Original Article

Journal of Food Safety and Hygiene

Assessment of meat preservation methods used by retailers and the estimation of direct economic losses associated with meat spoilage in Kenya

Nadia James Killa[*], Ombui Jackson Nyarongi, Gathura Peter Baaro

Department of Public Health, Pharmacology and Toxicology, Faculty of Veterinary Medicine, University of Nairobi, Nairobi, Kenya.

ARTICLE INFO	ABSTRACT
	Meat spoilage reduces the meat quality and the revenue from the meat industry. This study assessed the direct impact of ineffective meat preservation methods on economic loss among meat retailers in the Dagoretti region of Nairobi, Kenya. A cross-sectional survey was conducted in 87 butcheries and 9 supermarkets from low, middle, and high-income areas using a systematic sampling technique. The meat losses were measured by kilograms of spoilt meat and associated financial cost was estimated. Descriptive and Inferential statistics were used to establish the significance of the association between preservation and demographic factors. A correlation analysis was used to estimate the strength of the relationship between the factors. The study revealed that most of meat handlers heavily relied on refrigeration methods (73%) for storing meat, and 27% hung meat at room temperature due to the high cost of electricity and deep freezers. Furthermore, it revealed that each meat retail business lost 2.3 kg (1.0-3.0 kg) on average per week, which indicates financial losses of USD 11.5 (Range 5.0-15.0 USD) per week or USD 598 (Range USD 260-790) per year. These losses were mainly associated with moisture loss (49%) and microbial spoilage (22%). Poor storage and meat handling practices were blamed for spoilt meat. Meat retailers reported fly menace disturbing their business. It's recommended that the government implement policies to reduce electricity bills and enhance the adoption of refrigeration methods, while industry stakeholders should facilitate initiatives for public awareness on appropriate methods of meat preservation. Additionally, retail cut meat products on display should be wrapped with permeable film to reduce moisture loss. Further study is needed for a comprehensive analysis of direct economic losses segregated by meat types and preservation forms.

1. Introduction

Livestock rearing remains one of the most crucial socio-economic activities in Kenya as it contributes about 12 percent of the nation's GDP (1).

However, more than 50 percent of the livestock products, especially meat are lost in post-harvest-related losses. About 3.5 billion kg of meat and meat

[*]Corresponding author. Tel.: +254725952313 /+211916342979
E-mail address: nanykilla28@gmail.com

products are spoiled every year by consumers, retailers, and food services (2).

Poor handling and storage procedures can lead to microbial contamination of meat and loss of moisture. The main factors responsible for meat spoilage are bacterial activity, chemical oxidation, and enzymatic autolysis (3). The intestinal tract and the skin of the animal are the main sources of these microorganisms, and their composition in meat depends on various pre-slaughter animal handling and post-slaughter meat handling practices (4). The high nutrient content of meat provides an ideal habitat for harmful bacteria to thrive (5). Microbial activity causes meat spoilage and renders the meat unsafe for human consumption

Microbial spoilage of meat is attributed to improper handling and preservation of the meat (4,6). A Microbial analysis of meat by Kyayesimira et al., (7) showed that the butchery had the highest microbiological incidence (70-100%), followed by slaughter (50-80%), and transportation (30-50%). Oxidation of lipids occurs shortly after slaughter when blood circulation and metabolic processes stop affecting fatty acids and lead to oxidative deterioration of meat and off-flavor development (8,9). In addition, selling spoiled meat can lead to a loss of customer confidence in the affected retail outlets.

Traditional methods of meat preservation include; drying, smoking, brining, and canning. Current meat preservation methods include controlling temperature by chilling, freezing, and super chilling, controlling water activity with sodium chloride and sugars, and use of different chemicals such as chlorides, nitrites, sulfides, organic acids, phenolic antioxidants, and phosphates (10). This is intended to control the growth of microorganisms to prevent oxidative spoilage and to

control autolytic enzymatic spoilage. Meat preservation mechanisms including low-temperature storage and processing remedy the spoilage by delaying the breakdown of fatty acids and the subsequent development of microorganisms that cause rancidity (11). Therefore, the use of proper handling and preservation techniques improves the shelf life of the meat and hence prevents meat losses.

There is limited data on losses due to spoilage in butcheries and supermarkets in Nairobi County, Kenya. This study will be conducted to highlight the challenges leading to meat spoilage which when worked on may lead to food safety and food security.

This study aimed to determine meat preservation methods used by meat retailers and economic losses associated with meat spoilage in Nairobi, Kenya. Furthermore, microbial food contamination in the food supply chain causes food losses and food-borne illnesses that result in heavy economic losses (12). In Ethiopia, a loss equivalent to 28.45 USD was estimated to arise from every infected slaughtered cattle (13).

In one study in Uganda, the daily beef waste and drip loss was estimated in several butcheries and the sum of drip loss and beef waste gave the quantity loss per butchery. The daily quantity loss per butchery was higher for Mbale (3.19±2.60 kg) and lower for Mbarara (2.39±1.25 kg) and Kampala (2.39±1.61 kg) (14). This study aimed to determine meat preservation methods used by meat retailers and estimate the direct economic losses associated with meat spoilage in Nairobi, Kenya.

2. Materials and Methods

2.1. Study area

This study was carried out in the Dagoretti Sub-county of Nairobi County. The area is an urban settlement that is comprised of high, middle, and low-income areas. Meat is sold mainly in small-scale butcheries as well as in supermarkets. The meat is sourced from slaughterhouses located in the neighborhood of the study area.

2.2. Study design and target population

A cross-sectional study design was used targeting all the butcheries and supermarkets retailing meat in Dagoretti Sub-county.

2.3. Sample size determination

The sample size was determined using the formula $n = Z_a^2 \, pq/ \, L^2$ (15) with a 95% confidence interval and a desired accuracy of 10% (16). Where,

n= required sample size

Z = level of confidence according to the standard normal distribution (for a level of confidence of 95%, Z = 1.96)

p = estimated proportion of the population that presents the characteristic (when unknown p = 0.5 was used)

q = (1-p) = 0.5

L = 10 % tolerated margin of error = 0.1

Therefore, the sample size (n) was calculated to be:

$n = (1.96^2 \times 0.5 \times 0.5)/0.1^2 = 96$

A minimum sample size of 96 out of a total of 273 meat retail outlets (according to the Nairobi County Health Department records) was taken for this study.

2.4. Selection of study units

Ninety-six meat retail outlets were selected from three wards within the Dagoretti area using a systematic sampling technique. The three wards represented the Sub-county's socio-economic zones which included Kileleshwa (high income), Kilimani (middle to high income), Gatina, Kabori, and Kawangware (low income) areas. Every 3rd outlet was selected until the desired number of 96 outlets was achieved. In sampled butcheries and supermarkets, the informed consent of proprietors and managers was also obtained.

2.5. Data collection

Structured questionnaires were administered to the selected meat butcheries and supermarket outlets. The questionnaire captured information on the type of meat retailed, type of weighing machines, meat preservation techniques, safety and hygiene and storage, causes of meat losses, and how butchery owners managed spoiled meat.

A pilot study targeting 15 meat retailers that were not selected was done before the main study to generate data to measure the internal consistency and validity of the research tool.

2.6. Data management and statistical analysis

Data was entered into a spreadsheet and analyzed using SPSS version 20. Qualitative data was first coded, sorted, and then arranged in thematic categories before analysis. Association between preservation methods and demographic factors was made using Pearson's Chi-square test.

2.7. Ethical clearance

Research permits No.NACOSTI-P-2323662 and ethical approval were obtained from the National Committee of Science, Technology, and Innovation and the Ethical Approval Committee of the Faculty of Veterinary Medicine, University of Nairobi. Informed consent of the butchers' meat retail outlets and other stakeholders was taken.

Table 1. Summary statistics for demographic information of meat retailers in supermarkets and butcheries

Variable		Frequency	Percent
Gender	Male	85	89
	Female	11	11
Age (Years)	15 to 20	4	4
	> 20	91	95
Working duration	At most 10 hrs	36	39
	10hrs >	57	61
Educational level	Primary	21	26
	Secondary	52	63
	University	9	11
Status in business	Owner	47	51
	Partner	4	4
	Employee	42	45
Do you have a business license?	Yes	96	100
Do you have a county public health certificate?	Yes	37	39
	No	59	61
Do you have a medical certificate?	Yes	68	71
	No	28	29
How often do you go for medical checkups?	Every 3 months	20	32
	Every 6 months	37	60
	Every 12 months	5	8
Type of retail business	Supermarket	9	9
	Butchery	87	91

Table 2. Summary of sources, types, and species of meat sold

Variable		Frequency	Percent
Type of meat sold	Raw meat	74	77
	Processed meat	2	2
	Raw & Processed	20	21
Source of meat	Public slaughterhouse	78	81
	Private slaughterhouse	14	15
	Public & Private slaughterhouses	4	4
Species of meat sold	Beef	70	46
	Pork	21	14
	Chicken	27	18
	Goat	26	17
	Fish	7	5

3. Results

3.1. Demographic information

A total of 96 respondents, of which 9 and 87 were drawn from the meat retailers in supermarkets and butcheries, respectively were involved. The results of demographic factors are shown in Table 1.

Table 2 shows that 74 (77%) respondents retailed raw meat, 2 (2%) retailed processed meat and 10 (21%) retailed both raw and processed meat. It also revealed that the meat handlers mostly dealt in raw meat, and that very few transacted processed meat. The majority of 78 (81%) sourced their meat from public slaughterhouses while 14 (15%) sourced from private slaughterhouses. The preferred species of meat handled was beef (46%), followed by chicken (18%), goats (17%), pork (14%) and fish (5%).

3.2. Preservation of meat

Table 3 shows the analysis of storage methods that the meat retailers used and the challenges they faced.

The results indicate that the majority (54, 56%) of meat handlers relied on refrigeration methods for meat storage purposes.

Twenty-six (27%) said they hung the meat at room temperature, while 16 (17%) noted they used both refrigeration and hanging techniques for storing meat.

Concerning types of refrigeration facilities, 61 (87%) said they had refrigerators, while four mentioned they had cold rooms. In addition, 47 (49%) of respondents stated that they had refrigerated counters and 47 (49%) stated they hung the meat at room temperature.

3.3. Losses from meat spoilage

The study revealed that 71 (74%) of the meat retailers incurred losses related to meat spoilage, while 25 (26%) did not.

Sixty-seven (70%) of respondents said that the major cause of meat spoilage was due to poor storage, while 29 (30%) attributed the spoilage to poor handling. More than half 53 (55%) of the survey respondents said they lost at least 3kg of meat every week, 14 (15%) lost between 1-2 kg and 29 (30%) lost less than a kilo of meat within the same period. Table 4 shows the losses associated with meat spoilage.

Regarding disposal of spoiled meat, the study revealed that 57 (59%) of the meat handlers disposed of the spoilt meat by either burying (12%) or feeding animals 24 (88%) such as dogs. On the other hand, 39 (41%) indicated that they sold the spoiled meat at a cheaper price 20 (87%) of between Ksh 100 and Ksh 200 per kilogram.

The results revealed that even though many of the meat handlers experienced meat spoilage due to improper storage, they mostly sold it at a cheaper price to reduce their losses. Further analysis showed that moisture loss 27 (49%) and microbial spoilage 12 (22%) were the major factors associated with meat loss.

3.4. Analysis of financial losses

The results showed that traders lost on average 2.3 kg (range 1-3 kg) per week. Cumulatively, 69 respondents generated losses amounting to 158kgs of spoilt meat in one week. The financial losses were estimated using the prevailing price of meat (USD 5.0 per kilogram). This revealed that each meat retail enterprise on average lost

Table 3. Frequency of meat preservation methods

Variable		Frequency	Percent
How to store meat?	Hanging at room temperature	26	27
	Hanging and refrigeration	16	17
	Refrigeration	54	56
Type of refrigeration facilities	Cold room	4	6
	Refrigerator	61	87
	Cold room & refrigeration	5	7
Types of display	Refrigerated counter	47	49
	Hanging at room temperature	47	49
	Refrigerated counter and hanging at room temperature	2	2

Table 4. Summary information on associated meat losses

Variables		Frequency	Percent
Do you incur any meat spoilage?	Yes	71	74
	No	25	26
What do you think is the cause of meat spoilage?	Poor handling	29	30
	Poor storage	67	70
How many kilograms of meat do you normally lose per week?	Less than 1 kg	29	30
	2 kg	14	15
	3kgs and above	53	55
What do you do with spoiled meat?	Dispose	57	59
	sell at a cheaper price	39	41
If you dispose how do you dispose of the spoiled meat?	Burry	5	12
	animal feeding	24	88
If you sell the spoilt meat to dog farmers at a cheaper price, how much per kg?	Less than Ksh100	1	4
	Ksh100 to Ksh200	20	87
	Above Ksh200	3	9
What are the major causes of meat losses in your butchery?	chopping/splitting	7	13
	microbial spoilage	12	22
	moisture loss	27	49
	chopping & moisture loss	8	15
	Microbial spoilage & moisture loss	1	2

USD 11.50 (Range USD 5.0- USD 15.0) per week, with an estimated annual loss of (USD 598). The analysis further showed that the loss would range from USD 260 to USD 790 per enterprise per year. Overall the loss among the study respondents was estimated to be USD 41,080 per year as shown in Table 5.

3.5. Challenges faced in the preservation of meat and meat products

Meat retailers in the study areas faced meat spoilage due to a lack of cold facilities or unreliable power supply, fly menace, and low sales/demand due to a few customers.

The results indicate that 12 (10%) meat retailers lacked cold facilities which led to spoilage of meat products. Fourteen (14%) of the retailers complained of unreliable power supply 43 (35%) of the respondents noted that flies were a big problem in their businesses and 52 (43%) of respondents complained of low sales/demand as shown in Table 6. These results revealed that more meat retailers were affected by the low sales/demand of meat products compared to unreliable power or lack of cold facilities for the storage of meat.

When asked how they dealt with the fly problem, 43 (44.8%) of respondents stated they used anti-fly coil to repel the flies away from their businesses, 23 (24%) stated they maintained high level of cleanliness around the meat counters to keep the flies off their business, 7 (7.3%) used fumigation and insecticide sprays, 9 (9.4%) respondents indicated they manually kept the

flies away using the cow tail switch, 3 (3.1%) used to smoke and spray, 2 (2%) used tail switch and fly coil, while only 1 (1%) used fly traps. The results thus indicate the anti-flies coil was the most preferred method of managing the flies in meat retail shops.

3.6. Bivariate analysis between preservation methods and demographic information

Table 7 shows that a significant association exists between preservation methods and status in business (p=0.032), type of business (p=0.00), type of business sale (p-value=0.00), and type of meat sold (p=0.00). The results also showed that gender, level of education, and age did not influence the preservation methods.

The analysis reveals that a significant proportion of employees were likely to use both hanging and refrigeration methods, as opposed to just hanging the carcass, a method that was mostly preferred by the owners.

In addition, supermarkets fully relied on both hanging and refrigeration methods, while butcheries practiced hanging the carcass at room temperature as a method of preserving meat.

The results further reveal that chicken, fish, and processed meat were preserved by refrigeration, while, retailers of beef, goat, and pork mostly adopted the hanging technique.

Table 5. Estimation of meat losses due to spoilage

	Estimated financial loss per meat enterprise			
	Min	Average	Max	Overall
Meat loss (kg) per week	1.0	2.3	3	158
Total meat loss (kg) per year	52	119.6	158	8216
Price per kg of meat (USD)	5.0	5.0	5.0	5.0
Total cost of meat loss/week (USD)	5.0	11.5	15	790
Total loss per year (USD)	260	598	790	41,080

Table 6. Challenges in the preservation of meat

Variable		Frequency	Percent
Challenges faced	Cold facilities/ meat spoilage	12	10
	Unreliable power supply	14	12
	Flies	43	35
	Lack of demand	52	43
Do you have a flying problem?	Yes	67	70
	No	29	30
How do you keep flies away?	Use of anti-flies coil	43	45
	Cleanliness	23	24
	Cleanliness & use of Anti-flies coil	1	1
	Fumigation, sprays	7	7
	Manually by use of cow tail switch & use of anti-flies coil	2	2
	Manually by use of cow tail switch	9	9
	Smoking and spray	3	3
	Fly traps	1	1

Table 7. Bivariate analysis between preservation techniques and demographic characteristics

Variables	Categories	Preservation methods				Chi-square Tests		
		Hanging (26)	Hanging & refrigeration (16)	Refrigeration (54)	Total	X^2	df	p-value
Age	15 To 20	0	2 (12%)	2 (4%)	4 (4%)	3.859[a]	2	.145
	> 20	25 (100%)	14 (88%)	52 (96%)	91 (96%)			
Gender	Male	25 (96%)	14 (88%)	46 (85%)	85 (88%)	2.102[a]	2	.350
	Female	1 (4%)	2 (12%)	8 (15%)	11 (12%)			
Education Level	Primary	8 (33%)	1 (7%)	12 (28%)	21 (26%)	7.644[a]	4	.106
	Secondary	16 (67%)	12 (80%)	24 (56%)	52 (64%)			
	University	0	2 (13%)	7 (16%)	9 (11%)			
Status in Business	Owner	18 (69%)	4 (27%)	25 (48%)	47 (51%)	10.544[a]	4	.032
	Partner	0	0	4 (8%)	4 (4%)			
	Employee	8 (31%)	11 (73%)	23 (44%)	42 (45%)			
Type of retail outlet	Supermarket	0	7 (44%)	2 (4%)	9 (9%)	26.987[a]	2	.000
	Butchery	26 (100%)	9 (56%)	52 (96%)	87 (91%)			
Type of Meat Sold	Raw Meat	21 (81%)	7 (44%)	46 (85%)	74 (77%)	16.483[a]	4	.002
	Processed Meat	0	0	2 (4%)	2 (2%)			
	Raw & Processed	5 (19%)	9 (56%)	6 (11%)	20 (21%)			
Species of meat sold	Beef	15 (65%)	3 (19%)	25 (46%)	43 (46%)	46.989[a]	18	.000
	Pork	5 (22%)	0	7 (13%)	12 (13%)			
	Chicken	0	1 (6%)	6 (11%)	7 (7%)			
	Goat	0	1 (6%)	1 (2%)	2 (2%)			
	All	0	3 (19%)	0	3 (3%)			
	Beef, pork, chicken, goat	0	2 (12%)	2 (4%)	4 (4%)			
	Pork, chicken, fish	0	0	2 (4%)	2 (2%)			
	Beef, Chicken, Goat	0	2 (12%)	6 (11%)	8 (9%)			
	Beef, Chicken	3 (13%)	0	1 (2%)	4 (4%)			
	Beef, goat	0	4 (25%)	4 (7%)	8 (9%)			

4. Discussion

This study established that gender was a significant factor in meat entrepreneurship as the majority of the respondents were men (89%). This showed that men play a pivotal role in the meat business in Nairobi. Similarly, nearly all meat workers were adults over the age of twenty-five (95%). This is in line with the findings of Asuming-Bediako et al. (17) who reported that butchery business in Ghana is dominated by adult men.

Similarly, the study revealed that the majority of meat handlers (70%) were aged between 31 and 50 years, had a low level of education, and had between 11 and 26 years of experience in the business (18,19). Furthermore, Akabanda et al. (20) found that most meat workers were aged between 30 and 50 years old.

Regarding educational level, this study found that 95% of meat handlers were secondary school leavers (63%) aged 20 years and above.

Seemingly, high school dropouts dominated the meat retail industry since a few college graduates saw it as a promising career path.

This is in agreement with a report by Asuming-Bediako *et al.* (17) which ascertained that around three-fourths of the butcher workers in the Accra Metropolis had at least some kind of educational qualification, with nearly half of them possessing a basic level of education, and about one-third had no formal education. On their part, Adzitey (21) reported a resoundingly high proportion (64%) of butchers in the Bawku Municipalitylacksa lacking formal education. This shows that the butchery business is a promising industry that can employ a large number of youth who do not find opportunities to progress with their studies.

This study also revealed that 51% of Nairobi's meat retail businesses are owned and operated by business owners and their families compared to 49% which are run by staff employees. However, in Uganda, a study reported that only 38% of butcheries were managed by owners, while 61.2% were managed by employees (22). All the meat retail businesses had a valid business license, but only 39% of them confirmed to have a county public health certificate indicating laxity in the enforcement of public health regulations by concerned agencies.

Approximately, 71% of respondents in this study reported that they had valid medical certificates and 60% of them reported undertaking a medical examination once every six months.

The law requires that all food handlers in food retail businesses undergo medical examinations every six months and have a valid medical certificate.

In Ghana, Asuming-Bediako *et al.* (13) found that 80% of Ghanaian meat handlers undertook the recommended yearly medical examinations, compared to 20% who undertook the medical examination only sporadically.

In Uganda, butchery operators were found to have business registration certificates but only 55% of butchers had medical certificates (22).

In Ethiopia, approximately 84.6% of the abattoir workers had health certificates (23). Unhealthy meat handlers can be a source of food-borne pathogens and a great risk to meat consumers. Therefore, the requirement for food handlers to undergo regular medical examinations is meant to protect consumers against any potential health risks. Unlicensed meat sellers are not likely to comply with regular medical examination requirements and hence represent a threat to meat consumers.

Therefore, the public health authorities in Nairobi County must perform random inspections regularly to ensure compliance. The study also confirmed that the meat retail business was mostly done in butcheries, with a few supermarkets participating in the venture. Further analysis confirmed that many meat retailers handled raw meat (77%) and only 2% majored in processed meat. This indicated that

the majority of Nairobi's residents preferred raw meat and not processed meat. The major source of meat was the public abattoirs (81%) while the private sources accounted for 15%. Beef was the most popular meat sold by the meat retailers, as mentioned by 46% of the responses followed by chicken (18%) and goat meat (17%). The findings of this study compare well with practices in Ghana, where raw freshly slaughtered beef is the predominant meat sold in all the meat retail markets (17). The study also found that 56% of meat handlers relied on refrigeration methods for storing meat, while, over 27% of the respondents hung the meat at room temperature.

This finding is in line with the study showing that many meat handlers relied on refrigeration methods to preserve meat (24).

In contrast, Chepkemoi (25) found 83% and 47% of the operators in Nairobi and Isiolo Counties, respectively to store meat by hanging it in an open space in the butchery. The analysis shows that the majority of meat handlers owned a refrigerator (87%) and only 6% had the cold room facilities.

In addition, half of the respondents had refrigerated counters, which further helped to keep the meat products cold and safe for human consumption. This finding contrasts with the report by Kyayesimira et al. (14) in Uganda which indicated that 70-80% of butcheries lacked refrigeration facilities.

In Ghana, it was found that most meat markets and butcheries did not have adequate cold storage facilities for unsold meat (17). In this study, several respondents stated that they preferred hanging meat in an open space in the butchery, confirming the assertion by Mbugua and Karuri (26) that keeping meat at room temperature, inhibits microorganisms' growth due to reduced water activity on the surface of meat as a result of drying occasioned by moisture loss. This was revealed in this study as 49% of meat losses reported were associated with moisture loss (49%).

Meat spoilage was a common problem in the retail meat business in Nairobi as admitted by 74% of the respondents which they attributed to poor storage (70%) and poor handling (30%).

This reveals that personal factors such as hygiene and cleanliness bear less responsibility for the meat losses incurred.

About 59% of respondents indicated that they incurred losses of between 1-3 kg of meat/week due to spoilage which was mainly attributed to moisture loss and microbial spoilage as a result of poor storage. The spoilt meat was mostly disposed to dog farmers either free or at a price of between Ksh 100 and Ksh 200. A study in Ghana by Asuming-Bediako (17) also revealed that waste meat and bones from butcheries were collected by private individuals to feed to their pets. Kyayesimira *et al.* (14) reported meat losses to range between 2.39-3.2 kg per butchery including Mbale (3.19±2.60 kg) and lower for Mbarara (2.39±1.25 kg) and Kampala (2.39±1.61 kg) daily with economic losses equivalent to 787.50 USD dollars per day. The losses were attributed to wastage (22.4%), drip loss (19.7%), and microbial spoilage (18.4%).

5. Conclusion

Meat retail outlets including butcheries and supermarkets in Dagoretti Nairobi sell mainly raw meat of various animal species. These retail outlets display meat by hanging the carcasses in the open air, using refrigerated counters or both hanging and refrigerated counters. Unsold meat is stored in cold rooms or refrigerators or hang the meat at room temperature.

Retailers incur meat losses estimated at USD 5.0 per week which arise mainly from moisture loss and microbial spoilage. The main challenges faced by meat retailers are the high cost of electricity, fly menace, and low demand.

Meat retailers should be trained on proper methods of handling and storage of meat including keeping meat in coolers/refrigerators maintained at 0°C to 2°C with a humidity level of approximately 75% to 80% to prevent moisture loss.

The study recommends that the government should implement policies to reduce electricity bills and promote the adoption of refrigeration methods. Industry stakeholders should also initiate public health awareness campaigns regarding appropriate meat preservation methods. Furthermore, retail cut meat products on display should be wrapped in permeable film to reduce moisture loss.

Conflict of interest

The authors declare no conflict of interest to the present study.

References

1. SNV. Livestock. In: East and Southern African Annual Review, 2008; 20.

2. Kantor LS., Lipton K, Manchester A, et al. Estimating and addressing America's food losses. Food Rev 1997; 20: 3-11. http://www.ers.usda.gov/Publications/FoodRevie w/ Jan1997/Jan97a.pdf.

3. Mekonnen A. Major causes of meat spoilage and preservation techniques. Food Sci Qual Manage 2015; 41: 101-14.

4. Cerveny J, Meyer JD, Hall PA. Microbiological spoilage of meat and poultry products In: Compendium of the microbiological spoilage, of foods and beverages. Food Microbiology and Food Safety, W.H. Sperber and M.P. Doyle (Eds.). Springer Sci Bus Media NY, 2009; 69-868. DOI: 10.1007/978-1-4419- 0826-1-3.

5. Pighin D, Pazos A, Chamorro V, et al. Contribution of beef to human health. A review of the role of the animal production systems. Sci World J 2016; 8681491.

6. Gram L, Ravn L, Rasch M, et al. Food interactions between food spoilage bacteria. Int J Food Microbiol 2002; 78: 79-97.

7. Kyayesimira J, Wangalwa R, Kagoro GR, et al. Microbial quality of beef and hygiene practices in small and medium slaughterhouses and butcheries in Uganda. Research Square, 2020; 1-13, DOI: https://doi.org/10.21203/rs.3.rs-48693/v1.

8. Linares MB, Berruga, MI, Bornezv R, et al. Lipid oxidation in lamb meat: Effect of the weight, handling previous slaughter and modified atmosphere. Meat Sci 2007; 76: 715-20.

9. Simitzis PE, Deligeorgis SG. Lipid oxidation of meat and use of essential oils as antioxidants in meatproducts.http://www.scitopics.com/Lipid_Oxidation_of_Meat_and_Use_of_Essential_Oils_as_Antioxidants_in_Meat_Products.html, 2010.

10. Dave D, Ghaly AE. Meat spoilage mechanisms and preservation techniques: a critical review. Americ J Agri Biolog Sci 2011; 6: 486-510.

11. Luong NDM, Coroller L, Zagorec M, et al. Microorganisms spoilage of chilled fresh meat products during storage: a quantitative analysis of literature data. Microorgan 2020; 8: 1198.

12. Elkhishin MT, Gooneratne R, Hussain MA. Microbial safety of foods in the supply chain and food security. Advance Food Technol Nutr Sci 2017; 3: 22-32.

13. Fromsa A, Jobre Y. Estimated annual economic loss from organ condemnation, decreased carcass weight, and milk yield due to bovine hydatidosis (Echinococcus granulosus, Batsch, 1786) in Ethiopia. Ethiop Vet J 2012; 16: 1-14.

14. Kyayesimira J, Wangalwa R, Rugunda GK, et al. Causes of losses and the economic loss estimates at post-harvest handling points along the beef value chain in Uganda. J Agri Extension Rural Develop 2019; 11: 179-83.

15. Dohoo IR, Martin W, Stryhn HE. Veterinary Epidemiologic Research, 2003. Prevent Vet Med 2005; 68: 289-92.

16. Kongkaew W, Coleman P, Pfeiffer DU, et al. Vaccination coverage and epidemiological parameters of the owned-dog population in Thungsong District, Thailand. Prevent Vet Med 2004; 65: 105-15.

17. Asuming-Bediako S, Aikins-wilson S Affedzie-obresi, et al. Challenges in the Butchery Industry: Potential Opportunities for Business in Ghana. Ghana J Agri Sci 2018; 52: 121-29.

18. Adesokan HK, Raji AOQ. Safe meat-handling knowledge, attitudes and practices of private and government meat processing plants' workers: Implications for future policy. J Prevent Med Hyg 2014; 55: 10.

19. Tegegne HA, Phyo HWW. Food safety knowledge, attitude and practices of meat handler in abattoir and retail meat shops of Jigjiga Town, Ethiopia. J Prevent Med Hyg 2017; 58: e320.

20. Akabanda F, Hlortsi EH, Owusu-Kwarteng J. Food safety knowledge, attitudes and practices of institutional food-handlers in Ghana. BMC Pub Health 2017; 17: 1-9.

21. Adzitey F. Effect of pre-slaughter animal handling on carcass and meat quality. Int Food Res J 2011; 18: 485-91.

22. Lamunu G, Ddamulira C, Odoch FA, et al. Factors affecting adherence to meat hygiene practices of beef butcheries in Kasangati Town Council, Wakiso District, Uganda 2022. World J Advance Res Rev 2022; 14: 525–37.

23. Haileselassie M, Taddele H, Adhana K, et al. Food safety knowledge and practices of abattoir and butchery shops and the microbial profile of meat in Mekelle City, Ethiopia. Asian Pac J Tropic Biomed 2013; 3: 407-12.

24. Heinz G, Hautzinger P. Meat processing technology for small to medium scale producers. RAP Publication (FAO) 2007.

25. Chepkemoi S. Handling practices, microbial quality and weight loss of beef in small and medium enterprise butcheries in Nairobi and Isiolo Counties, Kenya. Doctoral dissertation, University of Nairobi 2016.

26. Mbugua SK, Karuri EG. Preservation of beef using bacteriostatic chemicals and solar drying. Food Nutr Bulletin 1994; 15: 1-6.

technology for small to medium scale producers. RAP Publication (FAO) 2007.