ABSTRACT

Meat hazards significantly affect the livelihood systems of meat stakeholders by limiting the growth and development of meat markets, incomes, and employment opportunities. Slaughterhouses are expected to release safe and wholesome carcasses to the public with a level of assurance. The aim of this review was to identify association between slaughterhouse operations, hygiene and worker practices with meat hazards across the major food animal species consumed in Kenya and identify factors leading to the hazards. A Google Scholar search was run, articles were screened, and 24 articles met the eligibility criteria and were included in the study. From this review it was found that poor biohazard control on-farm, low human capacity and infrastructural development of slaughterhouses, and non-compliance to regulations led to unsafe meat. The study concluded that slaughterhouses’ resilience can be enhanced by reviewing policy, regulatory facilitation compliance, collective responsibility, and prioritizing educational-driven behavioural and infrastructural development.

Keywords: resilience, meat hazards, meat safety slaughterhouses, hygiene

INTRODUCTION

It has been established that the safety status of meat originating from small and medium slaughter facilities in Kenya barely meets the country’s minimum hygiene and sanitary standards (Cook et al., 2017; Wambui, 2016). While parasites generally infect livestock on-farm (Kithuka, 2002), the contamination of meat by spoilage and pathogenic microorganisms from the environment mainly occurs at slaughter and if uncontrolled may proceed up the value chain, thus reaching the consumer (Diyantoro and Wardhana, 2019).

Kenya’s human population is projected to reach 96 million in 2050 compared to 47 million in 2019 (FAO, 2019; KNBS, 2019). Consequently, the demand for animal-derived foods is expected to increase, becoming a key agricultural sector (FAO, 2019). While red meat represents 80 % of the Kenyan domestic meat consumption, beef is the most preferred source and contributed to 84 %, 82 % and 79 % of all meat consumption by low-, middle- and high-income earning consumers, respectively (KMT, 2019).

Therefore, the study objective was to undertake a scoping literature review to identify studies associating slaughterhouse operations, hygiene and working practices with meat hazards across the major food animal species consumed in Kenya and identify factors leading to the occurrence of the hazards.

In this review, studies that focused on slaughterhouse operations including hygiene, worker practices and related factors affecting the occurrence of meat hazards across the major food animal species consumed in Kenya have been identified and discussed.

MATERIALS AND METHODS

This review was guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Moher et al., 2009). The review questions were, “What are the meat safety enhancing interventions and practices employed at the small and medium sized slaughterhouses to control meat-borne hazards in Kenya?”
Secondly what are the underlying factors that lead to these outcomes?” The PRISMA statement guided the selection of the study population, intervention, comparison groups and outcome.

Google Scholar Search

A Google Scholar search was run in August 2020 to identify relevant articles published from 1990 to 2020 using the search terms in Table I.

<table>
<thead>
<tr>
<th>Search strategy</th>
<th>Search terms run in Google Scholar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intervention</td>
<td>“Meat inspection in Kenya” OR “meat decontamination in Kenya” OR “HACCP in Kenya”</td>
</tr>
<tr>
<td>Comparison groups</td>
<td>“Meat” OR “beef” OR “poultry” OR “mutton” OR “goat meat” OR “camel meat” OR “pork” OR “donkey meat”</td>
</tr>
<tr>
<td>Outcome</td>
<td>“Meat hygiene in Kenya” OR “meat safety in Kenya” OR “slaughterhouse hygiene in Kenya” OR “meat spoilage in Kenya”</td>
</tr>
</tbody>
</table>

HACCP- Hazard Analysis Critical Control Points

A total of 120 articles were identified from the search. The titles and abstracts of the articles were screened for relevance and inclusion in the study. Where necessary, further screening of the introduction, results and discussion segments were done. The screening was done using Microsoft Excel, where articles were arranged under various criteria. Those not meeting the inclusion criteria such as articles not written in English language, those duplicated, studies outside Kenya, those older than 1990, those lacking accessibility to full texts and irrelevant topics were omitted. The remaining 24 full-text articles were assessed for eligibility, including studies carried out in Kenya, studies published in English, and studies carried out between 1990 and 2020. The relevant articles were downloaded and saved for further screening and inclusion based. They included six cross-sectional studies, two of which included retrospective studies, five experimental studies, six descriptive studies, four reports from nongovernmental organizations and one review and one online book (Table II). To supplement the search strategy, reference materials from the included studies were scanned, and 21 articles were identified and downloaded for inclusion in the research, making up 45 articles. The summary of the selection criteria methodology is shown in the PRISMA diagram in Figure 1.

Inclusion and exclusion criteria of literature sources

The studies that were included addressed ante-mortem inspection, slaughtering and post-slaughtering practices, worker practices, hygiene, health and hazards in meat.

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Inclusion and exclusion criteria of literature sources

The studies that were included addressed ante-mortem inspection, slaughtering and post-slaughtering practices, worker practices, hygiene, health and hazards in meat. The population studied were local slaughterhouses regulated by the Meat Control (Local Slaughterhouse) Regulations of 2010, whose meat is destined for the domestic market. This excluded export-oriented slaughterhouses and consequently the exclusion of donkey meat from the study. The interventions studied were meat inspection, meat decontamination methods and the application of the Hazard Analysis Critical Control Points (HACCP) concept. The meat groups investigated included beef, poultry, pork, mutton, goat, camel and rabbit meat. All articles containing information on meat hazards were reviewed, and these included zoonoses of microbial, parasitic, and viral origins and antibiotic residues. The outcomes studied included slaughterhouse hygiene, meat safety and meat spoilage. The eligible sources included journal articles, theses and dissertations, research reports, conference proceedings, government laws and Acts and books. Studies excluded included duplicates, studies not conducted in Kenya, those not published in English, those published before 1990 and those whose full texts were inaccessible.
Figure 1: Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) diagram illustrating the search process.
TABLE II- SUMMARY OF ARTICLES THAT WERE INCLUDED IN THE STUDY

<table>
<thead>
<tr>
<th>S/No.</th>
<th>Reference</th>
<th>Sources</th>
<th>Study type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Osoro et al., 2019</td>
<td>Journal</td>
<td>Cross-sectional</td>
</tr>
<tr>
<td>2</td>
<td>Kithuka, 2002</td>
<td>Research project report (MSc.)</td>
<td>Cross-sectional, Retrospective</td>
</tr>
<tr>
<td>3</td>
<td>Acholla, 2019</td>
<td>Thesis (MSc.)</td>
<td>Cross-sectional, Retrospective</td>
</tr>
<tr>
<td>4</td>
<td>Ajak, 2017</td>
<td>Thesis (MSc.)</td>
<td>Cross-sectional</td>
</tr>
<tr>
<td>5</td>
<td>Munyua, 2015</td>
<td>Thesis (PhD)</td>
<td>Cross-sectional</td>
</tr>
<tr>
<td>6</td>
<td>Mulimi et al., 2019</td>
<td>Conference Proc.</td>
<td>Experimental</td>
</tr>
<tr>
<td>7</td>
<td>Wambui, 2016</td>
<td>Dissertation (MSc.)</td>
<td>Experimental, Descriptive</td>
</tr>
<tr>
<td>8</td>
<td>Ochieng, 2015</td>
<td>Thesis (MSc.)</td>
<td>Experimental</td>
</tr>
<tr>
<td>9</td>
<td>Njagi et al., 2004</td>
<td>Journal</td>
<td>Experimental, Field survey</td>
</tr>
<tr>
<td>10</td>
<td>Akoko et al., 2019</td>
<td>Journal</td>
<td>Experimental</td>
</tr>
<tr>
<td>11</td>
<td>Kago, 2015</td>
<td>Research Project report (MSc)</td>
<td>Descriptive</td>
</tr>
<tr>
<td>12</td>
<td>Cook et al., 2016</td>
<td>Journal</td>
<td>Descriptive</td>
</tr>
<tr>
<td>13</td>
<td>Cook et al., 2017</td>
<td>Journal</td>
<td>Descriptive</td>
</tr>
<tr>
<td>14</td>
<td>Ombwayo, 2019</td>
<td>Research project report (MA)</td>
<td>Descriptive</td>
</tr>
<tr>
<td>15</td>
<td>Muthama et al., 2016</td>
<td>Journal</td>
<td>Descriptive</td>
</tr>
<tr>
<td>16</td>
<td>Ameso et al. 2017</td>
<td>Journal</td>
<td>Anthropological</td>
</tr>
<tr>
<td>17</td>
<td>Bergevoet &amp; Engelen, 2014</td>
<td>Research Project report (NGO)</td>
<td>Descriptive and Field survey</td>
</tr>
<tr>
<td>18</td>
<td>Omiti &amp; Okuthe, 2019</td>
<td>Research Project report (NGO)</td>
<td>Review</td>
</tr>
<tr>
<td>19</td>
<td>Muthee, 2006</td>
<td>Research Project report (NGO)</td>
<td>Descriptive and Field survey</td>
</tr>
<tr>
<td>20</td>
<td>Aklilu, 2008</td>
<td>Research Project report (NGO)</td>
<td>Review</td>
</tr>
<tr>
<td>21</td>
<td>Lam et al., 2019</td>
<td>Journal</td>
<td>Review</td>
</tr>
<tr>
<td>22</td>
<td>IIRR &amp; CTA, 2014</td>
<td>Book</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Kiugu, 2018</td>
<td>Research Project report (MSc)</td>
<td>Cross-sectional study</td>
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<tr>
<td>24</td>
<td>Meat Control Act, 2012</td>
<td>Statute</td>
<td>Laws of Kenya</td>
</tr>
</tbody>
</table>

RESULTS AND DISCUSSION

Meat safety concerns across livestock species

The review did not cover some of the most common foodborne pathogens found in beef, poultry meat and pork, such as Salmonella, Staphylococcus aureus, E. coli, and Campylobacter notably because publications containing these aspects did not meet the study’s criteria. However, lack of publications on such pathogens especially in the local small and medium slaughter facilities in the country, reveals a crucial research gap since these pathogens are prevalent public health concerns. Similarly, no studies were found on meat spoilage and camel meat. The following is the overview of animal species concerned.

Cattle

Fasciolosis

Fasciolosis is an infection affecting the liver of ruminants caused by parasitic trematodes of the genus Fasciola. In domestic ruminants, fasciolosis can result in gross
economic losses due to deaths, treatment costs of animals, and condemnation of emaciated carcasses and infected livers. In humans, it leads to liver damage, high cost of treatment and loss of employability (Kithuka, 2002). The reviewed articles revealed that fasciolosis had cost the Kenyan red meat industry around KES 206 million, approximately USD 2.5 million between 1990 and 1999 due to condemnation of Fasciola gigantica infected livers, greatly affecting livelihood systems of meat stakeholders.

With hepatic fasciolosis and hydatidosis considered as likely zoonotic agents to humans (Achollah, 2019), it is recommended to sensitize parasite control at farm level through to the slaughterhouse to lessen losses at the slaughterhouse (Achollah, 2019). The author identified that the key existing technologies used to control Fasciolosis for pastoral and agricultural areas include good grazing management, routine deworming with anthelmintic treatment and control of liver flukes by flukicides. In the slaughterhouses, routine post-mortem inspection is carried out on all organs and carcass portions by viewing, making incisions, palpations and olfaction techniques to detect gross pathological lesions to remove them from the food chain (Achollah, 2019). However, the degree of post-mortem inspection is dependent on the inspectors’ training, experience, and background.

Poultry

Listeriosis

Listeriosis is a devastating human infection usually caused by consuming food contaminated with the bacteria Listeria monocytogenes (Farber and Peterkin, 1991, as cited by Njagi et al., 2004). The infection is a major threat to high-risk groups, namely pregnant women, new-borns, the elderly and the immune-compromised. The symptoms include sepsicaemia and infections of the central nervous system characterized by headaches, vomiting and fever, which may lead to encephalitic infection and meningitis and finally death. Infections in pregnancy begin with symptoms of influenza and can lead to abortions at any stage of pregnancy, premature deliveries, stillbirths, or cause neonatal infections (Farber and Peterkin, 1991).

The carrier level of Listeria monocytogenes in 136 indigenous chicken and 39 ducks was studied across farms, open markets and at points of slaughter across Nairobi, Machakos and Kajiado (Njagi et al., 2004). Only nine indigenous chicken oropharyngeal samples (5.14 %) recovered Listeria spp., but none from cloacal nor duck samples. Of the positive samples, eight were from marketed chicken. No carcass swabs were investigated. The authors attributed the higher Listeria count to possible transport-related stress and overcrowding in cages.

Considering that 80 % of all birds in Kenya are kept in village and backyard production systems (Bergevoet et al., 2004) and that many indigenous chickens are slaughtered at the household level, the occurrence of Listeria spp. carriers in the poultry flock do pose an apparent public health concern as they are possible reservoirs for human infections (Njagi et al., 2004). Additionally, this study found limited data on the prevailing poultry carcass decontamination practices in Kenyan slaughterhouses. This review identifies the need for consumer awareness on safe handling and preparation of home-slaughtered birds.

Antibiotic Residues in poultry meat

It has been elucidated that antimicrobials and possibly other growth-promoting compounds are inappropriately used in ruminant and non-ruminant production, citing limited veterinary control (Kahi et al., 2006; Omiti and Okuthe, 2008). A study that investigated the use of antimicrobials in chicken broiler farms established that while the majority of the interviewed farmers acknowledged the required drug withdrawal period, 50 % of them admitted to selling broilers during the drug administration period to avoid incurring losses and earn income for the purchase of feed. The increase of antimicrobial use in livestock production is currently a public health concern as improper application leads to residues in meat, milk, eggs, and other livestock products, with the risk of transmission to consumers (Muthuma et al., 2016).

Highly pathogenic avian Influenza (Influenza A virus)

The recent global pandemics of Influenza indicate the emerging significance of influenza viruses to public health (EFSA & ECDC, 2019). Influenza A viruses are subtyped based on two surface proteins, namely hemagglutinin (H) and neuraminidase (N). Currently, there are 18 H and 11 N subtypes. The recent H1N1pdm09 virus for the 2009 Influenza A pandemic in USA caused a global death toll of 575,000 (EFSA and ECDC, 2019). Symptoms of avian influenza infections in humans include mild upper respiratory infection (fever and cough) progressing to
severe pneumonia, acute respiratory distress syndrome, shock and even death (EFSA and ECDC, 2019). In the Kenyan context, the primary meat safety concern arises from the fact that many birds, estimated to the tune of 70%, are homestead or backyard slaughtered (Bergevoet and Van Engelen, 2014). With hygiene and this virus in consideration, this situation is undesirable. It should be addressed through sensitization to spur a shift in practice (Bergevoet and Van Engelen, 2014).

**Pigs**

**Porcine cysticercosis**

Porcine cysticercosis is a parasitic infection in pigs caused by the larval stage of *Taenia solium, a human tapeworm*. In humans, the adult tapeworm sheds eggs in faeces which can then be picked up by scavenging pigs. In turn, consumption of raw or undercooked pork causes infection in humans, where the larvae lodges in different organs, but it is in the human intestines where it develops into an egg-laying adult tapeworm (Bergevoet and Van Engelen, 2014). When the larvae lodge in the brain it can lead to a condition called neurocysticercosis (NCC), a condition which is a major cause of acquired epilepsy and can be fatal (Bergevoet and Van Engelen, 2014).

A study investigated the circulation of antigens for *Taenia spp.* in 700 slaughtered pigs at a slaughterhouse that receives pigs mainly from Kiambu and Nairobi counties and intended for distribution mainly within Nairobi (70%), and the rest to Nakuru, Kajiado, Narok, Laikipia and Kwale counties (Akoko et al., 2019). While the official post-slaughter inspection techniques of palpation and incision failed to detect cysts, the Ag-ELISA method revealed an estimated true prevalence of 4.4%, with 61 pig samples testing positive. This finding supported the consensus that current inspection techniques have low sensitivity, lack reliability, and potentially lead to underreporting of the prevalence of porcine cysticercosis. The value chain currently lacks routine post-harvest interventions to inactivate the cysticerci to prevent *T. solium* from entering the food chain. This ultimately leaves the consumers responsible for practical cooking to inactivate the cysticerci (Akoko et al., 2019). This review identifies porcine cysticercosis as a disease of public health concern, especially for avid pork eaters.

**Influenza A virus**

A study evaluated the prevalence of the H1N1pdm09 virus in pig slaughterhouses sited in Western and Central Kenya (Osoro et al., 2019). From a serum sample of 1082 pigs, the prevalence of subtype A/H1N1/pdm09 was higher in two sites of Western, 22.6% (21 out of 93) in Kisumu and 34.5% (30 out of 87) in Bondo compared to 19.8% (47 out of 237) in Uthiru, Central Kenya. The prevailing free-range production system attributed this in Western, which is different from the confined production system in Central (Osoro et al., 2019). Pig slaughterhouses are reported to offer a favourable atmosphere for porcine-to-human transmission of the H1N1 virus (Munyua, 2015, as cited by Osoro et al., 2019). Similarly, the low biosecurity settings in pig production systems increase the risk of human exposure to swine influenza viruses (Munyua, 2015).

**Small ruminants**

In the review, no zoonoses were reported in small ruminants. However, the diseases studied were reported to impair the animal’s health, reproduction, growth, and productivity and were viewed more as diseases of economic concern rather than of human safety. Diseases of small ruminants include the Peste des Petits Ruminants (PPR) in goats and sheep, the endemic sheep pox and the Contagious Caprine Pleuropneumonia (CCPP) in goats that results in morbidity of up to 100% as well as high rates of mortalities (Bergevoet and Van Engelen, 2014). Outbreaks of Rift Valley Fever (RVF) continue to pose a risk to the trade of small ruminants. Of significance in the humid regions and seasons are the internal parasitic infestations of small ruminants by *Heamonchus*. These diseases will require timely vaccinations and an early warning and preparedness system (Bergevoet and Van Engelen, 2014). However, regulations require that carcases and viscera with lesions related to sheep pox be declared unfit for human consumption (Public Health Act, 2012).

**Rabbit**

Rabbit production in Kenya has been on the increase over the years. Besides *Coccidiosis*, *pasteurellosis*, and ear canker, which can be addressed by good hygiene management, the rabbit haemorrhagic viral disease (RHVD) has emerged in recent years (Bergevoet and Van Engelen, 2014). Similar to poultry slaughter, rabbit slaughter is predominantly carried out at homesteads and backyards, with only a portion slaughtered at the Rabbit...
Breeders Association of Kenya (RABAK) slaughterhouses (Bergevoet and Van Engelen, 2014).

Meat control and safety-enhancing interventions at small and medium slaughter facilities

Ante-mortem inspection

Ante-mortem or pre-slaughter inspection is the clinical examination of livestock by a veterinary officer that determines the type, breed, sex and screens for symptoms and signs of animal diseases prior to slaughter (Ameso et al., 2017). One study (Cook et al., 2017) indicated that ante-mortem inspection was practised at 7% (10 out of 142) of slaughterhouses. It further reported the slaughtering of sickly animals in 9% (12 out of 142) of the slaughterhouses. Another study on pastoralist livestock products (Muthee, 2006) revealed that it was common for animals to be slaughtered without undergoing ante-mortem examination, with much emphasis on post-mortem carcass and organ inspection to examine and control parasites. The lack of ante-mortem inspection poses a great health risk to slaughterhouse workers, households, and meat consumers against zoonotic infections (Cook et al., 2017). This study identifies a need to prioritize the control of the entry of meat hazards up the value chain to protect public health by the compliance of meat inspectors to carrying out this examination. Meat regulations state that slaughterhouses should provide cattle races equipped with facilities for washing the animals ahead of slaughter (Meat Control Act, 2010). This crucial decontamination step especially of the cattle hide, which is a major source of carcass contamination is lacking in small and medium slaughterhouses that lack such facilities.

Post-mortem inspection

Post-mortem inspection involves visual examination, incisions and palpation techniques on the head, tongue, the green, red offal and the carcass (Ameso et al., 2017) that screens for signs of disease such as anaemia, swellings, abscesses, organ abnormalities and parasites. It is an important step where the veterinary officer determines the appropriateness of the carcass and organs for human consumption (Ameso et al., 2017). When ideally post-mortem inspection should be done at the slaughterhouse, instances of the inspection being carried out at the butchery have been reported (Cook et al., 2017). This implies the existence of an extensive base of small and medium-scale slaughterhouses against a narrow capacity of the inspectorate. Consumer-related meat safety concerns arising from an overwhelmed inspectorate include, the risk of antibiotic residues in meat, fraudulent presentation of game meat as beef and the sale of uninspected dead carcasses in butcheries (KMT, 2019). Once carcasses and organs are declared fit for human consumption, the judgement is conveyed by markings on the carcass using a food-grade marker ink (Ameso et al., 2017).

Decontamination interventions

The carcass decontamination technologies addressed across the studies was majorly washing (Ameso et al., 2017; Wambui, 2016). A study of ten livestock markets in Nairobi and pastoral livestock markets revealed that in all slaughterhouses, cold water was used to clean carcasses (Wambui, 2016). As part of a decontamination intervention and to enhance the visual quality of the carcasses, they were hanged and washed with a cloth dipped in cold water to remove blood and bone splinters. The author reported that this step was ineffective in reducing microbial contamination and may have redistributed contamination from highly contaminated areas to other parts of the carcass. In the recent past, the emergence of zoonotic strains of Escherichia coli that are responsible for a large number of global morbidity and mortality, (Weinroth et al., 2018) necessitated the implementation of HACCP in export-oriented slaughterhouses in Kenya to reduce contamination of meat in compliance with the importing trading partner (National Food Safety Policy, 2013). This has seen upgrades in control systems and capacity enhancement in the export-oriented slaughterhouses. However, this trade-driven compliance to stringent meat safety regulations of the importing country (seeking to protect its consumers) has not transcended into developing domestic meat safety structures and capacities (Jaffe et al., 2019). For example, in instances where carcasses are examined and passed conditionally following the detection of light infestation (not exceeding 5 cysts) of parasitic cysts like Cysticercus bovis (Ameso et al., 2017) the slaughterhouse treats the carcass at -10 °C for 14 days. Alternatively, the infested carcasses are sterilized by steaming in an autoclave or boiling or rendering at 76.6 ℃ for 2.5 hours and 30 minutes for beef and pork, respectively (Meat Control Act, 2010). However, the lack of refrigeration system and sterilization equipment in many small and medium-sized slaughter facilities renders these decontamination techniques lacking, reducing
their livelihoods in terms of productivity losses due to condemnation and foregone sales. Another study (Cook et al., 2017) reported that only 3% of 142 slaughterhouses in Western Kenya had access to electricity, limiting practices such as refrigeration and carcass chilling. In Nairobi, only 1 out of 5 slaughterhouses studied (Wambui, 2016) chilled carcasses for 24 hrs prior to dispatch. A poor cold-chain supply will aggravate meat keeping quality (Bergevoet and Van Engelen, 2014), posing a risk of microbial contamination, meat spoilage and waste, and increased burden of meat-borne illnesses.

Considering the large sizes of these carcasses, the study finds that the Act does not give sufficient details of the sterilization process for bovines and pigs and should consider revising this segment of whole carcass decontamination to address the step-by-step process. Similarly, the study did not find any articles addressing consumer concerns about purchasing such decontaminated meat, a knowledge gap that should be addressed.

Slaughterhouse waste management

The slaughter process results in the production of solid waste and wastewaters that requires appropriate discharge as stipulated by the Law. However, the regulation and enforcement of manure management, waste-water discharge and even disposal of dead animal have been difficult, neglected or missing altogether in Kenya (Bergevoet and Van Engelen, 2014; FAO, 2019; Omiti and Okuthe, 2008). A study carried out in 17 slaughterhouses across four counties in Kenya reported that a common challenge faced has been the utilization and or disposal of slaughter by-products namely manure, blood and raw slaughterhouse wastewater. This leads to the piling or inappropriate disposal of these products within the slaughterhouse premise or neighbouring environment (Ombwayo, 2019), leading to ineffective and unacceptable solid and waste-water management, posing a pollution health risk and low quality of life to slaughterhouse workers and the neighbouring community as well as to terrestrial and aquatic life. Another study evaluating the effect of slaughterhouse waste management practices on natural environment conservation in Kiambu County also identified insufficient waste management practices (Kago, 2015). In the study, manure collection was the most common waste utilization method in the county, while open and closed rubbish pits were used for disposal. Recycling and treatment methods were considered intricate processes, requiring staff training. This perception was reported in Kiambu County (Mulimi et al., 2019), where particularly treatment of slaughterhouse waste-water is considered costly and complicated, leading to the water contaminated by dung, ingesta and blood getting released into the environment untreated, posing as a potential reservoir for microbial hazards in meat. Bacteria such as Salmonella and Shigella, viruses, prions, parasites, parasitic eggs, and anaerobic cysts are capable of infecting both animals and humans and contaminating surface and ground water (Mijinyawa and Lawal, 2008; Mulimi et al., 2019), necessitating the treatment of slaughterhouse effluent before discharge to reduce adverse environmental impacts (Ochieng’, 2015). The Meat Control Act has made requirements for slaughterhouses to be compliant with the provisions of the Environmental Management Coordination regulations through acceptable effluent treatment systems and solid wastes disposal, failure to which they face closure. Slaughterhouse closures lead to reduced livelihoods in terms of loss of incomes and wages, lost sales and paid penalties and even negative media exposure. Similarly, closures may cause meat retailers and meat consumers to pay much more for meat from distant slaughterhouses and meat retail outlets or miss out on consuming the product, contributing to food insecurity. This review identifies the needed shift in the regulatory approaches to now give prominence to facilitating compliance by offering awareness and extension services in low-cost slaughterhouse waste management instead of penalizing noncompliance.

Adherence to the Meat Control Act

Various studies have reported weak adherence, implementation, and enforcement of the Meat Control Acts and, in some instances, contravening the recommendations. For example, out of 142 slaughterhouses visited in Western Kenya, only one, a mixed ruminant slaughterhouse, stunned cattle prior to slaughter. The rest were slaughtered without prior stunning (Cook et al., 2017). In the same study, 74% (103 out of 140) of slaughter slabs were reported to have violated the Act by selling meat beyond the designated locality of sale, a practice that may potentially pose a risk to neighbouring and distant meat markets. These instances of non-compliance are indicative of poor oversite by the inspectorate, unfair practice by the slaughterhouses and a lack of transparency in the sector. Compliance to regulatory provisions may be achieved through sensitizing the
owners of the slaughterhouses and other value chain actors through regular extension services and disseminating information on importance of meat safety and hygiene, origins and consequences of meat hazards, the importance of good meat handling practices, detailed meat inspection, appropriate carcass decontamination interventions and proper handling of waste and contaminated materials.

Factors hindering meat safety in Kenya

Categorization of local slaughterhouses

The Meat Control (Local Slaughterhouses) Regulations (Meat Control Act, 2010) describes a slaughterhouse as a place reserved for slaughtering animals for human consumption. It further categorises local slaughterhouses by size as large (category A), medium (category B) and slaughter slabs (category C), details summarized in Table III. The former two categories of slaughterhouses are recognized as formal and are licensed to slaughter either for the domestic or export market (Farmer & Mbwika, 2012). Out of about 2000 licensed slaughterhouses in Kenya, only about 15 are export-oriented (KEPSA, 2019).

<table>
<thead>
<tr>
<th>Slaughterhouse category</th>
<th>Area under establishment</th>
<th>Capacity (Animal units per day)</th>
<th>Lairage accommodation</th>
<th>Presence of cooler or freezer</th>
<th>Sales designated area</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>≥2.5 hectares</td>
<td>&gt; 40 bovines / camels or &gt; 50 donkeys / horses or &gt; 20 sheep / goats or &gt; 8 small pigs or &gt; 15 units of porkers or &gt; 30 units of beckoners or &gt; 40 units of calves</td>
<td>2 days capacity</td>
<td>Obligatory</td>
<td>Whole country</td>
</tr>
<tr>
<td>B</td>
<td>&gt;1.5 hectares</td>
<td>16 – 24 sheep &amp; goats 1 – 7 small pigs or 2 – 14 porkers or 4 – 29 bacon pigs or 4 – 39 units of calves 6 – 39 bovine / camels or 9 – 49 donkeys / horses</td>
<td>1.5 days capacity</td>
<td>Obligatory</td>
<td>50 km radius of the slaughterhouse</td>
</tr>
<tr>
<td>C</td>
<td>&gt;0.5 hectares</td>
<td>≤ 15 goats or sheep ≤ 6 small pigs or ≤ 2 porkers or 1 beconer pigs or &lt; 3 calves per day</td>
<td>the days kill only</td>
<td>Not obligatory</td>
<td>Not allowed to be transported outside town</td>
</tr>
</tbody>
</table>
The categorization of slaughterhouses controls the distribution of meat to designated markets. It was reported (Bergevoet and Van Engelen, 2014) that high-income customers in urban areas can only be supplied meat from category A slaughterhouses where antemortem and post-mortem inspection is carried out thoroughly. Meat safety is assured compared to category B and C. First, this study identifies that this regulation impedes the meat distribution channels of the small and medium slaughterhouses to access high-value markets, limiting their livelihoods. Secondly, the market-driven regulation appears to have an unintended outcome to secure safe meat to only a small section of the consumers (the urban resource-rich) while allowing the circulation of potentially contaminated meat to the rural and urban resource-poor, contributing to food insecurity. Such regulation also does little to spur developments in meat safety management in these facilities, which already suffer poor infrastructural capacity and human expertise to meet safety regulations. This diminishes the institutional resilience of these slaughterhouses in reacting to present and emerging meat hazards.

Thirdly, the regulatory discrepancies across the three categories of local slaughterhouses destined to supply meat to the domestic market are counterproductive in boosting local trade and availing safe meat of known and uniform safety standards for all. For instance, the study identified discrepancies in meat safety management across the three levels as pertains to slaughterhouse biosecurity; in terms of fencing and decontamination facilities for personnel and vehicles, meat preservation; terms of provision for refrigeration, animal and carcass decontamination interventions, in terms of standard cattle and carcass washing procedures and carcass re-inspection.

Slaughterhouse workers knowledge of hygiene and practices

It has been previously reported that poor hygiene and inadequate facilities at slaughterhouses are key factors contributing to meat contamination and occupational exposure of hazards to workers (Cook et al., 2016). A study on the factors associated with the post-slaughter quality losses in beef in small and medium enterprise slaughterhouses located in Nairobi and other towns (Wambui, 2016) reported that handwashing practices of 207 meat handlers at 5 slaughterhouses located in Nairobi and its environs were reported as dissatisfactory. While 86.4 % said hand washing after toilet visits, only 42.0 % and 24.6 % used soap and towels. In the same slaughterhouses, all the beef carcasses released to the market were barely within the marginally acceptable microbial limits, ranging from 2.58 to 4.5 log cfu/cm² aerobic plate count (APC). The degree of contamination was reported to increase as the operations progressed from flaying, eviscerating, splitting up to dispatch. The author suggested improvement in monitoring of flaying and eviscerating procedures and meat handling practices to reduce meat contamination. This study identifies the need for slaughterhouse worker training to emphasise on teaching workers the details of each task in the slaughter operations, teaching how to manage meat safety risks in each step along with the slaughter operations, and instilling good hygienic practices in the slaughterhouse.

Meat regulations stipulate that meat handlers wear ‘suitable’ protective clothing, head covering and boots that are readily washable (Meat Control Act, 2010). A study on working conditions of slaughterhouse workers in Western Kenya interviewed 738 workers and reported that 78 % provided their coats. In contrast, 84 % provided their boots. Workers in mixed-species slaughterhouses (69 %) and ones for cattle only (49 %) were more likely to wear protective clothing than workers in pig slaughterhouses (27 %). Similarly, the authors observed 11 % of workers were seemingly intoxicated during work hours while 24 % reported defecating in the open. The low adherence to hygienic practices was attributed to the lack of protective equipment to the slaughterhouse workers by management. This review finds that the lack of keen worker behaviour at the slaughterhouse may exacerbate adherence to hygienic practices. This requires the slaughterhouse management to take more responsibility for human resource management in enhancing employee hygiene compliance.

The use of protective clothing has been identified to offer protection against zoonotic pathogens such as Brucellosis and Leptospirosis (Cook et al., 2017). Personal hygiene also has been identified as a key determinant of zoonotic disease transmission. A study on risk factors for leptospirosis seropositivity reported that consumption of food, smoking, and working with open wounds in slaughter facilities were reported risk factors for positive leptospirosis seroprevalence raise the likelihoods of spreading the agent from contaminated hands to the mucous membranes of the mouth or through wounds. The same author reported that about 42 % of the slaughterhouse workers knew that meat could be a source of disease, 31
% knew about zoonotic diseases. In comparison, 8% were able to name a zoonotic disease associated with meat. The author suggested that slaughterhouse workers be trained on the potential disease risks they face to lower their exposure to zoonotic disease burden.

Despite training efforts in hygiene and meat safety in local slaughterhouses meat hazards remain a challenge in the industry, attributed to the total lack of training in some slaughterhouses (Bergevoet and Van Engelen, 2014; Cook et al., 2017) or to low numbers of trained meat handlers (Wambui, 2016), which is insufficient to translate into improved worker practices. Training areas that have been previously emphasized by researchers include worker behavioural changes (Egan et al., 2007, as cited by Wambui, 2016) hand washing, correct use of personal protective equipment, sources of meat contamination, workplace sanitation, occupational hazards at the slaughterhouse and importance of antemortem examination of animals (Cook et al. 2017).

CONCLUSION

Parasitic contamination of meat continues to pose a major threat to public health as reported in cattle (fasciolosis) and pig (cysticercosis) carcasses. Similarly, backyard slaughter of livestock especially of poultry species yields uninspected carcasses that may pose a public health threat of present zoonoses as well as emerging hazards like the Influenza A virus and antimicrobial residues.

HACCP food safety management principles were not employed in small and medium slaughter facilities over the 30-year study period and only remained practised at export-oriented slaughterhouses. Meat safety-enhancing interventions in these slaughter facilities include antemortem and post-mortem inspection and carcass washing with cold water that are inadequate to detect microbial and other emerging hazards. Poor adherence to the Meat Control Act and poor slaughter waste utilization and management will continue to threaten the meat safety and sustainability of the meat enterprises.

The categorization of slaughter facilities, poor levels meat safety knowledge and practices of slaughterhouses workers were identified as key factors affecting the status of meat safety in Kenya. Only one article in this review carried out a national retrospective study (Kithuka et al., 2002). The lack of national studies in meat safety is a key research gap that needs to be addressed to expand knowledge on a national scale.

RECOMMENDATIONS

The Meat Control Act needs to be reviewed to harmonise regulatory requirements for all local slaughterhouses by supporting equity in compliance, responsibility in managing hazards and sustainability in running meat enterprises.

The weak adherence and non-compliance of small and medium slaughterhouses to regulatory provisions calls for a shift of regulatory approaches, to give prominence to facilitating compliance through awareness efforts and less on exposing and penalizing noncompliance.

The provision of technologies that are sustainably generated for basic slaughterhouse operations such as renewable energy from slaughterhouse waste, water treatment and recycling will contribute to enhancing sustainable operations of small and medium slaughter facilities.

Livestock keepers need to be sensitized on good animal husbandry practices with emphasis on biohazard control, proper use of antibiotics, and record keeping at farm level and animal welfare at transit to deter spread of parasites.

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REFERENCES


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