis and hydatidosis as the main cause of condemnation of liver; hydatid diseases and emphysema for lungs; unknown causes, pericarditis and hydatid cyst for heart; unknown causes and calcification for kidneys and hydatidosis for spleen. Further, a study by Mesele *et al.,* (2012) concluded that total condemnation of organs in slaughterhouses in Ethiopia resulted into major financial loses with the most prevalent conditions being fascioliasis, hydatidosis, cirrhosis, calcification, abscess, pneumonia, emphysema, pericarditis, pyelonephritis, infarcts, hydronephrosis, cysticercosis and wooden tongue.

Studies carried out in Kenya have also demonstrated prevalent carcass and/or organ condemnation in slaughtered animals. Helminthiasis have been reported to be a major cause of complete condemnation of carcasses during meat inspection in Kenya. A study carried out in 5 abattoirs reported that 3643 cattle and 139 sheep and goats were slaughtered during a 6-week study period. Out of this number, 11.8% of the total slaughtered cattle carcasses and 4.6% of sheep and goat carcasses were condemned due to C. bovis (Githigia *et al.,* 1995). Nginyi et al., 1995 reported that the conditions causing organ condemnation in 612 slaughtered sheep and goats were *Stilesia hepatica*, *Echinococcus granulosus*, *Fasciola gigantica*, perihepatitis, unidentified parasites, degeneration and abscesses. In another study, Maingi and Gichingi, (1999) reported high liver condemnation rate in cattle and sheep slaughtered during dry season. Condemnation was mainly occasioned by presence of *Stilesia hepatica*, oesophagostomum and *Cysticercus tennuicollis*.

2.3 Zoonotic conditions that cause carcass or organ condemnation

Meat inspection is an important activity along the value chain that not only guarantee food safety but equally plays an important role in safeguarding public health as some conditions that cause condemnation of carcasses and organs in slaughterhouses are zoonotic in nature. These zoonotic conditions include *C. bovis*, hydatidosis, tuberculosis, brucellosis, rift valley fever. *C. bovis* has been reported as one of the common condition that cause organ condemnation in Ethiopia. A study by Belachew and Ibrahim, (2012) reported a prevalence of *C. bovis* to be 67.74% in examined tongue, 52% in shoulder, 60% in heart and 75% in masseter muscle. *C. bovis* was also shown to have serious financial losses that were estimated

to be about 22,270 USD in human treatments with the cost excluding that accrued due to direct condemnation of carcasses and/or organs (Bekele *et al.,* 2010). In Kenya, cysticercosis has been attributed to high rate of carcass and organ condemnation and the estimated prevalence of the condition in Kisumu county slaughterhouses has been reported to be 38% (Kanyari *et al.,* 2012).

High prevalence of *T. saginata* metacestodes has been reported in edible organs of cattle slaughtered in Addis Ababa (Ibrahim and Zerihun, 2012). The study concluded that emphasis was needed to improve the health and quality of beef in Ethiopia. Hydatidosis has also been reported to be a leading cause of condemnation of liver in shoats (Ghebremariam *et al.*, 2014) and in 40% of all animals slaughtered during a defined study period (Terefe *et al*., 2012). A similar study carried out in Nigeria reported high incidence rate of hydatidosis in bovine liver followed by sheep and goats, while the lungs was the most affected organ in camel (Abdullahi *et al.,* 2011). In Kenya, the prevalence of hydatidosis in slaughtered animals has been reported to be 30% in cattle, 15% in goats and 13% in sheep (Gathura and Kaminya, 1990). In Kisumu east and west districts, hydatid cysts in liver was reported to be 4.2% in cattle, 4.52% in sheep, 2.02% in goats and 0.05% in pigs while in Isiolo district the prevalence was 6% in cattle 1.33% in sheep, 1% in goats and 25.3% in camels (Odero *et al.,* 2015).

Tuberculosis is also an important zoonotic disease that has been reported in 18.95% of the cattle slaughtered in Kenya with 29.6% of isolates being *Mycobacterium bovis* and 3.1% *Mycobacterium tuberculosis* (Gathogo *et al*., 2012). Other important zoonotic diseases that

are associated with condemnation of carcasses and organs in Kenya include brucellosis, hydatidosis, cysticercosis, toxoplasmosis, anthrax and Rift-valley fever (Lichoti, 2003).

2.4 Economic losses associated with carcass or organ condemnation

In Kenya, financial losses associated with condemnation of organs due to Echinococcosis has been estimated to be in excess of 4,976 USD in Kisumu East and West and 4,054USD in Isiolo with proper meat inspection and hygiene being the recommended control measure of the disease (Odero *et al.,* 2015). Gathura and Gathuma (1991) also evaluated the economic losses resulting from condemnation of cattle and small stock (sheep and goats) and concluded that the highest average annual loss for cattle was 97,393.2 USD in 1984, while for small stock it was 5,588.6 USD in 1986 from liver condemnations as a result of hydatid cysts.

Kanyari *et al*., (2012) estimated that annual financial losses associated with condemnation of organs due to Fascioliasis and *Stilesia hepatica* in Kisumu were about USD 12,034. Further Githigia *et al*. 1995 reported losses in five slaughterhouses over a period of 6 weeks to be about 1,262.5 USD for cattle and 24.89 USD for sheep and goats due to helminths. Additionally, Maingi and Gichingi, (1999) estimated that the annual losses from 30 slaughter slabs in central Kenya in the period between June 1994 and May 1995 were approximately USD 7,080 and 15,550 USD for cattle and sheep, respectively.

2.5 Challenges of meat inspection in Kenya

Meat inspection despite being a vital process that can safeguard public health and ensure safe meat for human consumption still faces a myriad of challenges. These challenges include but are not limited to underfunding, poor meat inspection facilities, shortage of qualified and certified meat and abattoir inspectors, ineffective and unskilled meat inspection, poor record keeping and irregularities like bribery during inspection, which lead to passing of unhygienic meat for public consumption (Nanyingi *et. al.,* 2011).

CHAPTER THREE: MATERIALS AND METHODS

3.1 Description of the study area

Kisii County is located to the southeast of Lake Victoria and is bordered by six counties including Narok to the south, Migori to the west, Homa Bay to the Northwest, Bomet to the south east and Nyamira to the east (Figure 1). Kisii town is the administrative headquarter of the County. Formerly the headquarters of the original and larger Kisii District before it was split to create a district located in the north and, a district located in the south. Gucha district was re-absorbed back into Kisii County whereas Nyamira district has since been renamed Nyamira County. Kisii municipality sits right at the centre of the Western Kenya tourist circuit that includes the Tabaka Soapstone Carvings, Maasai Mara Game Reserve, Lambwe Valley Game Reserve and the entire Lake Victoria basin. The County consists of 9 sub counties namely: Kitutu Chache South, Kitutu Chache North, Bonchari, Nyaribari Chache, South Mugirango, Bobasi, Bomachoge Chache, Nyaribari Masaba and Bomachoge Borabu.

Based on the 2019 Population and Housing Census, Kisii population is 1,266,860 (KNBS, 2019). Every household is dependent to some extent on livestock activity for their livelihoods. The County has mixed farming systems but also focuses on intensification and diversification of livestock production activities aimed at increasing production and ultimately promoting food security (Odhiambo, 2013). The main livestock kept in Kisii County are cattle, goats, sheep, donkeys, poultry, pigs and rabbits. Of these, cattle, goats, sheep and poultry are the most commonly slaughtered species for meat.

Kisii County has six slaughterhouses namely Riosiri, Suneka, Kisii Municipal, Keroka, Ogembo and Marani. There are 20 slaughter slabs distributed in the nine sub-counties namely, Nyanchenge 2, Tabaka 1, Msimba, Misesi 1, Ikoba 1, Nyabigena 1, Nyamarambe, Esaka 1, Mochengo 3, Openda 1, Etago 4, Moticho 1, Nyabera 1, Maroo, Suguta 1, Arura 1, Nyamaiya 1, Mogenda 1, Ekina 4, Nyabigege 1. Kisii County was selected for the study because of its importance as an animal transport and trade route and even as a source of animal meat for other counties in Kenya.

3.2 Summary of the study design

This study was carried out in three phases. In phase one, a retrospective study was conducted in order to determine the conditions which caused carcass/organ condemnation in Kisii County between January 2004 to December 2014. Phase two, was a cross sectional study where a questionnaire was administered to meat inspector and traders involved in meat industry in order to determine their knowledge, attitude and practices with regard to the conditions that causes carcass/organ condemnation in Kisii County. In phase three, economic losses attributed to condemnation of carcasses/organ in Kisii County between January 2004 to December 2014 were estimated using previously described tools and this is elaborated in details in the section below.
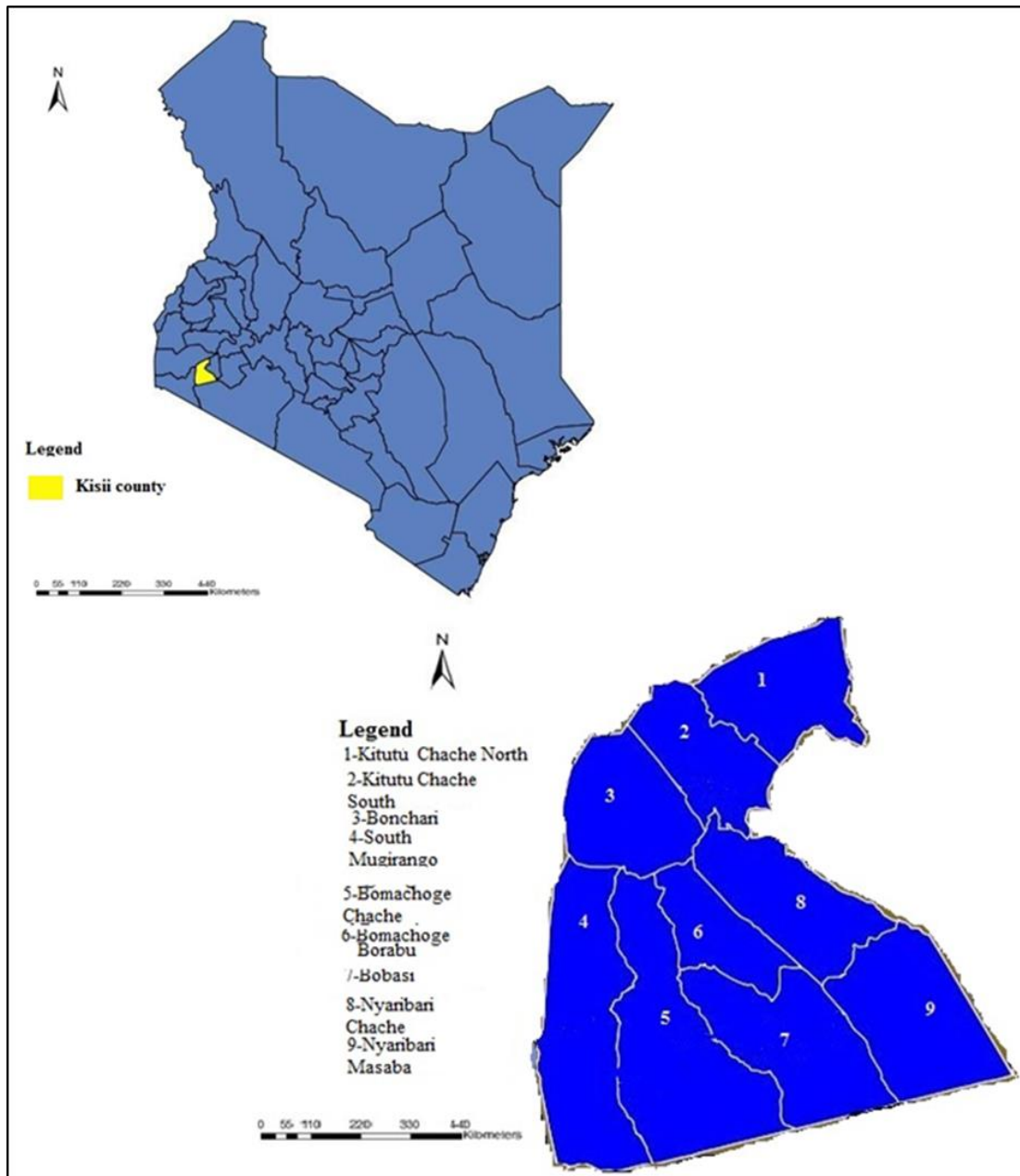
Figure 3. 1: Map outlining geographical extent of Kisii County where the study was carried out.

3.3 Computation of the sample size

This research was to a large extent retrospective and as such the sample size was determined mainly by the data on meat inspection reports in the study area and covering the study period of January 2004 to December 2014. However, a sample size estimation using the formula recommended by Dohoo *et al.,* 2003 and described below showed that the sample size was adequate to achieve the objective of this study. Considering 66% prevalence of parasitic infection in cattle meat in Kisii County (Nyarango *et al.* 2008), a sample size was estimated using the following formula:

$$n = \frac{Z_{0.05}^{2} * p\,q}{L^{2}}$$

(where L= 0.05 was margin of error, p= 0.66 which is the risk of parasitic infections documented by Nyarango *et al.*, 2008 from meat in Kisii, q= 1-p = 0.34, $Z_{0.05}$ is the normal deviate from the mean in Z distribution =1.96.). This estimated the sample size to be 176 condemned carcasses/organs.

Therefore, a sample size of 49,870 carcasses/organs condemned during the study period was way above the estimated requirement.

3.4 Description of how data was collected

3.4.1 Objective 1: Incidence of conditions causing carcass/organ condemnation

This was a retrospective study where Kisii County meat inspection records from January 2004 to December 2014 were scrutinized and data related to species slaughtered, carcass/organ condemned and conditions causing carcass/organ condemnation were extracted and recorded.

3.4.2 Objective 2: Knowledge and practices of meat inspectors and traders

To achieve this objective, a cross sectional study was conducted and data related to knowledge and practices of meat inspectors and traders, with regard to conditions causing carcass/organ condemnation obtained by administering a structured questionnaire (Appendix 1). A questionnaire was administered to the veterinary officers in charge of the respective inspection units to identify the common conditions that resulted in condemnation of organs and carcasses as well as their frequency of occurrence. Equally, another questionnaire was administered to the livestock traders and owners at the abattoirs to find out information on conditions that caused losses during meat inspection. This questionnaire also assessed the knowledge of these traders and farmers about zoonotic infections and how they influenced their cost of production as well as returns from sale of beef animals and animal by-products. Simple random sampling technique was used to select traders to be included in the study population in the particular abattoir visited on the particular day guided by a random number system after identifying the number of traders present at any given day.

3.4.3 Objective 3: Financial losses attributed to carcass/organ condemnation

Financial losses attributed to carcass and organ condemnation was estimated using a formula previously adopted by (Ogunrinade and Adesoke, 1982; Mohammed *et al.,* 2012) and shown below.

ALC = CSR x LC x P

Where:

ALC is the average Annual Loss from Condemnation

CSR is the mean annual cattle/sheep/goats slaughtered in Kisii abattoirs between 2004-2014. The number of animal slaughtered per year was obtained from meat inspection records from each of the slaughterhouses in Kisii County.

LC is the mean cost of a cattle/sheep/goat carcass/organ in Kisii County between 2004-2014. The mean cost of carcass and organs was determined based on average market price as informed by abattoir personnel and meat traders.

P is the carcass/organ condemnation rate in Kisii County between 2004-2014. The carcass/organ condemnation rate was determined from objective 1 of this study.

Based on the acquired data, the following financial losses were estimated

1.   Overall financial losses attributed to carcass/organ condemnation in Kisii County between 2004-2014

2.   Annual financial losses attributed to carcass/organ condemnation in Kisii County between 2004-2014

3.   Financial losses attributed to each carcass/organ condemned in Kisii County between 2004-2014

4.   Financial losses attributed to each species (cattle/sheep/goats) slaughtered in Kisii County between 2004-2014

3.3 Data handling and analysis.

A database was created in Microsoft Excel 2010 where generated data was entered then imported to R software version 2.1 for further statistical analysis which included descriptive summary statistics that include mean, standard deviation, range for continuous data and proportions and percentages for categorical data.

CHAPTER FOUR: RESULTS

4.1 Incidence of conditions causing carcass/organs condemnation in Kisii County between 2004-2014

In the period between 2004-2014, a total of 108,622 animals were slaughtered in abattoirs within Kisii County. Out of the 108,622 animals, 45.6% (49,481) were cattle, 43.1% (46,802) were goats and 11.4% (12,339) were sheep. Within the same study period, a total of 3,245 whole carcasses and 44, 371 organs were reported to have been condemned. Out of the 3,245 condemned whole carcasses, 1,478 were from cattle, 1,399 from goats and 369 were sheep. With regards to specific organs that were condemned, 43.5% (19,317) were lungs, 33.1% (14697) were livers, 9.7% (4,315) were kidneys, 8.8% (3,919) were intestines and stomach, 3.7% (1,643) were hearts and 1,1% (480) heads and tongues (Figure 2).

Abscesses (32.5%), pleurisy (22.5%) and pneumonia (15.2%) accounted for the major reasons for condemnation of lungs. Liver cirrhosis and degeneration accounted for 66.0% of causes of liver condemnation across the three species. This was followed by *Stilesia hepatica* 17.4%, inflammation of liver capsule at 10.5%, liver flukes 4.3%, and telangiectasis 1.5%. While the main reasons for condemnation of kidneys in bovine and shoats in Kisii County were hydronephrosis 34.1% (1471/4315), nephritis 26.1% (1124/4315) and inflammation of capsule 24.4% (1053/4315). The incidences of other conditions that caused intestines, stomach, hearts, head and tongue to be condemned are shown in table 1 below.

Generally, condemnation of organs was highest in 2016 and lowest in 2010. A time graph showing the two main conditions (Liver cirrhosis and Lung abscess) that resulted into organ condemnation is illustrated in figure 3.
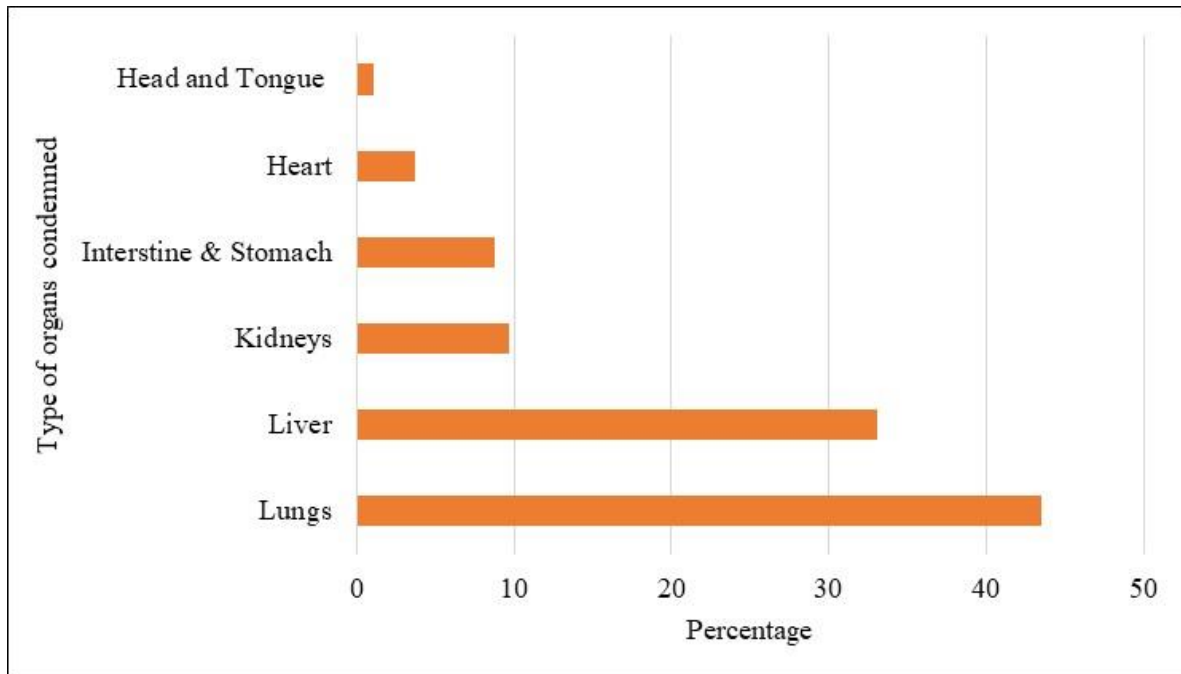
Figure 4. 1: Type of organs that were condemned during meat inspection in Kisii County

Table 4. 1: Incidence rate of various conditions that contribute to organ condemnation in slaughterhouses in Kisii County

Condemned organ(s)	Condition causing condemnation of an organ	Number of organs condemned due to a specific condition	Percentage (%) of the condition causing organ condemned
Liver N = 14, 697	Liver cirrhosis and degeneration	9705	66.0
	Stilesia hepatica	2553	17.4
	Inflamed capsule	1540	10.5
	Liver flukes	631	4.3
	Telangiectasis	225	1.5
	Abscess	19	0.1
	Echinococcosis (Hydatid cysts)	16	0.1
	Parasitic cysts	8	0.05
Lungs	Abscess	6278	32.5
	Pleurisy	4344	22.5

N =19,317	Pneumonia	2928	15.2
	Emphysema	1965	10.2
	Congestion	1423	7.4
	Parasites	1262	6.5
	Echinococcosis	1117	5.8
Kidneys	Hydronephrosis	1471	34.1
	Nephritis	1124	26.1
N = 4,315	Inflammation of capsules	1053	24.4
	Hemorrhages	624	14.5
	Infarcts	43	1
Intestines and Stomach	Pimply gut	1684	43.0
	Hemorrhages	1460	37.3
	Enteritis	324	8.3
N = 3,919	Parasites	265	6.7
	Infarcts	186	4.8

Hearts	Hemorrhages	988	60.1
	Pericarditis	422	25.7
N = 1,643	*Cysticercus bovis*	118	7.2
	Emphysema	73	4.4
	Congestion	42	2.6
Head and tongue	*Cysticercus bovis*	282	58.8
	Actinomycosis	111	23.1
N = 480	Hemorrhages	86	17.9
	Abscess	1	0.2
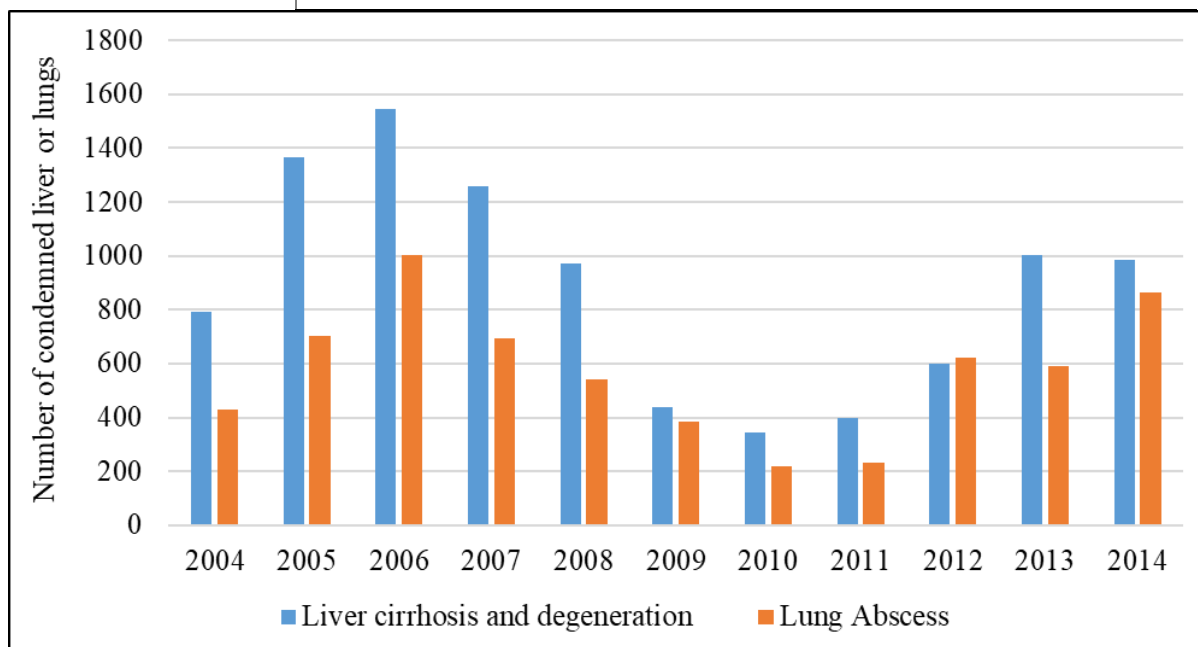
Figure 4. 2: A time graph showing the top two condition that caused organ condemnation in Kisii County between 2004 and 2014

4.2 Knowledge and practices with regard to conditions causing carcass/organ condemnation

A total of 87 randomly selected respondents participated in this survey. Out of the 87 respondents, meat inspectors were 11.5% (10/87), 72.4% (63/87) were meat traders and 16.1% (14/87) were live animal's traders. The mean duration of experience for meat inspectors was 15.4±2.7 years with a range of 8.0 to 27.0 years. With regard to education, 5/10 had attained a certificate in meat inspection, 2/10 had diploma in meat inspection and another 2/10 had certificate in meat grading. One person did not respond to the question regarding their education. When the meat inspectors were asked whether they understood what a zoonotic disease was, only one responded positively. Results from this survey further revealed that 20% (2/10) of meat inspectors had at one point in their career suffered from a zoonotic disease. One of them mentioned to having recovered from brucellosis while the other mentioned cysticercosis. Only one meat inspectors reported affirmatively with regard to regular medical examination. The average period between these health check-ups was 7.0±5.6 months with a range of between one and twelve months. When asked to rank the most important conditions leading to condemnation of carcasses and/or organs during meat inspections, the respondent mentioned hydatid cyst, cysticercosis, liver flukes and bacterial infection like anthrax and brucellosis in that descending order.

The average duration of being in meat business amongst the traders who were interviewed in this survey was 10.8±3.2 years. Result from this study further indicated that 4.7% (3/63) of meat traders had some knowledge about zoonotic diseases. When asked to mention the criteria that they used to decide which animal was to be taken for slaughter, 76% of them said that an animal had to be healthy, 15% mentioned animals at the prime age of reproduction and 4% mentioned male animals. Other factors considered when deciding which animal to take to slaughter are shown in table 2 below.

Irrespective of the species, the mean number of animals slaughtered per trader was 3.0±1.9 with a range of one to fourteen animals per day. 54% of traders who slaughtered animals at home said that they had the carcass and organs inspected before sale and/or consumption. Out of the 63 interviewed traders, 40 (63.49%) stated that they had incurred losses due to accidents, animals dying in transit and other infections resulting in whole carcass condemnation. Of the 23 traders that had not incurred whole carcass losses, 20 mentioned to have incurred losses due to liver, lung and intestine condemnations while 2 sited low dressed carcass weights due to organs condemnation as the main challenge to their trade.

Table 4. 2: Selection criteria as applied by livestock and meat traders for animals slaughtered in Kisii counties.

Criteria used to decide animals to slaughter	Percentage (%) as total of factors mentioned by respondents
Healthy animals	76
Sick animals	0
End of prime reproductive age	15
Male animal	4
Cost of animal	1
Cost and body weight of the animal	1
Profitability	1
Skin health and physical fitness	1

4.3 Financial losses attributed to condemnation of carcasses/organs in Kisii County

The total estimated financial loss attributed to carcass/organ condemnation in Kisii County between 2004 and 2014 was KES 57,121,157.22 (571211.57USD) which translated to approximate loss of KES 476,009.64 per month. The highest financial losses occurred in the 2006 with the least losses being observed in the year 2010. Economic losses attributed to whole carcass condemnation from bovine was KES 9,743,101.20, those from goats were KES 9,208,939.95 and sheep were KES 2,435,775.30.

Losses due to condemnation of the liver were KES 21,366,450 and accounted for 37.4% of the total losses in 10 years. Condemnation of lungs led to estimated loss of KES 19,223,698 which represented 33.7% of total losses. Estimated financial losses per condemned organ is summarized in table 3 below. Overall, the conditions that resulted into highest financial losses were congestion of the heart (KES 7,201,110.86), liver cirrhosis (KES 5,026,585.05), inflamed liver capsule (KES 4,275,136.66), *Stilesia hepatica* (KES 4,270,591.31), congestion of the lungs (KES 4,103,887.44) and lungs emphysema (KES 4,103,887.44). With reference to annual financial losses, 2016 recorded the highest losses from carcass and organ condemnation with the lowest losses recorded in 2010. The time graph showing annual financial losses is shown in figure 4.
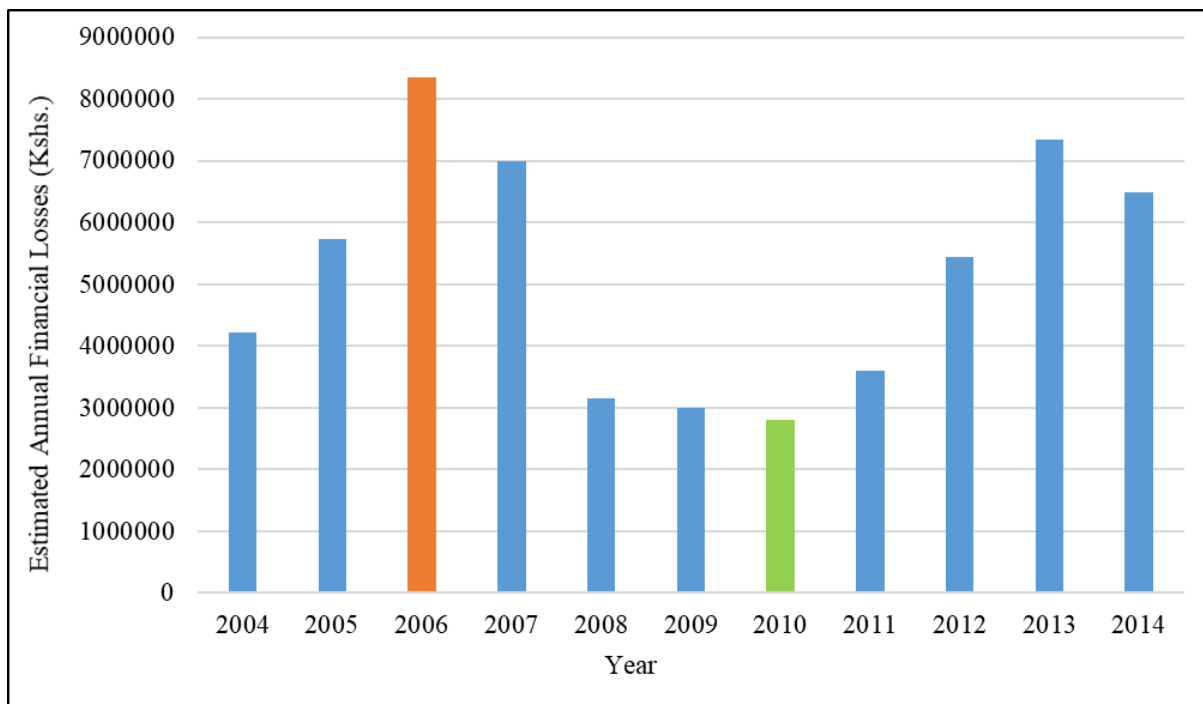
Figure 4. 3: Estimated annual financial losses due to condemned carcass/organs in Kisii County, Kenya between 2004 and 2014. Highest financial losses occurred in 2006 (Highlighted in Orange) and lowest financial losses occurred in 2010 (Highlighted in green)

Table 4. 3: Estimated economic loss due to condemnation attributed to specific conditions in slaughterhouses in Kisii County between 2004- 2014.

Condemned organ and attributed total loss	Condition causing condemnation of an organ	Estimated 10 year Loss from condemnation of an organ and contribution of a specific condition (KES)	Estimated 10 year Loss from condemnation of an organ and contribution of a specific condition (USD)
Whole carcass KES 3,001,427.89	Incomplete bleeding*	3,001,427.89	30,014.28
Head and tongue KES 1,865,307.87	Abscess	675,404.06	6754.04
	Actinomycosis*	508,086.44	5080.86
	C. bovis	64,5651.2	6456.51
	cysticercosis	36,166.166	361.66
Liver KES 21,366,449.69	Abscess	103,521.85	1035.21
	Cirrhosis*	5,026,585.05	50265.85
	Flukes	3,716,645.15	37166.45
	Echinococcosis	927,997.03	9279.97

	Inflamed capsule	4,275,136.66	42751.37
	Stilesia hepatica	4,270,591.31	42705.91
	Telengectasis	3,045,972.64	30459.73
Lungs	Abscess	3,100,872.61	31008.73
KES 19,223,698.3	Congestion*	4,103,887.44	41038.87
	Emphysema*	4,103,887.44	41038.87
	Parasites	1,981,825.32	19818.25
	Pleurisy	2,367,092.69	23670.93
	Echinococcosis	2,299,135.55	22991.36
	Pneumonia	1,266,997.25	12669.97

KEY: * Indicate conditions that led to highest financial loss per condemned organ

Condemned organ and attributed total loss	Condition causing condemnation of an organ	Estimated 10 year Loss from condemnation of an organ and contribution of a specific condition (KES)	Estimated 10 year Loss from condemnation of an organ and contribution of a specific condition (USD)
Stomach & intestines KES 2,132,001.48	Enteritis	358,658.6	3586.59
	Hemorrhages*	886,671.44	8866.71
	Pimply gut*	886,671.44	8866.71
Kidneys KES 1,573,405.78	Hydronephrosis	290,654.04	2906.54
	Hemorrhages*	515,390.75	5153.91
	Infarcts	515,390.75	5153.91
	Nephritis	93,719.95	937.20
	Inflamed capsule	158,250.29	1582.50
Heart KES 7,958,866.09	Hemorrhages	238,301.62	2383.02
	C.bovis	185,157.72	1851.58
	Pericarditis	185,157.72	1851.58

Empysema	149,138.17	1491.38
Congestion*	7,201,110.86	72011.11

KEY: * Indicate conditions that led to highest financial loss per condemned organ

CHAPTER FIVE: DISCUSSION

5.1 Conditions causing carcass and organ condemnations during meat inspection in Kisii County and their public health significance.

Due to the various public health risks posed by some of the conditions that animals suffer and are commonly diagnosed at post mortem, several rules and guidelines in various countries have been instituted to reduce the risk and prevent infection in humans. In slaughterhouses in Kisii county, whole carcass condemnation was as a result of improper bleeding. However, the different organs in all the species slaughtered were condemned from individual conditions such as: *Cysticercus bovis*, echinococcosis, congestions and hemorrhages, degenerative conditions, inflammation, *Stilesia hepatica* and other parasitic conditions. These causes of organ condemnation were similar to various findings found in Ethiopia where *Stelesia hepatica*, pneumonia, pericarditis and nephritis were found to be the main causes for goat and sheep organs condemnation in Bishoftu Elfora Export Abattoir (Aynalem *et al.* 2015). In another study in southern Ethiopia, which differed slightly with the findings in Kisii County, the major causes of condemnation in cattle carcasses were fascioliasis, hydatidosis, emphysema and pericarditis (Fufa and Debele 2013). In the study in Dodoma, Tanzania, Tembo and Nonga (2015) documented that a large number of condemned edible organs were as a result of hydatidosis, cysticercosis, fascioliasis and tuberculosis which illustrated the possible public health problem and presence of environmental infections. A similar study done in Kisumu between 2003 and 2008 found out that livers and lungs were condemned mainly due to parasitic conditions including fascioliasis, cysticercosis, cystic echinococcosis,

Stilesia hepatica and other parasitic cysts. All these conditions were reported to be equally prevalent and contributed to overall organ condemnation in abattoirs in Kisii county (Kanyari *et al.*, 2012).

5.2 Incidence rate of each of the conditions causing carcass and organ condemnation.

Condemnation of various organs in the study area was attributed to different conditions. For the period between 2004-2014 heads and tongues for all animals slaughtered in Kisii County, 479 were condemned of which 58.7% were condemned due to cysticercosis. Various studies have indicated cysticercosis to be a major cause of organ condemnation, however in these studies the rate of condemnation of heads and tongues attributed to *Cysticercus bovis* was not studied (Alembrhan and Haylegebriel, 2013). Other conditions causing condemnation of heads and tongues in Kisii County were actinomycosis abscesses, hemorrhages and echinococcosis.

The main causes of liver condemnations in animals slaughtered in the County were: degenerative conditions accounting for about 48%, inflammatory 25% and Stilesia 12%. These findings did not concur with the studies done by Alembrhan and Haylegebriel (2013); Abunna and Hordofa, (2013) in Ethiopia who reported hydatidosis as the most common cause of liver condemnations. The incidence rate of *Stilesia hepatica* was also much lower compared to that recorded in Ethiopia by Mandefro *et al.,* (2015) who recorded an incidence rate of about 38.3%.

The leading cause of condemnation of lungs in Kisii County was inflammatory conditions including pleurisy and pneumonia (37.6%) and abscesses (32.5%). This finding was not in agreement with a study done by Alembrhan and Haylegebriel (2013) in Ethiopia who found hydatidosis to be the leading cause of lung condemnations in slaughterhouse in northern Ethiopia. 37.6% of lung condemnation was attributed to inflammatory conditions which was much lower than that documented by (Mandefro *et al.*, 2015) at 60%.

The finding that pimply gut was leading causes of condemnation of stomachs and intestines in Kisii County was in agreement with Tembo and Nonga (2015). However, the rate of condemnation due to pimply gut was 7 times higher in Kisii County than in Dodoma (Tembo and Nonga, 2015). Other conditions observed in Kisii County such as: enteritis, infarcts and parasites were not being highlighted in other similar studies.

In the current study, hydronephrosis was found to be the leading cause of condemnation of kidneys. This is in contradiction with findings by Tembo and Nonga (2015) in Dodoma Tanzania who cited parasitic conditions and congenital cysts as the leading causes of kidney condemnations. Additionally, a study by Mandefro *et al.*, 2015 in Ethiopia concluded that nephritis contributed to 35.3% of kidney condemnations, which was much higher compared to the current report that found out that nephritis accounted for 26.5% of kidney condemnations. Other reported causes of kidney condemnations in Kisii county included capsular inflammation, hemorrhages and infarcts had not been reported before.

This study partially agreed with studies done in Ethiopia, Tanzania and Kenya on causes of heart condemnation. Of all 1643 hearts condemned in Kisii County (2004-2014), the two leading causes were hemorrhages (60.13%) and pericarditis (25.69%). A study done in Ethiopia (Mandefro *et al.*, 2015) attributed pericarditis to condemnation of 54.3% hearts Parasitic conditions such as *C. bovis* caused higher rate (7.18%) of condemnation of heart in the current study than the 4.35% reported elsewhere (Assefa and Tesfay, 2013).

5.3 Knowledge and practice of meat inspectors and traders

In general, despite the fact that meat inspectors were not well aware of zoonotic conditions that could be contracted during their occupations, only 1 % had suffered a zoonotic condition and as few as 10% went for regular health checkups. This low regard for the health risks posed to them could be attributed either to their low level of training and specialization given that majority of the inspectors had certificate level training or general apathy. More than 50% of all traders in the livestock value chain had knowledge on zoonotic infections and thus mainly selected the animals taken for slaughter on the basis of their health status. Healthy animals were most often taken to slaughter as opposed to the sick. In agreement with the findings the economic analysis on impact of organ condemnation, 20/23(87%) meat and livestock traders interviewed cited losses from liver condemnation as their highest source of losses in their business.

5.4 Financial losses attributed condemnation of organs.

Estimated losses due to carcass and organ condemnation in Kisii County ranged from 50,265.85 USD loss incurred due to condemnation of liver as a result of liver cirrhosis to 361.66 USD due to head and tongue condemnation as a result of cysticercosis per year between2004 and 2014. Annually, it was estimated that the county lost about 571,211.57 USD from organ and carcass condemnations as per this study. This was higher than the estimated losses recorded by Abunna and Hordofa, (2013) that was estimated to be 24,323.49 USD in Soddo municipality, southern Ethiopia. However, losses incurred in export abattoir in Ethiopia was estimated at 79,894.58 USD (Mandefro *et al.* 2015) which was higher than that recorded in Kisii county. Similarly, Assefa and Tesfay (2013) estimated an annual loss of 1,083.83 USD for an abattoir in Adigrat, which was less than that recorded in Ethiopia and Kisumu, Kenya.

In previous studies done in Kisumu, Kenya, Kanyari *et al.*, (2012) estimated that in 2007 and 2008, the total monetary loss from liver fluke infections was USD 12,034 and USD 13,413 respectively which was almost half as much as 21,664.50USD that was recorded in this study in Kisii county. The total estimated loss attributed to organ condemnations as a result of *C. bovis* in Kisii county was 8,308USD which was relatively lower than that recorded by Efrem *et al.*, (2015) where the total annual direct financial loss from organ condemnation due to hydatidosis, fascioliasis, *C. bovis* and other causes was estimated to be 52,807 USD annually with *C. bovis* accounting for 12,672.96 USD.

In a study done in Adigrat, Ethiopia, the annual loss from liver cirrhosis was estimated at 526 USD and only 55.25UDS worth of kidney condemned as a result of hydronephrosis. This loss was much lower compared to 50,265.85USD and 2906.54USD estimated annual loss due to liver cirrhosis and kidney hydronephrosis in Kisii County. In another study done in semi-arid coastal areas of Kenya, *Stilesia hepatica* accounted for an estimated loss of 14,807.80 USD over a period of 16 years (Mungube *et al.*, 2006) which was equivalent to an annual estimated loss of 925.49USD. An estimated annual loss of 42,705.91 USD as a result of *S. hepatica* liver condemnations was observed in Kisii County which was more than the losses recorded in semi-arid coastal areas.

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

1. Condemnation of whole carcass is rare and when it occurs the main cause is usually incomplete bleeding.

2. Liver, lungs and kidneys are the most commonly condemned organs in Kisii County. Liver cirrhosis and *Stelesia hepatica* are leading cause of liver condemnation, Lung abscess and pleurisy are major cause of lung condemnation while hydronephrosis and nephritis are leading cause of condemnation of kidneys.

3. Although a high number of meat inspectors and meat/livestock traders could identify conditions leading to condemnation of carcass/organs in abattoirs, their knowledge on zoonotic conditions was inadequate.

4. Condemnation of carcasses and organs in abattoirs in Kisii County was associated with high economic losses, which was estimated to be around 571,211.57 USD annually.

5. Condemnation of liver contributed to the highest source of annual losses from slaughtered animals in Kisii County.

6.2 RECOMMENDATIONS

1. In the light of the results from this study, it is recommended that the meat inspection process be strengthen in order to identify accurately conditions that cause carcass and organ condemnation. The meat inspectors who play a pivotal role in inspection require further training and/or continuous professional development in order to upgrade their knowledge and skills on meat inspection. This would heighten their ability to recognize conditions that require condemnation of organs, more so zoonotic diseases that pose a greater threat to public health. Additionally, it will be important for Kisii County Government to invest more in infrastructure of slaughter houses in addition to employing more meat inspectors.

2. To safeguard the livelihood of farmers and protect them from incurring high financial losses and thus increase the profits of their farming enterprises, this study recommends training of farmers on production of healthy animals that can produce meat products of high-quality standards.

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APPENDICES

Appendix 1: Questionnaire

Questionnaire to meat inspectors and traders to aide in completion of my MSc.

Name: …………………………………………………………………………………..

Location from…………………………………………………………………………..

Location at: ……………………………………………………………………………

I agree to participate in this questionnaire and to give correct information to the best of my knowledge.

Signature…………………………………………………

date………………………………………………………….

1.   Do you currently live in Kisii?

Yes ( )   No ( )

Specify the area from …………………………………………………………………….

2.   What is your main occupation?

…………………………………………………………………………………………

3.   What business do you have at the slaughter house?

a)   Meat inspector

b)   Livestock trader

c)   Meat trader

If meat inspector proceed to next question. If livestock or meat traders jump to Q 16.

4.   For how many years have you been a meat inspector?

……………………………………………………………………………..

5.   What level of training in meat inspection have you received?

………………………………………………………………………………

6.   For how long have you been a meat inspector in Kisii?

………………………………………………………………………………

7.   In your experience, what are the most common causes of organ and carcass condemnation in Kisii County?

a)   ……………………………………………………………………

b)   ……………………………………………………………………

c)   ……………………………………………………………………

d)   ……………………………………………………………………

e)   ……………………………………………………………………

8.   Do you understand what zoonoses are?

Yes ( )   No ( )

9. In your experience, what are the most common zoonoses causing condemnation or degradation of organs and carcasses in Kisii slaughter houses?

a) ……………………………………………………………………………………

b) ……………………………………………………………………………………

c) ……………………………………………………………………………………

d) ……………………………………………………………………………………

e) ……………………………………………………………………………………

10. Have you contacted any zoonosis directly attributed to inspection of animal carcasses in your years of experience as a meat inspector in Kisii?

Yes ( )   No ( )

If   yes,   name   the   condition(s)
……………………………………………………………………………………

11. Have any of your colleagues (in Kisii) contacted any zoonoses in the course of their meat inspection?

Yes ( )   No ( )

If   yes,   list   the   condition(s)
……………………………………………………………………………………

12. Do you go for health checks?

Yes ( )   No ( )

13.   How frequently?

……………………………………………………………………………………………………

14.   How frequently do you encounter the following conditions during meat inspection (
number of cases per month)

a)   Hydatidosis …………………………………………………………………

b)   Anthrax …………………………………………………………………

c)   Cysticercosis ………………………………………………………………..

d)   Liver flukes …………………………………………………………………

15.   Please rank these conditions in order of importance in causing condemnation and
degradation during inspection

a)

b)

c)

d)

16.   For how many years have you been a livestock / meat trader?

……………………………………………………………………………………………

17.   What animals do you bring to slaughter?

a.   ……………………………………………………………………….

b.   ………………………………………………………………………….

c.   ………………………………………………………………………….

18.   Where do you source your animals for slaughter from? (specify area)

……………………………………………………………………………………………

What criteria do you use to determine which animals you bring to slaughter?

a.   Healthy animals with good weight

b.   Sick animals in herd

c.   Those with reproductive losses

d.   Males born in your farm

e.   Any you purchase

f.   Other   criteria   (specify)

……………………………………………………………………………………………

19.   How frequently do you bring animals to slaughter?

……………………………………………………………………………………………

20.   On   average   how   many   animals   do   you   slaughter   in   a   day?

………………………………………………………………………………………………

21.   Do you the bring animals you eat at home during festivities for meat inspection first?

Yes ( )   no ( )

22.   What kind of losses have you experienced in the slaughter process?(carcass and organ condemnation)

……………………………………………………………………………………..

23.   How do these losses affect your returns?

……………………………………………………………………………………………

24.   Do you understand what zoonoses are?

Yes ( )   no ( )