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Meat quality status and postharvest handling practices along the meat value chain in Kenya

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In Kenya, meat value chain (MVC) is an important component of the food supply chain serving as a source of nutrients and income. However, information regarding processing practices, hygiene and equipment use as affecting meat quality still remains unclear despite its relevance for data and for assessment for development of meat quality in the meat trade. Therefore, a cross sectional survey of selected slaughterhouses and butcheries in Eastern region of Kenya was carried out to assess the postharvest handling practices and meat quality. Forty meat samples were collected from rump, neck, stomach and hind legs cuts of the carcass and analyzed for total viable counts, *Staphylococcus aureus, Escherichia coli* and *Listeria monocytogenes*. The findings indicate that over 50% of the meat handlers in slaughterhouses and butcheries have not received any formal training in good hygiene practices for meat handling. Total viable counts ranged from 2.159 to 2.736 log CFU/g, *Staphylococcus aureus* ranged from 1.112 to 1.324 log CFU/g, *Escherichia coli* ranged from 1.211 to 1.320 log CFU/g and *Listeria monocytogenes* ranged from 0.101 to 0.193 log CFU/g in the meat cuts. In conclusion, the study showed poor handling of meat which poses risks to consumers.

Key words: Meat quality, post-harvest practices, meat value chain.

INTRODUCTION

Livestock production is an important economic activity in the developing world. Livestock products contain high value proteins, fats, vitamins and minerals (Mallhi et al., 2019). In Kenya, the livestock sector contributes about 12% of Kenya's Gross Domestic Product, 40 to 42% to the agricultural GDP and 50% employment to the agriculture sector (Shibia et al., 2017; Dabasso et al., 2018). Currently, there is a growing demand for meat products mainly in the urban set up and a number of small scale meat processors have entered the business during the past few years. In Nairobi city, the increase in population growth has seen total meat consumption increase by a factor of 2.2 cementing the importance of meat and meat products to city dwellers (Bosire et al., 2017).

The consumption of meat products demonstrates an upward trend and is envisaged to increase further in the future. In addition, the potential for growth of the livestock enterprises in rural communities and pastoral regions of Kenya is significantly high due to the improvement of the

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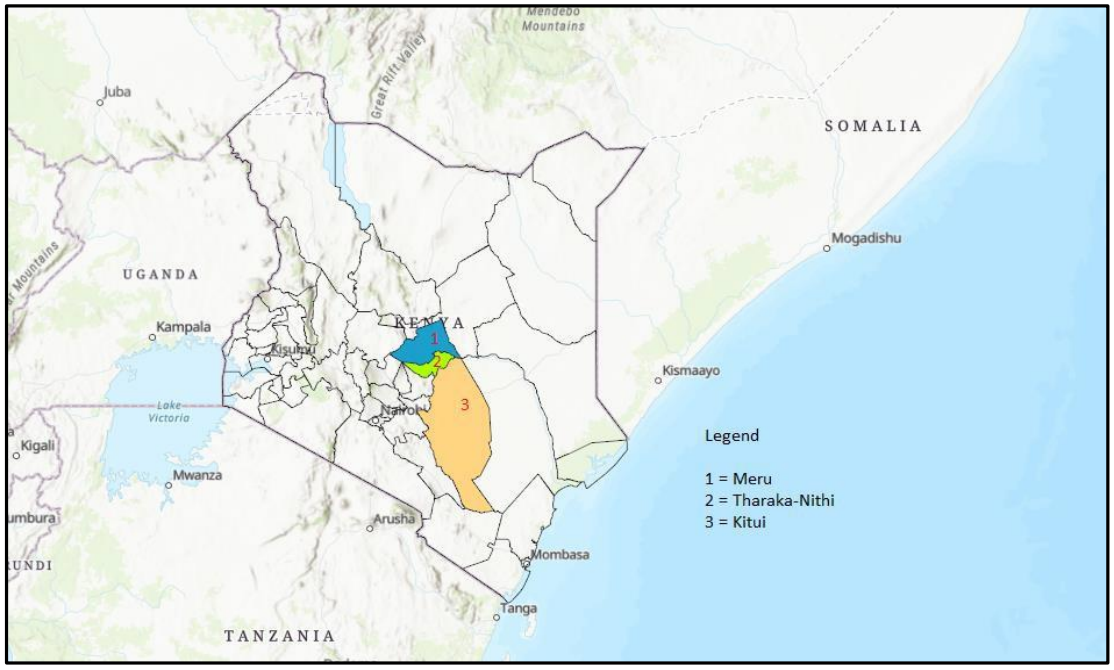

Figure 1. Map of Kenya showing the study areas.

market access, consumer perception and financial access by livestock owners. Red meat derived from cattle, goats, sheep and camel is highly consumed. Recent data puts the contribution of red meat in Kenya at 588693 tons with average carcass weight of 2273 hg/An (FAOSTAT, 2019).

The beef, value chain is a multi-sectoral system at various levels including primary meat producers, abattoirs, butcheries as well as traders, who buy, sell and transport livestock to and from primary and secondary markets (Dinku et al., 2019). Contamination of meat can occur at different stages of processing, distribution and retail (Mallhi et al., 2019). In this regard, it is imperative to process meat products in a safe and hygienic backdrop as they are essential for consumer protection and control of potential health risks (Wambui et al., 2017).

High levels of hygiene are necessary as meat is a perishable food and hence, food handlers in the meat value chain should have prerequisite food safety and hygiene knowledge (Tomasevic et al., 2016). Aspects of cleanliness of butcheries and personnel, hygiene of abattoirs is also very important since the feedback provides valuable insight that they can use to improve their businesses. A number of legislations and regulations that govern the management of livestock, their slaughter, handling and processing of meat as well as hygiene level have been developed in Kenya.

In Eastern regions of Kenya, the meat value chain serves as a source of nutrients and income enterprises to locals (Werikhe et al., 2019). However, the sector is hampered by poor meat quality, poor infrastructure, lack of capital, fluctuation in price of meat, weak extension services and low technical capabilities of processors (Gobena, 2017; Muzzo and Provenza, 2018). Price fluctuations where there is no government mechanism to reign in middlemen who reap a bigger chunk of cattle sales exacerbates the situation (Bunmee et al., 2018).

Addressing these challenges still remains unclear. This study was thus conducted to assess the different slaughterhouses/slaughter slabs, butcheries to understand how they work, identify gaps, and how to structure them for optimal performance.

MATERIALS AND METHODS

Study area

The study was carried out in Meru, Tharaka Nithi and Kitui counties (Figure 1). Meru County is situated in the former Eastern province. It has nine sub-counties, nine constituencies and forty five county assembly wards (County Government of Meru, 2018). It is found between latitudes 37° West and 38° East and between longitudes 0°6' North and 0°1' South. The county has an estimated total population of 1,535,635 (Kenya National Bureau of Statistics, 2019). Tharaka Nithi County is also located in the former Eastern province and divided into five administrative counties. It lies between latitude 00° 07' and 00° 26' South and between longitudes 37° 19' and 37° 46' East (County Government of Tharaka Nithi, 2018). The county comprises the highland and semi-arid zones. Based on the Kenya National Bureau of Statistics (KNBS, 2019) report, the population is estimated at 393,177. Kitui County is about 160 km from Nairobi city on the Eastern part of Kenya and divided into eight sub counties (County Government of Kitui, 2018). It is situated between latitudes 0°10 South and 3°0 South and

longitudes 37°50 East and 39°0 East. The population in the county is about 1,136,187 (Kenya National Bureau of Statistics, 2019).

Study design

The design was cross sectional involving a survey in the three counties namely Meru, Kitui and Tharaka Nithi. These areas were purposively selected due to large pastoral production and value addition of meat. A total of 26 main study sites in the counties were selected using the two-stage cluster sampling method. Out of the sites, a total of 100 respondents (31 slaughterhouses and 69 butcheries) were randomly sampled from the three counties. In each of the county, 23 butcheries were selected while for slaughterhouses 10, 11, and 10 were selected, respectively in Meru, Kitui and Tharaka Nithi.

Data collection

Primary data

Key informant interviews/individual interviews and Focus Group Discussions were conducted with value chain actors as well as the related service providers in the selected counties. The data collected was used to gain better understanding of the structure and dynamics of the meat value chains and the opportunities and barriers for private sector actors in the study region to improve availability of safe and quality meat products. This was meant to improve the understanding on the barriers to more effective integration between producers and private-sector food processors and vendors within the value chain. Simultaneously, observations of the slaughterhouses and butcheries were done during the study period.

Secondary data

The study also conducted review of relevant documents, including published literature, program reports, and county statistics.

Analytical methods

Sample collection and preparation

Meat and surface swab samples from equipment used for meat handling and personal protective equipment for the workers in the slaughterhouses were aseptically collected for further microbial analysis. Ten meat samples each weighing 1 g were cut from the rump, neck, stomach and hind leg of the carcass and thereafter aseptically transferred into tubes containing 10 ml buffered peptone water. For the meat handling equipment (weighing scale and wedging knife), an area of 100 cm^2 was swabbed for 50 s using sterile moistened cotton swab while for the steel file, an area of 10 cm^2 was swabbed for 50 s using sterile moistened cotton swabs and transferred into tubes containing 10 ml buffered peptone water. Samples were also collected from the gumboots, caps and dustcoats of the personnel. An area of 50 cm^2 was swabbed for 50 s using a sterile moistened cotton swab and transferred into 10 ml buffered peptone water.

Microbial analysis

Determination of total viable count

Total viable count was done by the pour plate method. 1 ml of the sample dilutions (10^{-4}, 10^{-5}, 10^{-6}) was poured on plates containing plate count agar. The plates were incubated at 35°C for 48 h and all grown colonies were enumerated thereafter.

Determination of Staphylococcus aureus

The *S. aureus* levels were determined as described by the ISO 6888-1 and ISO 6888-2 methods. 28 g of Baird parker selective media was mixed in 1 L of distilled water and autoclaved at 121°C for 15 min. It was then cooled to 45°C; thereafter 50 ml of egg yolk tellurite emulsion was added. 1 ml of each serial dilution of 10^{-4} to 10^{-6} was plated in duplicates using the spread plate method and the plates incubated at 37°C for 24 h. Coagulase positive black colonies on the selective media were indicative of *S aureus*.

Determination of Escherichia coli

Enumeration of *E. coli* was done as described in ISO 16649-1, ISO 16649-2 and ISO 16649-3. 28.1 g of Brilliance *E. coli*/coliform selective media was mixed in 1 L of distilled water and thereafter boiled to completely dissolve, and then cooled to 45°C. The molten media was then transferred to sterile plates. 1 ml of each serial dilution of 10^{-4} to 10^{-6} was plated in duplicates using the spread plate method and the plates incubated at 37°C for 24 h. A pink colony on the selective media was indicative of *E. coli*.

Determination of Listeria monocytogenes

The *L. monocytogenes* was determined by the ISO 11290-1:2004 method. 1 ml of the sample dilutions (10^{-4}, 10^{-5} and 10^{-6}) was spread on listeria selective agar plates which were inclusive of *L. monocytogenes* selective supplement. The plates were incubated at 35°C for 48 h and distinct *L. monocytogenes* colonies were counted after incubation.

Statistical data analysis

Field data obtained was entered in Microsoft excel 2013 spread sheet. Statistical computing of descriptive statistics of variables was done using STATA version 11. Microbial data was subjected to analysis of variance (ANOVA). The significance level was set at $p \leq 0.05$. Microbial counts were represented as log CFU/g.

RESULTS

Socio-demographic characteristics

The highest percentage of the meat handlers in both the slaughterhouses (68%) and butcheries (55%) was in the age bracket of 35 years and above (Tables 1 and 2), respectively. Most of the operators had attained basic education. Among the slaughterhouse operators, 39% had primary education, 32% secondary education and only 23% had tertiary education. On the other hand, most of the butchery operators (51%) had secondary level education, 39% primary level education, 9% tertiary level education and only 1% had no level of education. In terms of experience, majority of the respondents in the slaughterhouses (68%) and butcheries (46%) had an

Table 1. Socio-demographic characteristics of the operators in the slaughterhouses.

Demographics		Frequency	Percentage
Age (years)	Below 35	10	32
	Above 35	21	68
Education	No Education	2	6
	Primary	12	39
	Secondary	10	32
	Tertiary	7	23
Level of experience	Below 10	21	68
	11-15	5	16
	16-20	2	6
	Above 20	3	10

Table 2. Socio-demographic characteristics of the operators in the butcheries.

Demographics		Frequency	Percentage
Age (years)	Below 35	31	45
	Above 35	38	55
Education	No Education	1	1
	Primary	27	39
	Secondary	35	51
	Tertiary	6	9
Level of experience	Below 10	32	46
	11-15	23	34
	16-20	8	12
	Above 20	6	8

experience of below 10 years (Tables 1 and 2).

Hygiene practices during slaughter and butchery operations

In this study, postharvest handling begins immediately after stunning, where the animal is rendered unconscious before slaughter. After stunning, different actors including bleeders, flayers, carcass eviscerators and carcass dressers are involved in the follow up processes. Inspection is then done. Carcass is stamped if it meets the standard requirements as stipulated in the meat control act then transported to various butcheries. Tables 3 and 4 give the frequencies percentages of personnel hygiene practices by operators in the slaughterhouse and butcheries, respectively. All the meat handlers (100%) in the slaughterhouse and 97% in the butcheries possess a medical health certificate. Results of the study also show that over 50% of the respondents in the slaughterhouse and butcheries have not been trained in hygienic meat handling. From observations, in all the butcheries, the meat was hanged in open air for display and purchase by consumers. With regards to cleaning, most of the respondents in the slaughterhouse (93%) said that they cleaned the slaughterhouse after slaughter. On the other hand, all the meat handlers (100%) in the butcheries also indicated that they cleaned their facility after work. However, uncleaned ceilings and white walls with observable dirty spots were noticed. The findings also show that majority (90 and 84%) of the respondents in the slaughterhouses and butcheries, respectively wear protective clothing while working. However, from observations, most of the dust coats used had changed colour from white to brown and the gumboots were not nicely cleaned. Some of the operators were seen handling steel file used for sharpening the knives in their gumboots. When moving meat from the slaughter house

Table 3. Personnel hygiene practices by meat handlers in the slaughterhouses.

Attribute	Frequency	Percentage
Medical examination		
Yes	31	100
No	0	0
Training		
Yes	10	33
No	21	67
Cleaning schedule		
Yes	31	93
No	0	7
Personal protective clothing		
Yes	28	90
No	3	10

Table 4. Personnel hygiene practices by meat handlers in the butcheries.

Attribute	Frequency	Percentage
Medical examination		
Yes	67	97
No	2	3
Training		
Yes	21	31
No	48	69
Cleaning schedule		
Yes	69	100
No	0	0
Personal protective clothing		
Yes	58	84
No	11	16

to the vehicles they carry it on shoulders of their dirty coat. In addition, infrequent washing of hands was observed and standby hot water baths for sterilizing knives were also not available.

Meat handling and processing

With regards to processing, the findings showed a gap in meat value addition processing. All the slaughterhouses (100%) were not engaged in value addition of hides and skins, bones and horns. However, among the butcheries, 4% were engaged in value addition of hides and skins, 1% bones and horns and 3% deboning of meat for the market. In the slaughterhouses, most of the commonly used equipment included flaying knives, sharpening tools, handwashing basins, holding pen and hooks (Figure 2). In the butcheries, sharpening tools, soap and sanitizer dispenser, hooks and handwashing basins were the most commonly used equipment at retail level (Figure 3).

Transportation of meat and meat products to the meat enterprises

The results for mode of transport are shown in Table 5. In Meru and Kitui counties, 59.8 and 60.8%, respectively used motorbikes while in Tharaka Nithi County, 47.1% used pick-ups (Figure 4).

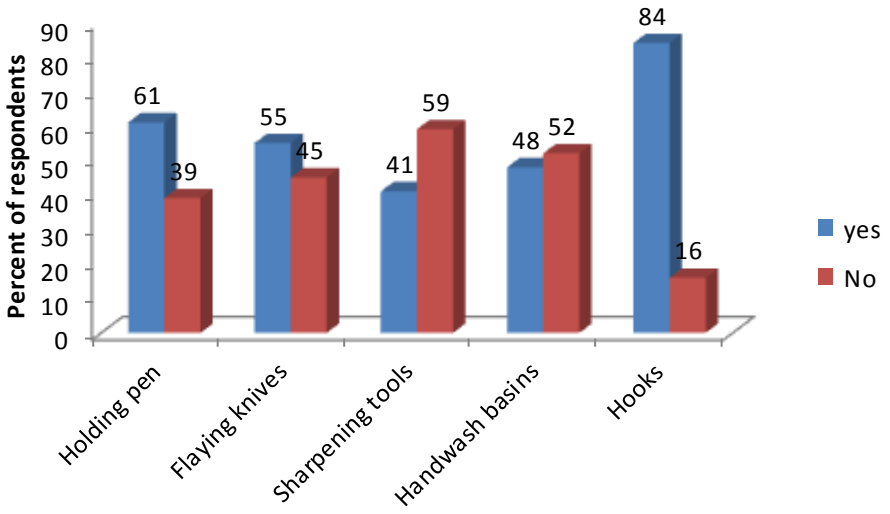

Figure 2. Equipment used in the slaughterhouse.

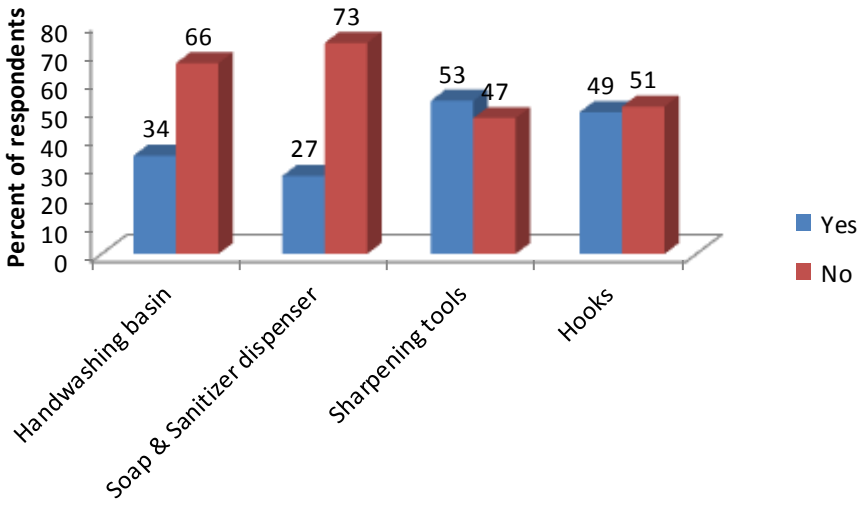

Figure 3. Equipment used in the butchery.

Microbial quality of meat samples obtained from slaughterhouses

Table 6 shows microbial counts of the different parts of the carcass: rump, neck, stomach and hind legs sampled. Total viable counts ranged from 2.159 to 2.736 log CFU/g, *S. aureus* ranged from 1.112 to 1.324 log CFU/g, *L. monocytogenes* ranged from 0.101 to 0.193 log CFU/g while *E. coli* ranged from 1.211 to 1.320 log CFU/g.

DISCUSSION

Postharvest handling of carcasses in the slaughterhouses begins immediately after stunning and proceeds during transport and then trading to consumers. Handling practices have been shown to affect the quality of meat (Bersisa et al., 2019). Several key aspects such as handling practices, personnel hygiene practices, mode of transportation, equipment usage and training were assessed in the present study. In addition, microbial quality of the carcasses at the slaughterhouses was quantified. The demographic results showed a variation in age, education and processing experience among the meat handlers. This indicates that the sample was indeed diverse. Good animal production practices on farm, good handling practices (GHPs), good hygienic practices (GHPs) and good manufacturing practices (GMPs) are crucial aspects in meat quality and lack of compliance

Table 5. Mode of transport used for meat and meat products.

Transportation mode	Meru	Kitui	Tharaka Nithi
Refrigerated vehicle	11.1±3.46[a]	11.1±2.56[a]	32.3±3.00 [b]
Metallic box mounted on pick up	11.1±2.09[b]	11.4±2.17	47.1±2.2 1[a]
Metallic box mounted on motor bike	59.8±1.39[a]	60.8±2.23[a]	17.6±2.04 [b]
Metallic box on a bicycle	12.3±1.75[a]	11.9±3.11[a]	2.4±1.68 [b]
Wooden box on bicycle	3.6±1.76[a]	3.00±1.90[a]	0.5±1.03 [b]
Wooden box on cart	2.1±1.02 [b]	1.8±1.15 [b]	0.1±1.25[a]

*Values=%means ± standard deviation; % means in the same row with different superscripts are significantly different p< 0.05.

Figure 4. Different modes of transport of meat from slaughterhouses to butcheries.

Table 6. Microbial counts (log CFU/g) of meat samples obtained from slaughterhouses.

Microbial Parameter	Carcass parts			
	Rump (n=10)	Neck (n=10)	Stomach (n=10)	Hindlegs (n=10)
TVC	2.736±0.033[a]	2.159±0.050[a]	2.360±0.076[a]	2.425±0.046[a]
Staphylococcus aureus	1.324±0.125[a]	1.241±0.104[a]	1.112±0.184[a]	1.235±0.177[a]
Listeria monocytogenes	0.138±0.123[a]	0.142±0.145[a]	0.101±0.821[a]	0.193±0.267[a]
Escherichia coli	1.214±0.103[a]	1.211±0.120[a]	1.320±0.120[a]	1.227±0.189[a]

*Values=means ± standard deviation, means in the same column with different superscripts are significantly different (p≤0.05). TVC=Total viable count, N=number of samples, CFU=colony forming unit.

can lead to meat contamination and spoilage (Idrees, 2016). However, most informal meat enterprises especially slaughterhouses and butcheries do not adhere to these good practices and standards; hence, a point of concern. Proper meat handling practices play a dominant role in ensuring meat quality and safety (Selepe and Mjoka, 2018). During meat processing and distribution, knowledge of meat hygienic handling practices are essential. Meat handlers can serve as a vehicle of cross contamination and spread of foodborne pathogens (Wambui et al., 2017).

In the present study, the results reveal both good and unhygienic practices in the slaughterhouses and butcheries. Wearing of dirty coats, infrequent washing of hands, lack of hot water baths for sterilizing of knives, keeping steel file in gumboots and carrying carcass on their dirty coats were unhygienic practices identified at the slaughterhouses and butchery retail shops. Similar results have been reported in a study conducted in slaughterhouses and butchery retail shops in Bishoftu, Ethiopia, where there was lack of hot water baths and infrequent handwashing by the meat handlers (Gutema et al., 2021).

In general, the observed unhygienic practices can be linked with lack of appropriate processing facilities, insufficient knowledge of basic hygienic practices and

poor compliance to standards of good handling practices of food. In the present study, proportion of the operators who needed training was considerably high. These findings agree with the results from previous studies conducted in small and medium enterprise butcheries in Nairobi and Isiolo counties in Kenya, where more than 50% of the operators had no training on meat handling hygiene (Chepkemoi et al., 2015). Improving the capacity of the meat handlers through training can translate into best practices in handling of meat and meat products (Akabanda et al., 2017).

In the present study, in terms of meat value addition processing, the gap identified was largely attributed by lack of equipment and skill. Additionally, the use of simple cutting tools indicates low level of professionalism of the enterprises. These findings relate to those reported by Asuming-Bediako et al. (2018) who found out those butchery operators in Accra, Ghana only use simple cutting tools such as axes and knives. Appropriate equipment for meat processing, storage and transportation are of uttermost importance for maintenance of quality and safety of meat (Kenya Market Trust, 2019). In addition, technical knowhow of the workers is also necessary. Limited use of appropriate equipment and lack of skills can result to poor quality of meat (Carron et al., 2017).

Most of the meat was transported under non-refrigerated conditions. This could be attributed by the low financial capacity of the butcheries which cannot afford to purchase refrigerated trucks, since most of them were small medium enterprises. Similar observations have been reported in various developing countries such as Uganda (Kyayesimira et al., 2018), where transportation of carcasses from slaughterhouses to butcheries was found to be carried using motorbikes fitted with an enclosed container.

The exposure of meat at ambient temperature in the butchery retail shop observed in the present study can also be explained by the low financial capacity of retailers to afford refrigeration facilities as well as insufficient knowledge in hygienic meat handling practices. These conditions in the butcher retail shops are comparable to the practices reported in Rwanda (Niyonzima et al., 2018), where they were associated with an increased risk of microbial contamination in the retailed meat.

Microbial quality of meat reflects the hygiene status and practice of workers (Teshome et al., 2020). In the present study, there was no significant difference in the mean microbial counts of the different carcass parts sampled. Among the isolated microbial pathogens, *Listeria monocytogenes* was above the acceptable limit compared to KEBS standards (KS 317-3: 2019) thus compromising on the quality and safety of the meat.

Detection of *L. monocytogenes* could be due to poor hygiene and sanitary practices through the value chain and indicates public health risk associated with the consumption of this meat. Using clean slaughter equipment, having trained personnel and following the right procedures in slaughtering can reduce the contamination (Maharjan et al., 2019).

Conclusion

Meat is an indispensable source of high-quality protein for most populations. Postharvest handling practices along the meat value chain are critical since they influence the quality and safety of meat. Hygiene practices identified in the slaughterhouses and butcheries were inadequate. High microbial contamination of meat was prevalent in most of the meat enterprises which increases public health risks. This necessitates the need for training in best practices along the meat value chain and implementation of stringent food safety management and quality control systems along the value chain.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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