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Causes of losses and the economic loss estimates at post-harvest handling points along the beef value chain in Uganda

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Uganda's beef industry has been growing slowly and requires sustained monitoring of actors at post-harvest handling points in order to decrease public health risks and losses. This study documented causes of losses and estimated economic values at post-harvest handling points along the beef value chain. It was carried out at slaughter houses, transporters and butcher shops in the districts of Western, Central and Eastern Uganda. A cross sectional study was conducted among meat handlers who were interviewed to find out the losses incurred in the value chain. Microbial load from carcass swabs were collected and evaluated using standard microbiological methods to determine microbial contamination of beef. The causes of losses varied at different handling points. The actors at slaughter houses indicated the major losses were due to low beef demand (15.3%), insecurity (13.4%) and poor weight estimation methods (11.03%). Losses at the butchery included, beef waste (22.4%), drip loss (19.7%) and beef spoilage (18.4%). Microbial analysis showed the highest microbial prevalence at the butchery (70-100%) followed by slaughter (50-80%) and lastly transport (30-50%). Microbial contamination on carcass leads to spoilage and hence market loss because exportation does not admit contaminated foods. Actors reported beef waste and drip loss as the major causes of losses at the butchery. To reduce losses, public health care education for meat handlers and adherence to strict standard operating procedures (SOPs) are a key.

Key words: Losses, post-harvest, beef value chain, handling points, Uganda.

INTRODUCTION

In Uganda, livestock sub sector contributes 9% of the Gross Domestic product and the sector comprises cattle, poultry, pigs, goats and sheep. Of the 9% of the GDP, cattle contribute about 72% (Mbabazi and Ahmed, 2012). Actually, cattle population is estimated at 11.4 millions and out of these 93.6% are indigenous breeds (UBOS, 2008). However, cattle are the most important livestock supporting the livelihood of about 4.5 million people in

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in Uganda (Mbabazi and Ahmed, 2012) and are the leading source of meat in the country (FAO, 2018). In Uganda, beef sector is the most vibrant meat sector with the highest per capita consumption and with the highest potential for local and regional growth in demand (Agriterra, 2012). The annual national beef production was estimated at 202,929 metric tons in 2014 (MAAIF, 2016) but could increase greatly if there were reduced losses in the sector.

Safety, quality and quantity losses of meat are however still a challenge in the country. Safety and quality losses by microbiological causes are a hazard for consumers because of pathogenic microorganisms on the product and the economic losses that result from microbial spoilage (Raybaudi-Massilia et al., 2009).

During beef processing and preparation (post harvesting stage), microbial contamination of beef can occur (Lawan et al., 2013; Fearon; Mensah and Boateng, 2014) and this may be as a result of contact with contaminated tools or equipment (Birhanu et al., 2017). The contaminated tools and equipment may harbor and introduce pathogens into beef (Bogere and Baluka, 2014; Chepkemoi et al., 2015). In addition, during unhygienic processing of beef, handling practices are also known to play a role. For example, poor handling practices can contribute to microbial contamination of tools, equipment and beef itself. Yet, consumption of microbiologically contaminated food can bring unimaginable economic loses (Hussain and Dawson, 2013) in various forms including unexpected expenditure on hospitalization bills, treatment costs, lost markets (for exports) and financial loss due to loss of business (Akanele et al., 2016).

Furthermore, microbial food contamination in the food supply chain cause food losses and foodborne illnesses that result in heavy economic losses (Elkhishin et al., 2017). In Ethiopia, a loss equivalent to 28.45 USD was estimated to arise from every infected slaughtered cattle (Fromsa and Jobre, 2012) while in Egypt, direct economic loss was valued at 28544.3 USD and said to arise from condemnation of meat and liver (Elmonir and Ramadan, 2016). However, in Uganda such economic losses have not been adequately evaluated. There are several fragmented studies that have been conducted on the Uganda's beef value chain but very few attempts have been made to estimate the economic losses. Therefore, the present study was made to document causes of losses and estimated economic losses at post-harvest handling points in the beef value chain in Uganda.

MATERIALS AND METHODS

Sample collection and preparation

A total of 94 carcass surface swab samples were randomly collected from slaughter houses, transporters and the retail meat outlets (butchery) from the districts of Mbarara (Western region), Kampala (Central region) and Mbale (Eastern region) in Uganda. The carcass surface swabs were aseptically collected. These were transferred into sterile transport medium (STUARTS), labeled and then placed in a cool box lined with ice packs awaiting transportation to the laboratory for examination. Interviews were conducted to document the perception of meat handlers about the causes and the estimated postharvest economic losses of beef at slaughter houses, transportation and butchery.

Determination of microbial load

Microbiological analysis was carried out using standard methods (Adams and Maurice, 2008; Da Silva et al., 2013). Total Viable Counts (TVC) was inoculated by surface spreading onto standard methods Plate Count Agar (PCA). Dilutions of 10^{-8} were prepared. Dilutions of each sample were inoculated in duplicate in the standard plate count agar medium just before solidification of the agar. On solidification of agar, the plates were incubated at 37°C for 24 h. After 24 h of incubation, the colonies were counted using colony counter.

Coliforms or Total Coliform Counts (TCC) *and E. coli* were inoculated by surface spreading onto Violet Red Bile Agar (VRBA) and incubation done at 37°C for 24-48 h. For *E. coli,* the incubation was done at 45°C for 24-48 h. Total Coliforms Counts formed pink colonies while for *E. coli*, blue/violet colonies were observed. The colonies were expressed in colony forming units (CFU) per cm^2.

Determination of economic loss at post-harvest handling points and loss hot spots along the beef value chain

Face to face interviews were used to collect information on the actors' perception of economic post-harvest losses incurred in the beef value chain. A total of 601 respondents were randomly selected and interviewed and these included actors at abattoirs/ slaughter houses/slabs (105), butchery (355) and transporters (141) from the districts of the study area.

At slaughter, the economic loss due to quality of beef was evaluated based on the microbial data results. All carcass surface swabs that were positive for coliforms were considered to be unfit for human consumption and hence used to calculate percentage quality loss. The data on average weight and cost of carcass was later used to compute economic losses.

Microbial data collected during beef transportation was used to compute for the loss in the transport value chain. Beef transported in unclean and dirty containers could get contaminated. Swabs of transport containers collected were analysed for microbial contamination. The average weight of carcass being transported and the price of beef in kilograms (kg) was used to compute the economic loss.

The economic loss of beef at butchery was also computed based on the microbial data results. All carcass surface swabs that were positive for coliforms were considered to be unfit for human consumption and hence used to calculate percentage quality loss. Additionally, drip loss and beef wastes were measured and used to compute for economic loss based on quantity. The weight of beef waste was obtained by measuring the drops of meat and bones that fall off during the cutting of beef during sale. Drip loss was determined by measuring the weight of beef at the close of business at the butchery and weight of beef at the start of business the next day (the balance). The weight of beef waste and weight of drip loss was taken as the loss in kilograms and hence used to calculate the economic loss.

A formula was developed based on related formulas used in previous related studies (Fromsa and Jobre, 2012; Ejeh et al., 2014; Elmonir and Ramadan, 2016; Rahayu et al., 2016; Jaja et al., 2017). The developed formula was adapted to Uganda's conditions in the post-harvest beef value chain using collected data during the

Table 1. Formulae used to estimate economic losses.

Type of loss	Formula	Explanation
Quantity loss	QL=DL+ BW	DL: Drip Loss (daily)
		BW: Beef Waste (daily)
		QL: Quantity Loss (daily)
	TQL=QL*n(b)	TQL: Total Quality Loss (daily)
		n(b): number of butcheries samples
	TDBS=DBS*n(b)	TDBS: Total Daily Beef in Stock
		DBS: Daily Beef in stock
	%TQL=TQL/TDBS*100%	
Quality loss	% CC=n(CC)/n(CS)*100%	CC: Carcass Contaminated
		n(CS): number of Carcass Sampled
		n(CC): number of Carcass Contaminated
	TCC(kg)=AVG CW*n(CC)	TCC: Total Carcass Contaminated
		AVG CW: Average Carcass weight
		n(CC): number of Carcass Contaminated
		kg: means Kilograms

study. The direct economic losses were associated with microbial contamination of beef (this is unfit for exportation) and wastage due to drip loss and beef waste (Table 1).

Data analysis

Data was analyzed using descriptive statistics and presented as means ± standard deviation. Variations in the mean microbial counts among districts and the nodes of the beef value chain were also determined. All analysis was run in SPSS ver. 20*.*

RESULTS

Attributes of economic loss at post-harvest handling points along the beef value chain

The perception of losses from actors at slaughter houses was obtained through interviews. The causes of losses at the slaughter were mainly due to low beef demand (16.1%), too much heat/ dry season (12.5%) and poor weight estimation methods/ Animal fatigue (9.8%) as shown in Table 2. Other causes of losses include animal disease (8.9%), thieves (8.9%), insecurity/ poor monitoring of slaughter process (8.0%), wet season/high diseases (8.0%) among others. Animal fatigue often leads to poor quality of meat and at times death of animals during transit and animal diseases lead to quarantines that prevent cattle movements.

For beef transporters, they indicated that they do not experience losses since their role is to transport the beef meat and they are paid. The loss would come in case of an accident leading to meat falling in dirt but this rarely happens.

Based on the results from face-to face interviews, the actors at butchery perceive the losses based on what causes them to get less money in their business. In Mbarara, the losses at the butchery were attributed mainly to beef spoilage (29.7%) and beef waste (22.9%). In Kampala, the main cause of losses were bad debtors (31.1%) and beef wastes (20.2%) while for Mbale district, it was drip loss (35.8%) and beef waste (24.1%) as shown in Table 3. In all the districts of the study, beef waste (22.4%) was listed as the major cause of losses at the butchery followed by drip loss (19.7%) and then beef spoilage (18.4%). Beef waste results from cutting meat and makes up the small chippings that fall off during the cutting of carcass at the butchery whereas drip loss is the loss of water from meat tissue during storage and is high when meat is left overnight in air (air borne) as witnessed in majority of butcheries.

Economic loss based on microbial quality

To determine economic loss due to post harvest handling, the microbial load data was used. Prevalence of Total Coliform Counts (TCC) from carcass swabs at slaughter house, transport and butchery were counted per district based on microbial results as shown in Table 4. The estimated economic loss was calculated and results are shown in Table 4 and price of beef per kg was based on samples where the swabs were collected. The trend of quality losses was the highest at the butchery where 70-100% of samples were found contaminated. Transporters were found to experience the least rate of coliform prevalence (30-50%). When these rates of contamination were translated into monetary value,

Table 2. Causes of losses encountered at slaughter houses/slabs, % response (n).

Cause for losses	Mbarara	Kampala	Mbale	Overall
Poor monitoring of slaughter process	6.8 (n=2)	4.3 (n=2)	14.3 (n=5)	8.0(9)
Using eyes to estimate weight	13.3 (n=4)	4.3 (n=2)	14.3 (n=5)	9.8(11)
Emaciated cattle	3.3 (n=1)	0	0	0.9(1)
Too much heat/ dry season	3.3 (n=1)	17.0 (n=8)	14.3 (n=5)	12.5(14)
Low beef demand	13.3 (n=4)	19.1 (n=9)	14.3 (n=5)	16.1(18)
Poor slaughter shelter	3.3 (n=1)	0	2.9 (n=1)	1.9(2)
Condemned meat	3.3 (n=1)	0	0	0.9(1)
Animal disease	6.7 (n=2)	10.6 (n=5)	8.6 (n=3)	8.9(10)
Thieves	10 (n=3)	8.5 (n=4)	8.6 (n=3)	8.9(10)
Poor transportation /animal fatigue	6.8 (n=2)	0	0	1.9(2)
Insecurity	20.0 (n=6)	6.4 (n=3)	0	8.0(9)
Animal fatigue	3.3 (n=1)	10.6 (n=5)	14.3 (n=5)	9.8(11)
Unfaithful bosses/customers	3.3 (n=1)	8.5 (n=4)	0	4.5(5)
Wet season/high diseases	3.3 (n=1)	10.6 (n=5)	8.6 (n=3)	8.0(9)
Total	100 (30)	100 (47)	100 (35)	100(112)

Table 3. Causes of losses at the butchery in all the Districts of the study; % response (n).

Nature of losses	Mbarara (%)	Kampala (%)	Mbale (%)	Overall
Poor estimation of weight	2.5 (n=2)	5.7 (n=11)	0_	4.1(n=13)
Bad debtors	13.6 (n=14)	31.1 (n=60)	6.9 (n=4)	17.2 (n=78)
Beef waste	22.9 (n=24)	20.2 (n=39)	24.1 (n=15)	22.4 (n=78)
Meat theft butchery	0.8 (n=1)	0.9 (n=2)	2.3 (n=1)	1.33 (n=4)
Beef spoilage	29.7 (n=30)	10.5 (n=20)	14.9 (n=9)	18.4 (n=59)
Drip loss	10.2 (n=10)	13.2 (n=25)	35.8 (n=23)	19.7 (n=58)
Low meat demand	13.6(n=14)	8.4 (n=16)	10.3 (n=6)	10.8 (n=36)
High tax levy	0.8 (n=1)	1.8 (n=3)	0	1.3 (n=4)
Bones and fats	5.9 (n=6)	3.5 (n=7)	5.7 (n=3)	5.03 (n=16)
Price fluctuation	0	4.8 (n=9)	0	4.8 (n=9)
Total	102	192	61	355

butcheries were found to be experiencing the highest economic loss. Among the districts, butcheries in Mbale were found to have the highest quality economic loss. In this district, the ten butcheries sampled, all had contaminated meat which totaled to 1410 kg and this was an equivalent of 3095 USD dollars loss per day.

Economic loss based on quantity (drip loss and beef waste)

Since results from interviews indicated that major losses were due to beef waste and drip loss, the study used these variables to estimate economic loss. At each butchery, the economic loss was determined from the drip loss and beef waste resulting from the daily beef stock. The daily beef waste and drip loss was estimated from several butcheries in the areas of the study. The sum of drip loss and beef waste gives the quantity loss per butchery. The 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) on a daily basis as shown in Table 5a.

The total quantity loss as indicated in Table 5a and the sale price of meat per kg in each district was used to compute the economic loss accrued in each district as indicated in Table 5b. Computation was based on the price of beef as of January 2018 (the time when data was collected); the total economic loss experienced per district at the butchery was 2,834,354.24 UGX an equivalent of 787.50 USD dollars on a daily basis.

DISCUSSION

The actors at the different nodes in post-harvest beef

Table 4. Economic loss at slaughter, transport and butchery.

District	Value chain point	Prevalence of coliform contamination	% contamination	Avg. weight of carcass (kg)	Total carcass contaminated (kg)	Price per kg	Economic Loss (UGX) from contaminated beef	Total Economic Loss (USD)
	S (n=14)	7	50	155	1085	7800	8,463,000	2,351
Mb'ra	T(n=10)	4	40	155	620	7800	4,836,000	1,344
	B (n=10)	8	80	155	1240	7800	9,672,000	2,687
	S (n=10)	5	50	164	820	7800	6,396,000	1,777
K'la	T (n=10)	3	30	164	492	7800	3,837,600	1,066
	B (n=10)	7	70	164	1148	7800	8,954,400	2,488
	S (n=10)	8	80	141	1128	7900	8,911,200	2,476
Mbale	T (n=10)	5	50	141	705	7900	5,569,500	1,547
	B (n=10)	10	100	141	1410	7900	11,139,000	3,095

Mbra,Mbarara; K'la,Kampala; S,Slaughter; T,Transport; B,Butchery; Avg,Average; UGX,Uganda shillings; USD, United States Dollars.

Table 5a. The daily drip loss and beef waste and quantity loss of beef.

District	Drip loss (kg)	Beef waste (kg)	Quantity loss per butchery (kg)	Daily total quantity loss in a district (kg)
Mbarara (n=102)	0.89±0.69	1.50±0.93	2.39±1.25	243.78
Kampala (n=192)	0.70±0.58	1.69±1.45	2.39±1.61	458.88
Mbale (n=61)	0.96±0.71	2.23±2.49	3.19±2.60	194.59
Average	0.85	1.81	2.66	299.08

handling value chain perceived losses in terms of how they impacted on their incomes It is also important to note that post-harvest losses do not only impact on income of different actors but also contribute to food insecurity as observed by Diei-Ouadi and Mgawe (2011) who studied the fish value chain.

The perceived losses at the slaughter were mainly due to low beef demand, insecurity and poor weight estimation methods. Because of low demand of beef that is less meat bought in a day, the left over is reported to be sold at a low price. This is as a result of loss of attractiveness to the consumers. In Uganda, good quality beef (attractive meat) is perceived by the freshness that is the shiny fats, whoozing blood and juiciness/wetness of muscle. If meat is not bought on the day slaughtered, by the next day, it appears dry due to drip loss thus fetching less price leading to losses.

The other cause of loss is insecurity which leads to theft of animals. This happens when the animals are stolen when they are being held at the liarage. In this case, the business man losses the whole animal leading to 100% loss.

Poor weight estimation methods were identified as another cause of losses. At slaughter houses, actors rely on visual weight estimations for the live animals without use of weighing scales and this limits their profits. This finding is in agreement

Table 5b. The Estimated quantity economic losses per district.

District	Avg. daily beef in stock (Avg± SD)	Avg. sale price per kg (Avg± SD)	Total meat in stock (kg)	Total daily stock value (UGX)	Economic loss (UGX)	Economic loss (USD)
Mbarara (n=102)	44.43±36.85	9002.45±1406.09	4518.6	398,808.54	2,194,617.26	609.75
Kampala (n=192)	80.05±96.71	10125±6541.40	15360	810,000.00	4,646,160.00	1,290.89
Mbale (n=61)	54.11±42.66	9303.27±917.55	3294	502,376.58	1,810,323.31	502.98
AVERAGE	59.53	9476.91		562,928.45	2,834,354.24	787.50

Avg,Average; Kg,Kilogram; UGX,Uganda shillings USD, United States Dollars.

with those of Mpairwe et al. (2015). The authors reported that lack of weighing equipment limits profit maximization since size and weight are major determinants of cattle prices. The person buying needs to know the weight of the animal before payments so that it is comparable with the carcass weight after slaughter. It was noted that though beef traders have a high bargaining power in setting up cattle prices, lack of weighing in the process of purchases often lands them into losses.

Other factors mentioned to cause losses included animal disease, emaciated cattle and poor transportation/animal fatigue. This is in agreement with previous studies on food commodities which reported pest and disease and poor transportation facilities to be the leading causes of post-harvest losses (Affognon et al., 2015; Kasso and Bekele, 2016; Jaja et al., 2017). Unlike in other studies, the current study did not quantify the economic losses as a result of pests and diseases. Although a number of factors in the supply chain like transportation (distance and temperature) have been reported to affect meat quality and its shelf-life (Rosenvold and Andersen, 2018; Rani et al., 2017), results from the interviews of actors indicated no losses in beef during transportation in this present study. Much as the actors at transport reported not to experience any losses, microbial load was observed in the surface swabs from the carcasses at this stage. These findings are comparable to the results of Bogere and Baluka (2014). The authors found that microbial contamination is common among transporters and causes loss of the quality of beef. Containers used for transporting carcasses can act as a vehicle of transmitting microbial loads (Chepkemoi, 2016). This is attributed to the poor hygiene of the containers used for carrying carcasses as transporters usually neglect their hygiene due to lack of direct economic losses accruing from them. Likewise, Rani et al. (2017), reported that poor handling of meat during transportation may result in a high rate of contamination and spoilage.

Unlike actors at transport who reported not to experience losses, actors (respondents) at the butchery indicated to incur losses. They attributed beef spoilage as a major cause of losses which was further explained to be as a result of temperature variation. This response is supported by findings of Aburi (2012), which showed that high temperatures accelerate spoilage leading to unsafe meat. From observations, there is inadequate cleaning of surfaces, personnel hands and tools and this is suspected to have also contributed to microbial contamination which can further lead to losses. Inadequate cleaning practices exposes meat to contamination by spoilage and pathogenic microorganisms and this causes post-harvest losses of beef (Chepkemoi et al., 2015; Rani et al., 2017).

Beef waste generated during cutting of carcass was reported to be the leading contributor of losses at the butchery. The beef waste consists of beef and bones that fall off during the cutting of carcass and portions could be a lot if the chopping is done by unskilled personnel. Studies by Fearon et al. (2014) reported waste tissue loss and this leads to loss of income. Birhanu et al. (2017) in a study carried in Gondar Northwest region of Ethiopia noted that there were beef weight losses in butcher shops and hence economic loss.

The current study findings indicate that there was careless handling of meat at the slaughter houses, transportation and butcher shops. This practice affects the quality of meat in terms of microbial contamination and this is congruent with the results of Kebede et al. (2014).

Meat condemnation has been reported to be one of the major causes of economic loss for example in South Africa (Jaja et al., 2017). However, in Uganda meat condemnation was found to be a minor cause of economic loss in this current study since it was reported by 3.3% of respondents. Actually, this cause was reported only in one district out of the 3 studied and that was Mbarara district. In Ethiopia, meat condemnation was estimated to cause economic loss of 28.45 USD per every infected slaughtered cattle (Fromsa and Jobre, 2012). However, in the current study, the amount of economic loss caused by meat condemnation was not estimated.

Drip loss that is the loss in weight due to loss of moisture during storage resulted into quantity losses in the beef value chain in this study. It was revealed that, the weight of carcass stored by the closure of the day, would be found less by the opening of the next business day if its left hanging in air. Drip loss leads to reduction in carcass weight hence causing economic loss. In a study in Ethiopia, reduction in carcass weight was attributed to animal diseases leading to economic loss (Fromsa and Jobre, 2012). Likewise, in the current study, animal disease was reported among the causes of economic loss in the meat sector. It is important to note that animal diseases lead to emaciated cattle which cause reduction in carcass weight at slaughter. Not only in Uganda and Ethiopia, drip loss was also reported in Kenya as one of the leading causes of economic loss (Chepkemoi, 2016). The author further highlighted that meat with a high drip loss has an unattractive appearance. Other studies have reported drip loss to cause financial loss for actors in the meat value chain because it affects meat quality (Aaslynga et al., 2003). This is because drip loss leads to dry meat that has poor appearance, less juicy which attributes to low demand among consumers and leading to less sales.

Conclusions and recommendations

Microbiological contamination was found at all different post-harvest handling points since, at every point, there were samples that were contaminated. Of all different handling points, butchery showed the highest economic loss. The study recommends for public education in health care, proper handling and adherence to strict standard operating procedures (SOPs) in slaughterhouses, at transportation and butchery in order to reduce microbial food contamination. Based on the findings, handling practices should be improved especially at butchery since this is where the highest levels of contamination and economic losses are experienced.

Beef waste generated during cutting of carcass is one of the major causes of losses at the butchery and so modern cutting tools need to be used to prevent this loss. To reduce on drip losses, meat sales should be made in cold rooms to reduce on carcass weight reduction that are as a result of exposure to harsh dry environmental conditions. Butchery establishments should also utilize refrigeration facilities instead of hanging meat overnight in air so as to reduce drip loss.

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CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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