Effect of pre-slaughter beef cattle handling on welfare and beef quality in Ambo and Guder markets and abattoirs, Oromia Regional State, Ethiopia

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ABSTRACT

Improper beef cattle handling could affect welfare and meat quality. The effect of beef cattle handling during transportation and in the lairage on the animal welfare and beef quality was studied in relation to Guder and Ambo markets and abattoirs. Data were collected from 200 respondents using a semi-structured questionnaire. For laboratory analysis, animals were randomly assigned into three groups: Group I - trekked from the nearest places (≤30 km), Group II - trekked farthest places (>30 km), and Group III - transported using vehicles (>50 km). One-hundred pooled beef swab samples were collected from the flank, brisket, and rump to determine aerobic bacterial load and another 100 beef samples to assess pH values. Descriptive statistics, independent t-test, and ANOVA were used for analysis. The result of the study indicated that trekking was the major means of transportation (72%). The majority of animal handlers (92%) did not allow animals to feed, water, and rest during trekking. Beef cattle were overcrowded and beaten during vehicle transport. About 47% of the beef samples were abnormal of which the majority were DFD (dark, firm and dry) beef and DFD beef with spoilage. The pH of meat was significantly affected by the distance traveled before slaughter using both trekking and vehicle transportation ($t= -3.5$, $p=0.001$). Therefore, it is concluded that there was poor handling and stressful situation of beef cattle before slaughtering, which negatively affected the welfare and beef quality. Hence, pertinent proclamations, regulations, and delivery of animal welfare awareness training for different stakeholders are urgently needed.

Keywords: Abattoirs; Ambo and Guder market; Beef quality; Pre-slaughter cattle handling; Transportation; Welfare.
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INTRODUCTION

Animal welfare refers to the prevention of mishandling and misuse of animals by mankind. Animal welfare also refers to the state of the animal and the treatment that an animal receives such as animal care, animal husbandry and humane treatment. Good animal welfare necessitates disease prevention and veterinary treatment, suitable housing, management, diet, and compassionate handling (OIE, 2010).

Beef animal producers take several days and efforts to raise an animal to required age, weight, and quality on the farm. But, the condition may change appreciably within few days before slaughter which undesirably decreases weight, affects the welfare, meat quality, and afterward decreases profit due to stress from poor handling conditions before slaughtering (Gebawo Tibesso and Adem Hiko, 2019). Pre-slaughter cattle handling activities take place on the farmstead, throughout transportation, selling, and at the slaughter plant. Animals could also suffer from pre-slaughter stresses arising from bruises, injuries, hunger, fatigue, water, and lack of food, and improper loading and unloading on the vehicles (Adzitey, 2011).

Animal handling affects not only the emotional states of animals but also the economies of the producers since rude treatment is associated with lowered production (Price, 2008). Proper handling of animals is not only a matter of welfare but also an issue of meat quality and safety. Beef from poorly handled cattle is poor in quality and leads to poor processing properties, functional, and eating quality and less likely to be accepted by consumers. When the animals are stressed before and/or during slaughter, it affects not only animal welfare but also stretches to objectionable consequences on the beef quality (Gregory *et al*., 2010; Adziety *et al.,* 2011; Frimpong *et al*., 2014). However, stress during transportation could be reduced using properly designed vehicles, by improving facilities and handling techniques.

In Ethiopia, beef cattle are transported long distances from farms or primary markets to secondary markets and then to terminal markets mostly using trekking. Berhanu Gebremedhin *et al.* (2007) stated that almost all livestock in Ethiopia is transported by people on foot, in rare cases during longer distances by ill-designed vehicles, but usually not preferred since trekking is cheaper. These conditions could cause stress and affect the welfare of cattle and beef quality. Gebresenbet Girma *et al*. (2005) reported that transport and handling events are stressful for the cattle as a whole, and loading and unloading are among the most stressful events. The transportation of cattle using inappropriately designed vehicles for over six hours was particularly stressful for the cattle. The study conducted by Frimpong *et al*. (2014) in Ghana revealed that

more than 16% of expected income was lost due to the incidence of death and illness or injuries of cattle during transportation from farms to cattle markets and abattoirs. Guder and Ambo markets are the biggest and potential secondary markets in Oromia Regional State, Ethiopia. To these markets, a large number of animals such as cattle, sheep, and goats are transported long distances for a long period for sale. Among these species of animals, cattle especially oxen and bulls are purchased from Guder and Ambo markets in large numbers mostly by beef cattle traders and butchers and again transported long distances to abattoirs and other farthest markets like Addis Ababa mostly using trekking in hot and cold climatic condtion without provision of feed and water. Such methods of animal transportation are of great concern since they lead to undeniable and undesirable consequences in welfare and beef quality. The Guder and Ambo abattoirs are the main sources of slaughtered beef cattle for Guder and Ambo town residents, respectively.

Although these markets are potential markets, little research works have been conducted so far related to these markets to assess the animal welfare and beef quality and come up with intervention measures. Therefore, the current research work was undertaken to assess the effect of beef cattle handling during transportation and in the lairage of abattoirs on the welfare of cattle and beef quality and to determine the effects of beef cattle transportation distances and means of transportation on beef quality.

MATERIALS AND METHODS

Description of the study areas

The effect of beef cattle handling during transportation and in the lairage of abattoirs on the welfare of cattle and beef quality was studied in Ambo and Guder markets and abattoirs. Ambo town is located about 114 km and Guder town 126 km West of Addis Ababa. The altitude of Ambo district ranges from 1380 to 3030 meters above sea level (masl), temperatures range from 15 to 29 ˚C and the annual rainfall from 800 to 1000 mm. The altitude of Toke Kutaye district ranges from1600 to 3194 masl, temperatures from 10 to 29 ˚C and the annual rainfall from 800 to 1100 mm (West Shewa Zone Livestock Development Office, unpublished, 2019).

Study design, sampling techniques, and sample size determination

A cross-sectional study design was used for this study. Field questionnaire survey and laboratory analysis were carried out. Ambo and Guder markets were selected purposively as they are potential and known markets in West Shewa Zone,

Oromia Region, Ethiopia. Guder market is one of the biggest secondary markets in the country where buyers come from the different corners of the country to purchase and transport a large number of beef cattle.

Questionnaire servey:A semi-structured questionnaire survey was used to collect data from four different target groups (Group I–IV) which included beef cattle traders, animal handlers, abattoir workers and professionals of animal health and animal science working in the abattoirs, and butchers. The descriptions of different target groups (respondents), the methods used to determine the sample size and the number of respondents interviewed from each group of actor are described below.

Traders and animal handlers: Beef cattle traders (Group I) were involved in selling or purchaing of beef cattle in Guder and Ambo markets. On the other hand, animal handlers (Group II) were involved in the transporting of beef cattle using trekking from markets to abattoirs and other farthest markets like Addis Ababa. Group II was also involved in loading and unloading activities.

To determine the sample size of traders and animal handlers, preliminary survey was carried out before the start of the experiment in 2018 to determine the total number of traders and animal handlers working actively in Guder and Ambo markets. Based on this, the total number of active traders were 70 in Guder and 20 in Ambo markets, while animal handlers were 30 in Guder and 20 in Ambo markets. Thus, to calculate the number of respondents for an interview, 43% of cattle traders working in Guder market (n=30) and 100% of cattle traders working in Ambo market (n=20) were considered for the study. In the case of interviews of animal handlers, 100% were taken for both Guder (n=30) and Ambo (n=20) markets.

Abattoir workers and butcher shops owners: Abattoirs workers and professionals (Group III) included workers in the abattoirs engaged in slaughtering beef cattle and distributing the carcass to the butcher shops while professionals included animal health and animal science experts involved mainly in antemortem and postmortem examinations in Ambo and Guder municipal abattoirs. Group IV (butcher shop owners) included those workers who sold beef to consumers residing in Ambo and Guder towns.

For these groups of actors, data of 2018 were collected from Ambo Municipal Office and from Toke Kutaye Livestock Development and Fishery Office to determine the total number of abattoir workers and professionals working in the abattoirs, and butcher shops in Ambo and Guder towns. Based on the collected data, the total numberof abattoirs workers and professionals including administrative staff working in Ambo abattoir were 40 and the number of butcher

shops in Ambo town were 42 (Ambo Town Municipal Office, unpublished data, 2018). There was a total number of 10 abattoirs workers and professionals including administrative staff in Gudder Municipal Abattoirs and 8 butchers in Guder town (Toke Kutaye Livestock Development and Fishery Office, 2018). Considering the above data, 100% of abattoir workers and professionals in Ambo (n=40) and Guder (n=10) were interviewed for the study.

For butcher shop owners, considering the above data, 93% and 100% of the total number of butcher shops from Ambo and Guder towns, respectively were considered for calculation of the number of respondents. Therefore, 39 butcher shop owners from Ambo and 11 from Guder towns were considered for the interview. For Guder town, some assistants of butcher shop owners were also interviewed.

The interviews were focused to assess how far the animals were transported by trekking or by vehicles, whether or not beef cattle were allowed to take feed, water and rest during trekking, whether or not animals were beaten during transportation using trekking and during loading and unloading in vehicles transportation. Besides, management conditions in the lairage were assessed concerning animal welfare and beef quality.

Laboratory analysis: For the laboratory analysis, beef samples were taken from three different groups of slaughtered cattle for the determination of pH, which include the following: Group I: Included beef cattle transported from the nearest places using trekking (≤ 30 km) to secondary markets and abattoirs of Ambo and Guder. GroupII: Included beef cattle transported from farthest places using trekking (> 30 km) to secondary markets and abattoirs of Ambo and Guder. Group III: Included beef cattle transported from farthest places using vehicles (> 50 km) to secondary markets and abattoirs of Ambo and Guder for slaughter.

The average slaughtered beef cattle per day in 2018 in Ambo abattoir were 25 (Ambo Town Municipal Office, 2018) while that of Guder abattoir was 4 (Toke Kutaye Livestock Development and Fishery Office, 2018). Considering these figures and slaughtering days of 20 per month, 1116 beef cattle were slaughtered during two-month period in 2018, of which 10% was considered to calculate the sample size. Hence, 100 beef swab samples were collected from flank, the brisket and rump of 100 beef cattle slaughtred in the abattoirs (59 samples from trekked and 41 samples from cattle transported >50 km using vehicles) for the analysis of aerobic bacterial load. Again, from the above number of slaughtred beef cattle, 100 beef samples (small proportion of meat samples**)** were collected from the *Longissimus dorsi* muscle at the level of the 10^{th} ribs to determine pH values. For sensory evaluation, the whole carcass of the slaughtered beef cattle was

observed, palpated, and smelled by keeping strictly the hygienic condition of the meat with wearing surgical gloves and aprons.

Before taking the samples from the abattoirs and butcher shops, thorough conversation and discussions were conducted among authors, coordinators of abattoirs and butcher shops owners about the aim of taking samples, the amount of meat samples to be taken and how strict the hygienic conditions could be kept during taking samples. Based on this, the meat samples were taken under strict hygienic conditions using surgical gloves and aprons.

The laboratory analysis of the microbial load was undertaken in the Microbiology Laboratory of the Department of Veterinary Laboratory Technology in the College of Agriculture and Veterinary Science, Ambo University. On the other hand, measurement of pH and visual inspections were conducted in Ambo and Guder abattoirs, and butchers'shops of Guder and Ambo towns. The following parameters were studied during the laboratory analysis.

1. Sensory evaluation of the collected meat samples: The smell, taste, sight, and touch were studied to check whether the beef was normal or unpleasant.

2. Determination of quality parameters from meat samples: A calibrated digital pH meter (MP511, China) was used to measure the pH value of meat by making direct contact between the sensitive diaphragm of the electrode and the meat tissue. In raw fresh meat, a small amount of distilled water was sprayed on to the tissue at the point of measurement before inserting the electrode as the operation requires some fluidity in the sample, and then the glass electrode was thoroughly inserted. The reading was done through the diaphragm differences in electrical load between the meat and electrolyte solution (e.g., Potassium chloride, inside the glass electrode was measured and directly indicated as the pH reading) (Gunter and Hautzinger, 2019).

For accurate pH readings, the pH-meter was calibrated before use and adjusted to the temperature of the tissues to be measured. The electrode was rinsed with distilled water after each measurement. The collected samples from the Longissimus Dorsi muscle at the level of the 10^{th} ribs were refrigerated at 0-3 °C for approximately 24 hours and then the measurement of pH was taken using calibrated digital pH meter. The carcass was classified as normal when the pH was 5.4 to 6; PSE meat (pale, soft and exudative) when the pH of the beef was less than 5.4 and DFD meat (dark firm and dry) when the meat pH was greater than 6 (Gunter and Hautzinger, 2019).

3. Determination of aerobic bacterial load: The Aerobic Plate Count (APC) method was used to determine the bacterial load from swab samples. The total

of 100 beef swab samples (10 cm × 10 cm) were randomly collected from the carcass in the abattoirs **(**50 samples) and butcher shops (50 samples). The samples were collected in twenty successive visits using sterile plastic bags and transported immediately under 4 ˚C in an icebox filled with ice packs to the laboratory. The samples were analysed immediately upon arrival in the laboratory. The procedure of the swab method recommended by Adzitey *et al*. (2011) was followed for culturing and enumeration. Beef surfaces were swabbed from the flank, brisket and rump with cotton and pooled swabs were inoculated into 10 ml 0.1% peptone water and homogenized for 2 minutes. Decimal serial dilutions were made by transferring 1 ml homogenized samples into 9 ml 0.1% peptone water. About 0.1 ml of each homogenized serial diluted samples were pipetted into empty Petri dishes (two for each dilution) and about 12- 15 ml of molten plate count agar (PCA) at 45 ± 1 ºC was poured on it and this was then mixed thoroughly by rotating the Petri dish gently. The agar was allowed to solidify and then incubated at 37 ºC for 24 hours. After incubation, plates of consecutive dilutions containing 30–300 colonies were counted to determine the colony-forming unit per centimeter square (CFU/cm^2) using the following formula below (FSSAI, 2012).

$$N = \frac{\sum C}{(N_1 + 0.2N_2)D}$$

Where ΣC is the sum of colonies counted on all the dishes retained, N_1 is the number of dishes retained in the first dilution, N_2 in the second dilution and D is the dilution factor corresponding to the first dilution.

If a bacterial load count equals to 10^7-10^8, then spoilage of meat was apparent (Teye and Okutu, 2009).

Data analysis

The collected data were entered into Microsoft Excel and checked before analysis. The data were analyzed using the statistical package for social sciences (SPSS, version 20). Descriptive statistics were used to summarize the results; independent t-test and one way ANOVA were used to analyze the beef quality data. A p-value of less than 0.05 was considered significant.

Ethical considerations

This research work was approved by Ambo University Research and Ethical Committee. Permission to conduct the study was also obtained from the town municipality with a letter written from Ambo University. Informed oral consent was obtained from each study participant.

RESULTS AND DISCUSSION

Effect of handling beef cattle during transportation on the welfare of cattle

Effect of trekking on the welfare of beef cattle

Beef cattle are transported by different means of transportation from farms and primary markets to secondary and terminal markets in the study areas. According to the majority of beef cattle traders, animal handlers, and butchers (72%), trekking was the major means of transportation to transport beef cattle to secondary markets of Ambo and Guder and away from these markets to terminal markets (Figure 1). Only 8% were transported by using vehicles. Fufa Sorri (2015) reported a similar finding that the most common means of transportation of beef cattle to livestock markets in Ethiopia was by trekking because of lack of suitable and appropriately designed vehicles dedicated to cattle transport and because cattle trekking was cheap transport.

Beef cattle were transported long distance of up to 462 km, with an average of 98.2 ± 41.8 km to reach Guder market and 105.9 ± 42.7 km to reach Ambo market (Table 1). Most of the traders who purchased beef cattle from Guder and Ambo markets again transported mostly using trekking to abattoirs and other farthest market places like Addis Ababa and other towns. This type of long-distance transportation exposed cattle to hot temperatures during the dry season and a high amount of rainfall and severe cold during the rainy season. Such conditions caused stress to beef cattle and hence adversely affected the welfare of animals and beef quality. Murata and Hirose (1991) reported that the process of transport and length of transport time played an important role in animal welfare where the long duration of transport caused stress in cattle that may alter physiological variables with a negative impact on production and health of animals.

The beef cattle were not usually allowed to take rest, feed, and water during long-distance trekking from primary markets to and away from secondary markets of Ambo and Guder. This was witnessed by 92% of animal handlers during the present study (Table 2). Moreover, all of the animal handlers (100%) beat the cattle frequently during trekking mostly on the legs and backbones (42%), followed by all body parts (36%), and legs (22%) (Table 2). Such kinds of improper handling during long-distance transportation of beef cattle caused stress and hence negatively affected the welfare of cattle and beef quality. The current finding of improper handling of beef cattle during long-distance transportation agreed with the findings of Grönvall (2013) who stated that the main factors leading to inadequate hygiene and animal welfare to animal

transportation included no or less feed and water while trekking and in open and overcrowded conditions while using vehicles.

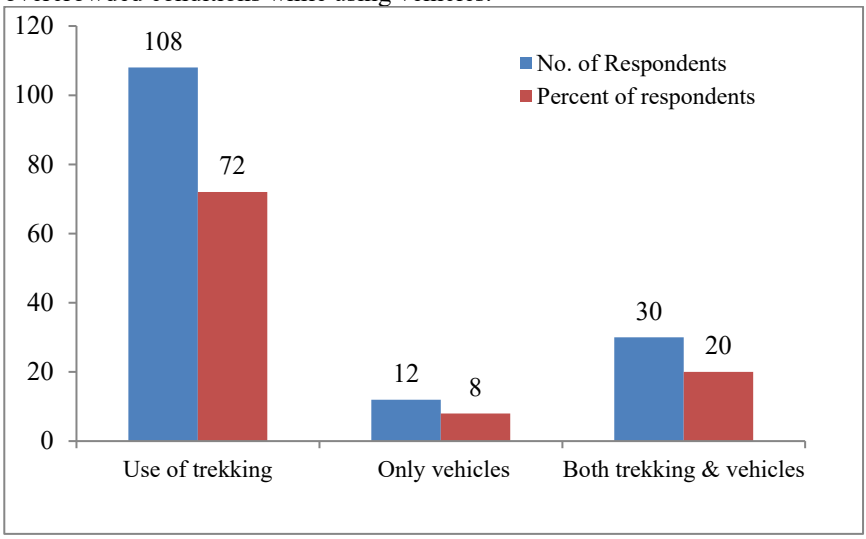

Figure 1. Means of animal transport in the study area (according to traders and butchers).

Table 1. Estimated distance (km) travelled by beef cattle from primary markets to secondary markets of Guder and Ambo.

Primary markets (towns) from around	**Estimated distance from primary to secondary markets**		**Average distance from primary to secondary markets**	
	Guder	**Ambo**	**Guder**	**Ambo**
Guder	3 to 8	15 to 20	5.5	17.5
Ambo	16 to 22	4 to 10	19	7
Wollega	388 - 450	400 - 462	419	431
Shambu	100 - 350	112 - 362	225	237
Gedo	37 - 41	49 - 63	39	56
Babechi	25 - 34	37 - 46	29.5	41.5
Shenen	30 - 42	42 - 54	36	48
Encheni	15 - 28	27 - 40	21.5	33.5
Genchi	37 - 47	25 - 35	42	30
Godera	10 - 280	22 - 292	145	157
Mean ± SE			98.2 ± 41.8	105.9 ± 42.7

SE = standard error

The improper handling of cattle in the present study might be due to the lack of education and poor knowledge of animal handlers about the effect of stress due

to improper handling of cattle during transportation on the welfare of animals and the quality of their meat after slaughtering.

Effect of using vehicles for transport on the welfare of beef cattle

In the study areas, a small number of beef cattle traders (8%) used vehicles to transport beef cattle to and away from Guder and Ambo livestock markets (Figure 1). During vehicle transport, loading and unloading of beef cattle are the main activities. All animal handlers claimed that all beef cattle resisted the loading and unloading process on vehicles, resulting in repeated beating of the animals.

Table 2. The different activities animal handlers performed during trekking of beef cattle (N=50).

Types of activities done during trekking	Respondents	
	Number	%
Provision of feed and water during trekking		
Allowed them to take feed and water	4	8
Did not allow them to take rest, feed and water	46	92
The beating of beef cattle		
Animal handlers were beating beef cattle during trekking	50	100
Body parts mostly beat by animal handlers		
Leg	11	22
Leg and back bone	21	42
All body parts	18	36
Total	50	100

Beef cattle were loaded using ordinary vehicles (Isuzu truck), mostly under overcrowded conditions. Concerning the number of beef cattle to be loaded, the majority of the traders (66%) revealed that 12 - 17 good condition cattle were loaded per vehicle (Table 3). Loading of such number of beef cattle per vehicle created overcrowding as the recommended number of good condition zebu cattle to be loaded per vehicle (Isuzu truck) is about seven to nine, considering the loading size of one vehicle (Isuzu truck) as 9 m^2 (2.10 × 4.30 m) and the requirement of loading space per zebu cattle is 1 to 1.4 m^2 (FAO, 2001). Such poor handling practices (repeated beating of beef cattle during loading and unloading and overcrowding on the vehicles) increased the level of stress and hence negatively affected the welfare of animals and beef quality. Overloading, unloading and generally poor handling of cattle during vehicle transportation could result in injury, carcass damage, increased bruising, reduced dressed carcass weight and dark cutting beef (Tarrant and Grandin, 2000; Barham *et al*., 2002). Cattle transport is done using mainly inappropriately designed and substandard vehicles (Fufa Sorri, 2015; Kenny and Tarrant, 1987).

Effect of lairage conditions in the abattoirs on the welfare of cattle

Beef cattle were transported long distance from different markets before reaching the abattoirs. After reaching the abattoirs, beef cattle should get sufficient rest, feed, and water in the lairage of abattoirs. Concerning the handling of beef cattle in the lairage of Ambo and Guder municipal abattoirs, 94% (47/50) of abattoir workers and professionals revealed that beef cattle were not getting adequate rest in the lairage of abattoirs to recover from stresses.

Table 3. Response of traders about the number of beef cattle loaded and handling during vehicle transportation.

No. of beef cattle transported using vehicles	No. of respondents	%
Transport of 6-7 good condition cattle per vehicle and feel comfort	2	4
Transport of 8-9 good condition cattle per vehicle without comfort	15	30
Transport of 12-17 good condition cattle per vehicle without comfort and sometimes injury	33	66

No feed and water were given to the animals. The majority abattoir workers and professionals (94%) also described that there were occasional fighting and injuries among beef cattle. All the aforementioned management practices at the lairage of Ambo and Guder municipal abattoirs indicate the poor handling of animals, resulting in stress and adversely affecting the welfare and beef quality.

Gregory *et al*. (2010) reported similar findings before, i.e., when animals are stressed in the lairage and/or during slaughter, it affects the welfare of the animal and the meat/beef quality.

Effect of beef cattle transportation distance and means of transportation on beef quality

The result of beef quality parameters based on pH values indicated that 53% of the beef samples were normal as they had pH values between 5.4 to 6 while 47% of the beef samples were abnormal, where 33% had pH values > 6.0 resulting in DFD beef (17%) and DFD beef with spoilage (16%). Besides, 4% of the beef samples had pH values < 5.4 resulting in PSE (Pale, Soft and Exudative) beef (2%), and PSE beef with spoilage (2%) while 10% of the beef samples were spoiled beef (Table 4). The current findings of 33% DFD beef and DFD beef with spoilage were in close agreement with the reports of Gebawo Tibesso and Adem Hiko (2019) who reported 38.3% DFD beef from 300 slaughtered cattle in three abattoirs of Batu, Meki and Shashemane, Southern Oromia Regional State, Ethiopia. The result of the sensory evaluation indicated that 53% of the

beef samples were normal while 47% of the beef samples were abnormal (Table 4).

The result of beef quality evaluation based on pH and microbial load determination with different distances traveled by beef cattle using trekking and vehicles indicated that transportation of beef cattle > 50 km using vehicles had the highest share of abnormal beef (23%) from which the majority (22%) were due to DFD beef (8% i.e., 2% from Guder and 6% from Ambo) and DFD beef with spoilage (14% i.e., 6% from Guder and 8% from Ambo) while 1% was microbial spoiled beef from Ambo (Table 4).

Table 4. The results of beef quality parameters of sampled beef animals (n=100) in relation to means of transport and distance covered (km).

Beef quality parameters		**Guder**			**Ambo**			**%**
		Trekking		**Vehicle**	**Trekking**		**Vehicle**	
		≤30	**>30**	**>50**	**≤30**	**>30**	**>50**	
		%	**%**	**%**	**%**	**%**	**%**	
pH	5.4 to 6 (normal)	12	4	4	8	11	14	53
	< 5.4 (PSE)	1	-	-	1	-	-	2
	> 6 (DFD)	2	3	2	2	2	6	17
	> 6 (DFD with spoilage)	-	1	6	1	-	8	16
	< 5.4 (PSE with spoilage)	1	-	-	1	-	-	2
Microbial load	Spoiled	4	-	-	1	4	1	10
Sensory evaluation	Normal	12	4	4	8	11	14	53
	Abnormal	8	4	8	6	6	15	47

Generally, the result of beef samples analysis based on pH and microbial load determination indicated that DFD beef and DFD beef with spoilage from abnormal beef had the major share. These DFD beef and DFD beef with spoilage were created due to stress as a result of long transportation, repeated beating of beef cattle in both means of transportation, overcrowding during vehicle transportation, and the lack of feed, water and rest during transportation and in the lairage of abattoirs. Such a high level of stress resulted in higher depletion of glycogen content in the muscle before slaughter; consequently, leading to high pH of the meat due to the low acid content of the meat after slaughter and hence caused DFD beef and DFD beef with spoilage.

The DFD meat was dark in color, firm, dry, and tougher with poor palatability, which is categorized as abnormal beef. On the other hand, PSE meat indicated that the meat was pale in color, had soft structure, and released liquid in drops (exudative). Such PSE meat might have been created when the cattle stressed for

a short period of time usually before slaughter of which the glycogen content of the muscle had not been depleted.

Hence, high level of acid would be created after slaughtering, which was indicated by very low pH content of meat resulting PSE meat. Concerning this, Adzitey (2011) reported that acute or short-term stress such as the use of electric goods, fighting among animals just before sticking, and overcrowding in the lairage cause PSE meat. On the other hand, exposing animals to chronic or long time stress such as long hours of transportation, feed and water deprivation and overcrowding of animals in the lairage can cause DFD carcasses. PSE and DFD meats are unattractive and more likely face rejection by consumers and have low water holding capacity. Increase in physiological stress or physical activity in cattle during pre-slaughter handling leads to depletion of muscle glycogen reserves, which may result in a higher ultimate beef pH (above 6.0) (Apple *et al.*, 2005; Muchenje *et al*., 2009; Ekiz *et al.*, 2012).

The result of microbial load analysis indicated that 28% of meat samples were abnormal beef with spoilage (16% DFD meat with spoilage, 2% PSE meat with spoilage, and 10% pure spoilage) (Table 5). Meat samples taken from beef cattle transported greater than 50 km using vehicles and slaughtered in Ambo and Guder abattoirs had the major share of abnormal beef with spoilage (15%), i.e. 14 DFD meat with spoilage and 1% pure spoilage (Table 5). The abnormal beef with spoilage might have been due to several processes, including how the animal was transported, handling at purchasing points, lairage conditions, slaughter in an abattoir, distribution, and consumption.

Table 5. Results of beef quality evaluation based on pH and microbial load versus transportation distance using trekking and vehicles.

Distance transported	**Normal beef (%)**	**Abnormal beef (%) based on pH**				***Pure spoiled beef (%)**	**Total abnormal (%)**
		DFD (%)	**DFD + spoilage (%)**	**PSE (%)**	**PSE+spoilage (%)**		
≤ 30 km*	20	4	1	2	2	5	14
>30 km†	15	5	1	-	-	4	10
>50 km †	18	8	14	-	-	1	23
Total	53	17	16	2	2	10	47

*and † stand for trekking, † for vehicle transport.

Independent sample t-test statistics showed that the *pH* of beef was significantly affected by the distance covered by animals both using trekking and vehicle transportation (*t = -3.45, df=98, p=0.001*). The microbial load was also significantly higher in cattle transported with vehicles than on feet/trekking (*t = -2.902, df=98, p=0.005*) (Table 6).

Table 6. Results of independent sample t-test showing the effect of distance covered on the *pH* and aerobic microbial load.

Variables	*pH*			Microbial load		
	t-test	df	*p*-value	t-test	df	*p*-value
Bacterial load between *pH*	-5.94	55.7	<0.001	-	-	-
Distance travelled	-3.45	98.0	0.001	-2.90	98	0.005

Transportation distance affected *pH* of the beef significantly; the longer the distance, the more the *pH* (Table 7). Similarly, logarithm of microbial load (log_{10}) analysis showed that microbial load was significantly higher in vehicle transport.

Table 7. Results of ANOVA showing the effect of different distances travelled on the *pH* and aerobic microbial load.

Variables	Different transportation distances			*F*-value	*p*-value
	< 30 km on trekking	> 30 km on trekking	> 50 km on vehicle		
Average *pH*	5.78[b]	5.78[b]	6.01[a]	6.098	0.003
Average Log $_{10}$ of microbial load	5.57[ab]	5.25[b]	6.32[a]	4.526	0.013

CONCLUSION

Beef cattle were transported long distances for a long period to and away from markets mainly using trekking, which exposed animals to extreme weather conditions and improper handling. Trekking and vehicle transportation were very poor and stressful, a situation that was against animal welfare and ethical principles. Furthermore, the handling and management practices of cattle in the lairage were stressful and had negatively affected the welfare of cattle. These conditions significantly contributed to the inferior quality of the beef traded, which might have undesirable economic and public health consequences. Therefore, farmers, animal handlers, traders, and butcher owners should be trained to be knowledgeable about the proper handling, feeding, watering and resting during transportation and before slaughtering for the welfare of cattle and for quality beef production. During transport by trekking, beef cattle must be handled in such a way that they are free from hazards and stress that can cause poor welfare of the animals. Cattle transport by trekking should be avoided during extreme weather conditions and should be limited to short journeys. Adequate transport and lairage related facilities must be made available, and

animal welfare proclamations and regulations must be drafted, ratified, and enforced to guarantee quality beef production and trading.

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