

Article

Effect of Transportation and Pre-Slaughter Handling on Welfare and Meat Quality of Cattle: Case Study of Kumasi Abattoir, Ghana

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Abstract: This study was conducted at the Kumasi Abattoir Company Limited (K.A.C.L) in Ghana to assess the effect of pre-slaughter handling on welfare and meat quality of cattle. Behaviour measurements were done on 200 cattle pre-slaughter and the methods by which the cattle were handled were recorded to evaluate the effect of pre-slaughter handling on their welfare. Ultimate pH₂₄ and percent cooking loss were measured on 50 poorly-handled cattle pre-slaughter. The cattle were poorly-handled because they were beaten and, whipped. Based on pH₂₄, meat quality was assessed as normal (pH from 5.5–5.8), moderate dark, firm and dry (DFD) (5.8 ≤ pH ≤ 6.2), and DFD (pH from 6.2–6.7). Five hundred carcasses were visually observed for bruising in them and the number of non-ambulatory cattle slaughtered in a week was recorded. The relationship between pH₂₄ value and cooking loss in meat from the 50 poorly-handled cattle was investigated. Behaviours exhibited by poorly-handled cattle pre-slaughter included raising of their tail, kicking, lying down and refusing to move, jumping, vocalising, panting, and charging at handlers. Also lashes/whips, pulling of animals' tails, stamping on their tails, and hitting them with sticks, stones and ropes were among the prominent methods by which the cattle

were handled. Mean pH₂₄ and mean percent cooking loss were significant ($p < 0.05$) at 6.22 ± 0.10 and 22.51 ± 3.25 , respectively, for poorly-handled cattle. There was a strong negative correlation between pH₂₄ and percent cooking loss in poorly-handled cattle ($r = -0.77$). Out of the 500 carcasses assessed for bruising, 18% had no bruises, 60% had slight bruises while 22% had severe bruises. Ninety (90) non-ambulatory cattle were slaughtered within seven (7) days, representing 7.1% of the total number of cattle slaughtered within that period. The results indicated that handling of cattle pre-slaughter have effects on their meat quality and welfare. Eighty-two percent of the bruised carcass and 7.1% of non-ambulatory animals indicated poor meat quality. Meat quality assessment indicated that most of the meat had dark, firm and dry (DFD) tendency. The water holding capacity of the meat sampled in this study (by means of cooking loss) indicated that the meat quality was compromised.

Keywords: welfare; transport; meat quality; non-ambulatory

1. Introduction

Pre-slaughter transport and handling of animals are accompanied by many stressful events, which affect animal welfare and meat quality [1–3]. Pre-slaughter handling involves a number of critical points which include loading of animals at the farm, transport from farm to abattoir, unloading of animals at the abattoir, and slaughter [2]. A study by Gebresenbet *et al.* [2] revealed that loading and unloading are among the main activities that cause an increase in heart rate of cattle. Stress is an invariable consequence of transporting animals destined for slaughter from the farm to the abattoir [3–5]. However, stress during transport can be minimized by improving facilities, vehicle designed, and handling methods. As is also widely known, pre-slaughter stress commences during loading of animals onto a vehicle that sends them to abattoirs [4]. Transport time is also known to have an impact on transported animals. A study by Gebresenbet *et al.* [2] showed that concentration of plasma cortisol (stress hormone) decreased with an increase in transport time while lactate and creatine kinase (CK) increased significantly ($p < 0.001$) after 6 h of transport time.

During transport and handling, animals are sometimes faced with unfavourable conditions, which compromise their welfare and meat quality [5,6] such as food and water deprivation, unfavourable temperature or ventilation, aggressions and physical shocks which cause hunger and thirst, heat stress and pain [7]. To some extent, mortality of animals during transport may be an indication of their welfare and transport conditions [8,9]. People occasionally hit animals and cause great pain and injury mostly because they consider the animals as commodities and not as sentient beings that feel pain and stress, or because of lack of knowledge about animals and their welfare [10].

Inappropriate handling, improper use of sticks by handlers, violent impact of the animals against facilities or impact with other animals are potential bruising events [11]. Handling animals without the practice of using sticks results in better welfare and less risk of poor carcass quality [8]. Poor handling or a physical blow that leads to bruising or other animal injury can lead to parts of the carcass being condemned or the meat being dark [12]. Such meat, they say, does not appeal to consumers and spoils

quickly. A study in Canada [13] revealed that 15% of the cattle showed severe bruising while 78% of the carcasses exhibited bruising of some sort. Indicators of an animal having difficulty coping with handling or transport are changes in behaviour, which show that some aspect of the situation is aversive [14].

Assessment of culled cattle in holding pens at 21 slaughter facilities in the United States recorded an overall incidence of 1.1% non-ambulatory cattle [13]. Estimated number of starved cattle slaughtered at federally inspected facilities showed that the incidence of non-ambulatory cattle was between 0.7% and 1.1% [15]. The same study [16] recorded an aggregated sum of beef and dairy cattle that could not stand and walk in the years 2003 and 2004 to be 0.04% and 0.38%, respectively. According to [16], causes of non-ambulatory cattle differ by region, herd size and herd management. Main causes of non-ambulatory conditions in cattle are injuries related to dystocia, fractures, muscle and ligament damage, infectious diseases such as toxic mastitis, lymphoma, peritonitis, and metabolic disorders such as acidosis [16].

The abattoir system in the developed world is quite different from that in the developing world. While the abattoir system in the developed world provides services that are geared towards meat quality, the abattoir system in the developing world typically may not always consider animal welfare and meat quality issues [17,18]. Cattle destined for slaughter at the Kumasi Abattoir are transported from Burkina Faso (800–1000 km), Mali (1500–2500 km), Niger (1800–2500 km), Yeji (180–250 km) in Brong Ahafo and the three northern regions of Ghana [17]. The animals are bought from individual farms, small and big markets and are sent to a collection centre before onward transportation to Kumasi. At the farm, the animals are treated humanely as they are precious assets to the family that owns them. As soon as they are bought from the farm, they are treated as a commodity. During loading and unloading, the animals are subjected to lashes (whips) with sticks and ropes that compromise their welfare and meat quality. Some of these events were observed during the study.

The vehicles used to transport the animals are mostly unsuitable for such a purpose and this could induce stress on the animals. The vehicles do not have loading ramps and majority of them are not suitable for animal transport because, for instance, they do not have top covers to protect the animals from the vagaries of the weather. Many animals are often crammed into vehicles without due consideration of appropriate loading densities. This brings about bruises, downed or crippled or non-ambulatory animals and damage to animal hides. During transportation, the animals are exposed to extremes of temperature, rain and humidity because they are not offered any form of protection against the weather. The vehicles used are mostly not designed for animal transport. Most of the vehicles have exposed tops making the animals liable to extremes of the weather. The movement of the animals from the cattle market at the abattoir premises to the lairage and subsequently into the abattoir is often marked by inappropriate handling. They were stoned, beaten with sticks and ropes and other inhumane treatments. Lairage times vary and while some animals spend less than five (5) min in the lairage, others are moved straight from the cattle market into the abattoir for slaughter. There is insufficient knowledge among stakeholders that bad handling of animals can impinge on their welfare and meat quality. This knowledge gap led to the present study.

Objective

The aim of the study was to investigate the effect of transport and pre-slaughter handling on welfare and meat quality of cattle.

2. Methodology

2.1. The Study Area

The Kumasi Abattoir Company Limited (K.A.C.L) was established in 1997 with grants from the Government of Ghana and the Canadian International Development Agency (CIDA) and commenced its operations in 1998. The Abattoir is located at a suburb called *Kaase* in Kumasi. Kumasi Abattoir is located on latitude 6°43'55"N, longitude 1°31'28"W and at an altitude of 274 m. There is a cattle market at the Abattoir premises about 150 m away from the Abattoir. At the cattle market, there are kraals which are used to house the animals while they are being sold. There is a holding pen for the cattle which are destined for slaughter. The holding pen which is about 10 m away from the slaughterhouse is used to keep cattle overnight until the next morning when they are slaughtered. There is a lairage which is supposed to be used to rest animals for some time before slaughter. There is a defunct waste treatment plant and an abandoned fish pond about 100 m away from the slaughterhouse.

The company slaughters cattle, pigs, sheep and goats for processing and packaging for the targeted Ghanaian market. The company has 151 regular employees and 15 casual employees. The original daily slaughtering capacity of the Abattoir was 200 cattle, 100 pigs, and 250 sheep and goats. The production facility has been redesigned to enable the company to slaughter an additional 200 cattle daily. This was achieved by converting one of the slaughter lines meant for the slaughter of sheep and goats into another cattle line and developing a singeing platform with the support of the Kwame Nkrumah University of Science and Technology (KNUST) to take care of the singeing of sheep and goat carcasses [19].

2.2. Data Collection

In this study, the bases of sampling were interviews, field measurements, and observations of activities during animal transport and slaughter operations. For better planning of field work and proper design of questionnaires, preceding exploratory visits and interviews with key people at the Abattoir were made.

2.3. Interview of Stakeholders

Face-to-face interviews were conducted of dealers (merchants), middlemen (landlords), and butchers to investigate how transport and pre-slaughter could affect welfare and meat quality of cattle. The dealers' work is to go to the points of purchase, buy animals and transport them to the Abattoir. The middlemen's work is to receive and sell the animals brought to the Abattoir by the dealers, while the butchers' work is to buy, slaughter the animals, and sell the meat.

2.4. Measurement of Cattle Behaviours and Methods of Handling

A pre-feasibility study was done to observe and record the behaviour of the animals as they were being moved by cattle handlers from the cattle market until they were slaughtered in the abattoir. To record behaviour of the animals, a video film was shot at random on 200 animals. Ten animals were sampled each day for 20 days. The selection of the different behavioural observations was partly based on literature and partly on preceding exploratory work. Behaviours and handling methods observed and recorded are shown in Table 1.

Table 1. Definitions of observed behaviours.

Behaviour	Definition
Easily pulled	The number of animals allowing themselves to be moved from the Cattle Market into the Abattoir by cattle handlers.
Beatings (whips)	Animals which failed to move voluntarily were whipped/ lashed by cattle handlers with ropes and sticks or clubs until they moved.
Charging at handlers	Sometimes as the animals were being moved by cattle handlers, they charged at the handlers.
Defecation and urinating	Due to inappropriate handling by cattle handlers, animals mostly defecated and or urinated.
Ear erection	Some animals due to agitation and stress, raised their ears while they were being moved by cattle handlers into the Abattoir.
Foaming	Some animals foamed at the mouth due to stress from handling by cattle handlers as they were moved into the Abattoir.
Forcing animals to fall down	When some animals got to the entrance of the lairage or the entrance of the Abattoir, they resisted entry and the cattle handlers had to physically restrain those animals and force them to fall down before dragging them into the Abattoir for slaughter.
Head swings	Some animals swung their heads from one side to the other as an indication of being traumatised while they were being moved into the Abattoir.
Horn pulling	Sometimes some animals which failed to move voluntarily as they were sent into the Abattoir had to be held by the horn by cattle handlers and pulled.
Jumping	Sometimes some animals while in their natural environments, exhibit play behaviours such as jumping but when they are inhumanely handled, they jump as well in distress.
Kicking	Animals which were traumatised and were temperamental, tried to kick the cattle handlers with their hind legs while they were being moved into the Abattoir for slaughter.
Crippled during handling	Animals which became lame and could not continue walking due to inappropriate handling by cattle handlers as they were being moved into the Abattoir were counted and recorded.
Leg pulling	Some animals instead of being pulled by ropes attached to their horns were pulled by ropes attached to their leg(s) because those animals stopped, lay down and would not move.
Lying down and refusing to move	Sometimes some of the animals lay down and refused to move during handling.
Moving without pulling	Some animals moved voluntarily into the Abattoir without being pulled by cattle handlers.
Panting	At certain times, some of the animals panted for breath while being moved by cattle handlers into the Abattoir due to stress from inappropriate handling.
Raising of tail	Some animals due to agitation raised their tails while they were being moved by cattle handlers into the Abattoir.

Table 1. Cont.

Behaviour	Definition
Resistance to be lazoed	Before each animal was moved into the Abattoir for slaughter, it was tied by the horns with a rope. Some animals resisted these restrictions by running away from the cattle handlers.
Resistance to be pulled	Some of the animals resisted pulling by cattle handlers from the cattle market into the Abattoir.
Retreating	Due to fear and inappropriate handling by cattle handlers, some animals moved backwards while they were being moved into the Abattoir for slaughter.
Running	Some animals ran when being moved by cattle handlers into the Abattoir.
Slapping	Sometimes the cattle handlers had to use their bare hands to slap recalcitrant animals which offered some resistance to pulling.
Sniffing	Due to fear and inappropriate handling by cattle handlers, some animals sniffed while they were being moved into the Abattoir for slaughter.
Stoning	Hitting animals with stones when animals failed to move voluntarily
Stretching	Some animals stretched their bodies by extending their forelegs forward and their hind legs backwards and arched their bodies due to stress from inappropriate handling by cattle handlers.
Stamping of feet	Due to fear and inappropriate handling by cowboys, some animals remained stationary and kept stamping their feet on the ground while they were being moved into the Abattoir for slaughter.
Tail pulling/twisting and, Stumping on tail	Animals which lay down and refused to stand up while they were being sent into the Abattoir had to have their tails pulled, twisted or stamped upon by the cattle handlers before they stood up and began to move.
Vocalisations	At certain times, some of the animals vocalised not because they were badly handled or stressed (vocalisation level 1) while others vocalised because they were inappropriately handled by cattle handlers (vocalisation level 2).

2.5. Measurement of pH of Meat from Poorly-Handled Cattle

By visual observation, meat from 50 poorly-handled cattle was sampled for determination of pH value. Fifty meat samples were excised from the left *longissimus muscle* between the 11th and 12th ribs of each of 50 cattle postmortem. Ten meat samples were taken each day for 5 days. Each sample was taken immediately after slaughter, placed in an air tight bag (a sandwich sealer), and put into an ice chest [20]. Ice blocks were placed on the meat samples and then sent to the Biochemistry Laboratory at the Kwame Nkrumah University of Science and Technology for pH readings to be taken. Transportation of the samples to the laboratory took about 30 min. Two (2 g) of each sample was taken and homogenised in 20 mL of distilled water (1:10 ratio) [21]. The spear tip electrode (Model: PE- 06HD, OCS GMBH/TOP MESSTECHNIK, Deutschland) of a pH metre (Model:PH-212, OCS GMBH/TOP MESSTECHNIK, Deutschland) was dipped into the mixture to read the pH. For each sample, pH was determined at various time intervals of 0 (immediately after slaughter), 6, 18, and 24 h after slaughter. Sections of each excised meat sample were kept refrigerated at +4 °C for determination of pH at the specified times.

2.6. Measurement of Cooking Loss of Meat from Poorly-Handled Cattle

Samples were taken from longissimus in the same way as elaborated under Section 2.5. At the laboratory, 15 g each of the fresh meat samples was weighed, put back into the self-sealing air tight bags and cooked for 35 min in a hot water bath (Büchi Waterbath B-480, Switzerland) at 75 °C. After cooking, the samples were cooled to room temperature in a bucket containing ice.

Each of the samples was re-weighed after cooling to room temperature and cooking loss was calculated as the weight lost during cooking divided by fresh sample weight and expressed as a percentage. Determination of cooking loss was adopted from [22] with some modifications. The modifications were made because the fresh samples had to be transported over a distance (about 30 min), from the Abattoir to the laboratory where the cooking loss determination apparatus was set up.

2.7. Measurement of Carcass Bruising

To investigate carcass bruising, 500 carcasses were evaluated at random for bruises according to the Finnish Meat Research Institute's carcass-evaluation system [23]. Three evaluation categories used in this system were: "none", denoting a clean non-bruised surface; "slight" denoting a reddish area with damage on the surface and "severe", meaning the bruise is reddish, deep and bleeding damage can be observed on the surface.

2.8. Measurement of Proportion of Non-Ambulatory Cattle

Cattle that were non-ambulatory and were drawn by cart to the abattoir to be slaughtered were counted for a period of one week of 7 days. The researcher sat at the gate of the cattle market and counted the number of non-ambulatory animals drawn by cart into the abattoir. The proportion of non-ambulatory animals was calculated as the ratio of the total number of non-ambulatory animals drawn by cart to the total number of animals moved from the cattle market into the abattoir for slaughter expressed as a percentage.

2.9. Data Analysis

Data analyses of the face-to-face interviews and the correlation co-efficients for percent cooking loss and ultimate pH were done with the Statistical Package for the Social Sciences (SPSS Version 16). Microsoft Office Excel 2007 was used to generate the charts for the pre-slaughter handling methods of animals and the behaviours expressed by those stressed animals. Excel was also used to generate the charts showing percent normal, moderate DFD, and DFD meat, ultimate pH of meat against time postmortem, and the charts showing the relationships between percent cooking loss and ultimate pH.

3. Results

3.1. Interview Results

The dealers were asked whether animals were whipped/lashed during loading and unloading and 88% answered in the affirmative while 12% answered otherwise. Eighty-two percent (82%) reported they did not use rest stops for the animals while being sent to Kumasi. All the dealers interviewed

(100%) reported they did not protect their animals from bad weather. Eighteen percent (18%) of the dealers said they fed and watered their animals during transport to Kumasi while 82% of them reported they did not feed and water their animals during transport to Kumasi.

Ninety-seven percent (96.9%) of the middlemen interviewed reported receiving crippled or non-ambulatory animals. All the middlemen (100%) who said they received non-ambulatory animals said those animals were put up for sale. Ninety-one percent (90.6%) of the landlords interviewed reported receiving dead animals from dealers. On the issue of sickness of animals while being sold, 71.9% ($n = 23$) of the interviewed middlemen confirmed such incidences while 28.1% ($n = 9$) did not report any such incidences. Also, all the middlemen interviewed reported that while the animals were being sold, no form of protection against bad weather was provided for them. Ninety-four percent (93.8%) of the middlemen said animals put up for sale were fed and watered while 6.2% ($n = 2$) of them said no feed or water was provided for such animals.

Fifty-six percent (55.8%) of the butchers interviewed said they did not provide their animals feed and water before slaughter while the rest provided them feed and water before slaughter. On the issue of purchase of non-ambulatory animals, 60.5% of the butchers said they purchased non-ambulatory animals while the rest did not purchase such animals. Also, 58.1% purchased sick animals while the rest did not. All the butchers said cattle handlers were responsible for moving animals destined for slaughter from the cattle market into the abattoir and 100% of the butchers reported that they were responsible for paying the cattle handlers for services rendered.

3.2. Behaviours Shown by Cattle and Pre-Slaughter Handling Methods

Prominent among the behaviours regularly exhibited by the cattle during handling were raising of tail, kicking, lying down and refusing to move and jumping (Figure 1).

Among the inhumane methods of handling by cattle handlers, whips ranked highest followed by tail pulling, stamping on the tail of the cattle, stoning, slapping of the cattle with bare hands, forcing animal to fall down, leg pulling, and horn pulling (Figure 2).

3.3. Meat Quality

According to [24], the pH range of normal meat from an animal which is not stressed is 5.4–5.7. DFD meat will have a much higher pH of 5.9–6.5, with some meat being as high as a pH of 6.8. However, the cause of DFD is not primarily due to stress.

The percentage cooking loss of meat samples from the cattle that were subjected to poor handling ranged from 19.10–34.70 with a mean of 22.51 ± 3.25 . From Figure 3, the ultimate pH of meat from the poorly-handled cattle averaged (6.22 ± 0.10 , $p \leq 0.05$).

Of the 50 cattle that were poorly-handled, none had normal meat (pH from 5.5–5.8) in relation to ultimate pH, 14% had moderate DFD ($5.8 \leq \text{pH} \leq 6.2$) tendency, while 86% had DFD (from 6.2–6.7) meat (Figure 4).

The correlation analysis and the fitted equation (Figure 5) show that meat from the cattle that were subjected to poor handling, percentage cooking loss increased as ultimate pH decreased (a strong negative correlation, $r = -0.77$, $p \leq 0.05$).

Figure 1. Frequency of occurrence of regularly-occurring behaviours exhibited by cattle (n = 200) as they were moved from the cattle market into the abattoir.

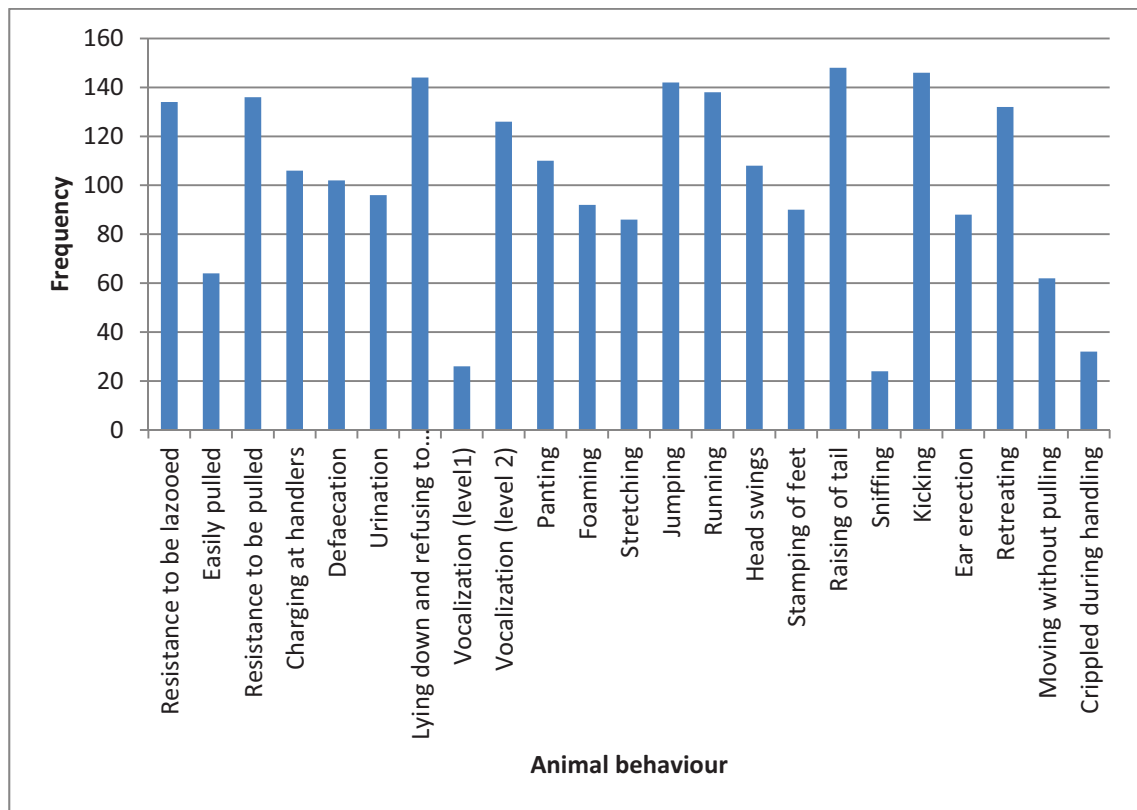


Figure 2. Frequency of occurrence of ways of handling cattle (n = 200) as they were being moved from the cattle market into the abattoir.

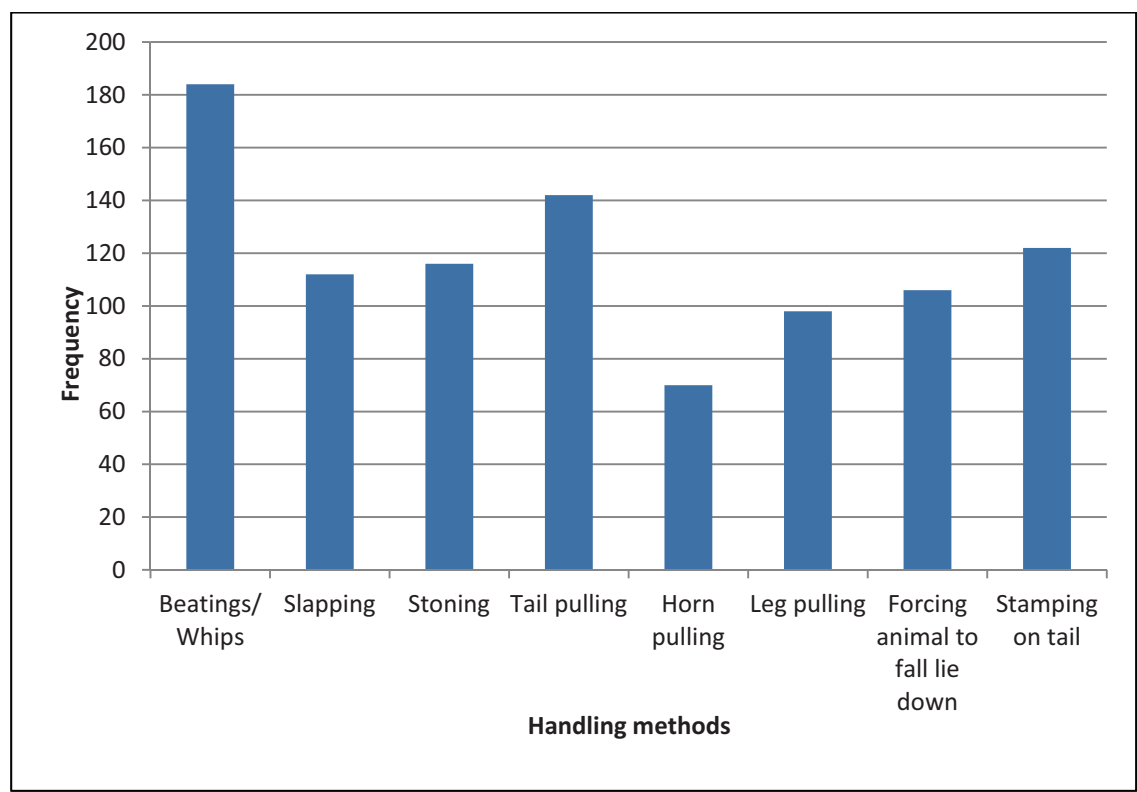


Figure 3. Mean pH of meat against time postmortem for poorly-handled cattle (PHC), non-ambulatory cattle (NAC), bruised carcasses (BRC), and unbruised carcasses (UBRC).

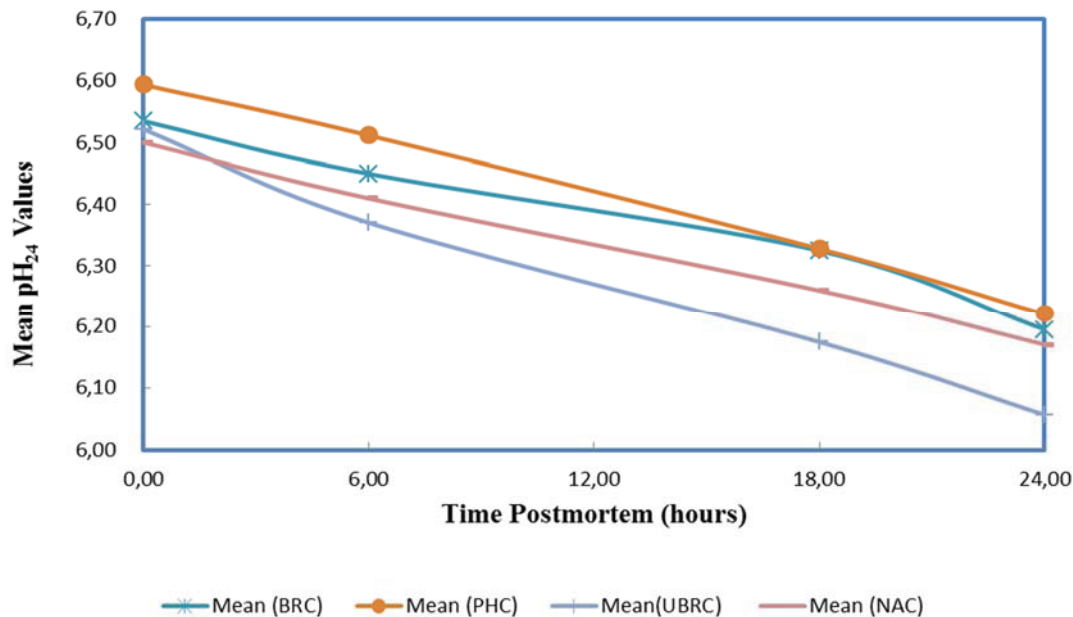


Figure 4. Percent normal, moderate DFD, and DFD meat from poorly-handled cattle.

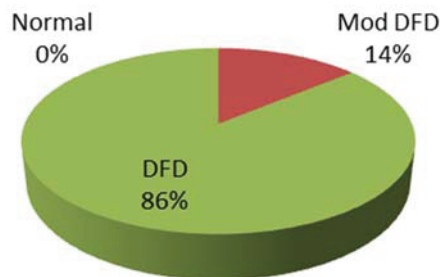
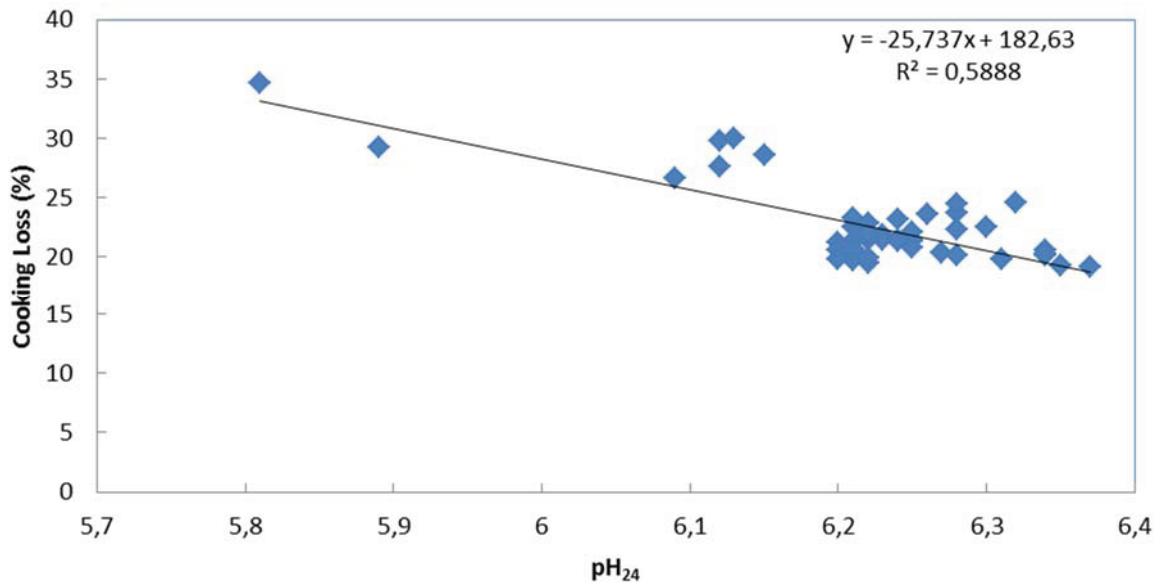


Figure 5. Linear correlation of percent cooking loss and ultimate pH (pH₂₄) of poorly-handled cattle.



Of the 500 carcasses that were visually observed for bruises (Table 2), 18% had no bruises, 60% showed slight bruises while 22% showed severe bruises. The numbers that showed no bruises ranged from 5–13 carcasses per day with a mean of 8.9 ± 2.60 , those which showed slight bruises ranged from 21–37 carcasses per day with a mean of 30.3 ± 4.62 , while those that showed severe bruises ranged from 5–17 carcasses per day with a mean of 10.8 ± 4.02 . In total, 82.2% ($n = 411$) of the carcasses observed were bruised (Figure 6).

Table 2. Bruising in carcasses ($n = 500$).

Bruising Category	Minimum No. of Carcasses/Day	Maximum No. of Carcasses/Day	Mean \pm SD	n	Percentage of Carcasses (%)
None ¹	5	13	8.9 ± 2.60	89	17.8
Slight ²	21	37	30.3 ± 4.62	303	60.6
Severe ³	5	17	10.8 ± 4.02	108	21.6

¹ clean non-bruised surface of carcass; ² reddish area with damage on the surface of carcass; ³ bruise is reddish, deep and bleeding damage can be observed on the surface of carcass.

Figure 6. Meat bruise of a carcass at Kumasi Abattoir.



3.4. Non-Ambulatory Cattle

For a period of 7 days, 90 non-ambulatory cattle were sent by carts into the abattoir for slaughter among a total slaughtered animals of 1260. This represents 7.1% of the total number of animals slaughtered within that period. The number of non-ambulatory cattle ranged from 8–21 per day with a mean of 12.86 ± 5.08 .

4. Discussion

4.1. Interview of Stakeholders

The dealers were asked whether animals were whipped/lashed during loading and unloading and majority answered in the affirmative. Whipping animals is known to have welfare and economic implications because when the animals are lashed it can lead to bruises, which may have to be trimmed. These trimmings may reduce the quality of the carcass as well as profits gained [25]. Most of the dealers reported they did not use rest stops for the animals sent to Kumasi. The chain of events associated with marketing may be prolonged if animals are sold through live auctions, as is the case of Kumasi Abattoir, rather than directly from farm to slaughter plant [26]. This practice puts physical fatigue on the animals, which are transported from long distances to Kumasi. According to [11], physical stress by hunger, fatigue, and lesions, besides the physiological stress, can lead to depletion of muscle glycogen reserves and lead to the incidence of DFD meat. All the dealers interviewed reported they did not protect their animals from bad weather. Less than 20% of the dealers said they fed and watered their animals transported to Kumasi. According to [4], during transport and handling, animals are faced with unfavourable conditions that compromise their welfare and meat quality. These include food and water deprivation, unfavourable temperature or ventilation, aggressions and physical shocks which cause hunger and thirst, heat stress and pain [6].

Almost all of the middlemen interviewed reported of incidences of receiving crippled or non-ambulatory animals. All the landlords who said they received non-ambulatory animals said those animals were put up for sale. The fact that most of the middlemen confirmed that they received non-ambulatory animals may show that the animals were often overcrowded and when one falls due to poor driving coupled with poor road networks, it finds it difficult to get up again. Majority of the middlemen interviewed reported receiving dead animals from dealers sometimes. Since most of the middlemen confirmed that they received dead animals on arrival, it may indicate that the welfare of the animals was compromised during transportation to the abattoir. According to [8, 9], to some extent, mortality of animals during transport may be an indication of their welfare and transport conditions. On the issue of sickness of animals sold, approximately 72% of the interviewed middlemen confirmed such incidences. The fact that some of the animals displayed for sale fell sick or died, could be attributed to their exposure to the harsh weather without being offered any protection in such weather. Also, all the middlemen interviewed reported that while the animals were being sold, no form of protection against bad weather was provided for them. A great majority of the middlemen said animals put up for sale were fed and watered.

More than half of the butchers interviewed said they did not provide their animals feed and water before slaughter while the rest provided them feed and water before slaughter. On the issue of purchase of non-ambulatory animals, 60.5% of the butchers said they purchased non-ambulatory animals while the rest did not purchase such animals. Also, 58.1% purchased sick animals while the rest did not. This proves that most of the butchers are willing to buy animals without much worry about the health status of the animals. All the butchers said cattle handlers were responsible for moving animals destined for slaughter from the cattle market into the abattoir.

4.2. Behaviours Shown by Cattle and Pre-Slaughter Handling Methods

Among the methods of handling by cattle handlers, whips ranked highest followed by tail pulling, stamping on the tail of the cattle, stoning, slapping the animals with bare hands, forcing animal to fall down, leg pulling, and horn pulling (Figure 2). The methods of handling were ranked by frequency of occurrence. These maltreatments could be associated with the high proportion of bruised carcasses (82.2%) in this study. According to [11], inappropriate handling, improper use of sticks by handlers violent impact of the animals against facilities or impact with other animals are potential bruising events. In a study by [12], it was reported that poor handling or a physical blow that leads to bruising or other animal injury can lead to parts of the carcass being condemned or the meat being dark. Such meat, they say, does not appeal to consumers and spoils quickly.

The most frequently occurring behaviours (Figure 1) exhibited by the cattle while being moved by cattle handlers from the cattle market to the abattoir were raising of tail, kicking, lying down and refusing to move, jumping, running, resistance to being pulled, resistance to being lazoed, retreating, vocalisation (level 2), panting, head swings, charging at handlers, defecation, urinating, foaming at the mouth, stamping of feet repeatedly on the ground, and stretching. According to [14], feedlot and slaughter-plant managers have reported that animals that rear-kick, struggle, and run into objects are not easy to handle and have more dark-cutters. The most obvious indicators that an animal is having difficulty coping with handling or transport are changes in behaviour which show that some aspect of the situation is aversive. The animal may stop moving forward, freeze, back off, rapidly move away, vocalise or show other behaviours including lying down [26]. Handling animals without the practice of using sticks results in better welfare and less risk of poor carcass quality [8]. The cattle in this study were difficult to handle by cattle handlers because they (the cattle) were sent into the abattoir in isolation (individually) from their groups but cattle are known to be herd animals so when one gets nearer to them, they instinctively want to rejoin their herd mates [27]. The handlers had no basic training in animal handling which also made it difficult to handle the cattle.

According to [28], if animal handlers learnt the basics of animal behaviour, their ability to move animals in a safer, more efficient and less stressful manner would improve. According to the dealers and middlemen, while cattle were being loaded and unloaded, they were whipped with sticks. This is a bad handling practice which might have contributed to the difficulty in moving the cattle from the cattle market to the abattoir. This is because cattle have long memories so their previous experiences will affect their stress reaction to handling. Roughly handled cattle will be more stressed and difficult to handle in the future [27].

4.3. Meat Quality

As long as there is adequate glycogen present at slaughter, the pH of cattle will fall to within the normal range of 5.4–5.7 [29]. If there is not enough glycogen (due to stress or poor nutrition) then pH will remain above the acceptable limit of pH 5.7 and the meat is likely to be dark in colour, with poor keeping quality [30]. As muscle is converted to meat, a host of metabolic and structural changes occur. In the immediate postmortem period, as the muscle attempts to maintain homeostasis, muscle glycogen is metabolised through anaerobic glycolysis, thus phosphorylating ADP to ATP. Anaerobic glycolysis

generates lactate that builds up, lowering the intracellular pH, so that by 24 h postmortem the pH has fallen to an ultimate pH value of about 5.4–5.7 [29]. In a study in summer on pigs by [31], pigs that were transported for longer times had higher pH₂₄ (5.99 ± 0.29 for 12 h; 5.79 ± 0.18 for 8 h; and 5.65 ± 0.17 for 4 h of travel). According to [23], the pH range of normal meat from an animal which is not stressed is 5.4–5.7. DFD meat will have a much higher pH of 5.9–6.5, with some meat having as high a pH as 6.8. Previous studies have found out that dark-cutting meat is more prevalent in cattle, which become agitated or excited immediately before slaughter [1, 32] stated that meat from such cattle are darker, drier and firmer and has a shorter shelf life. All the meat sampled in this study were poor in quality based on pH₂₄ (Figure 4), due to stress of the cattle from factors such as poor pre-slaughter handling, feed and water deprivation, mixing of unfamiliar animals, exposure to poor weather, and long distances the animals mostly travel.

Water-holding capacity has been significantly correlated with muscle pH, exhibiting that lower cook losses are associated with higher muscle pH and better protein functionality [33]. Higher muscle pH values are farther from the isoelectric point of the contractile proteins; as a result, the proteins are more functional, resulting in lower cook losses [33]. The correlation analyses in this present study are in agreement with these assertions. In a study on turkeys [34], ultimate pH was found to be negatively correlated with cooking loss ($r = -0.52$) which is in agreement with what was reported in this study though beef and turkey meat are different.

4.4. Carcass Bruising

In a study on the relationship between pre-slaughter and bull carcass bruising, bruised carcasses constituted 66.9% [35]. This was less than what was observed in the present study because cattle in this study mostly suffered inhumane handling prior to slaughter. They reported that slightly bruised bull carcasses constituted 54.9% as against 12.0% in severely bruised bull carcasses. Although the amounts of slight and severe bruising in this study were more than those reported by [35], the trend is the same, with more slight bruises observed than severe bruises. In a study by [36], cattle from a feedlot where handlers handled them roughly had 15.5% bruising. A Canadian study [37] revealed that 15% of the cattle showed severe bruising while 78% of the carcasses exhibited bruising of some sort. These results are not in agreement with those of the present study.

4.5. Non-Ambulatory Cattle

In an assessment of culled cattle in holding pens at 21 slaughter facilities in the United States, approximate overall incidence of non-ambulatory cattle of 1.1% was recorded [38]. Estimates of the number of starved cattle slaughtered at federally inspected facilities showed that the incidence of non-ambulatory cattle was between 0.7% and 1.1%. The aggregated sum of beef and dairy cattle that could not stand and walk in the years 2003 and 2004 were 0.04% and 0.38%, respectively [15]. What was recorded in this study exceeds what were observed in the above assessments. According to [36], causes of downed or non-ambulatory cattle probably differ by region, herd size and herd management. The major kinds of causes for non-ambulatory cattle are injuries related to dystocia, other injuries such as fractures, muscle and ligament damage, infectious diseases such as toxic mastitis, lymphoma, peritonitis, and metabolic disorders such as acidosis. According to Carolyn *et al.* [16], if the

non-ambulatory animal is suffering and the pain or distress cannot be controlled or is not likely to be controlled quickly, the animal should be euthanised. However, during this study, non-ambulatory cattle which were in pain were not slaughtered without being euthanized.

5. Conclusions and Recommendations

The main conclusions from the present study are that:

- The indications of compromised welfare of the cattle as deduced from the interviews conducted in this study were feed and water deprivation by some dealers and middlemen, avoidance of the use of animal rest stops by some dealers, overcrowding in vehicles, no protection against bad weather, and maltreatment of animals by handlers.
- The prominent methods of handling by cattle handlers which put stress on the animals were lashes/whips, pulling the tails of the animals, stamping on their tails, and hitting them with stones. As a result of these inhumane ways of handling the animals, they exhibited some behaviours to show that they were stressed. Prominent among those behaviours were raising of their tails, kicking, lying down and refusing to move, jumping, running, resistance to be lazoed and pulled, retreating, vocalisation (level 2), panting, head swings, charging at handlers, defecation, urination, and foaming at the mouth.
- Poor handling of cattle prior to slaughter might led to a high incidence of DFD meat (6.22 ± 0.10) and a low mean value of percent cooking loss (22.5 ± 3.25). This proves that poor handling of cattle immediately before slaughter had an effect on meat quality in terms of ultimate pH and percent cooking loss.
- In poorly-handled cattle, cooking loss increased as ultimate pH decreased (that is, an inverse relationship as can be seen from the correlation co-efficient).
- For a period of 7 days, 90 non-ambulatory cattle were sent by carts into the abattoir for slaughter among a total slaughtered animals of 1260. This represents 7.1% of the total number of animals slaughtered within that period. This to some extent is an indication of compromised welfare of cattle pre-slaughter. This study is useful in exposing the sufferings that slaughter animals suffer in the hands of handlers from some farms through transport to the abattoir in Kumasi.
- It is recommended that the preliminary results from this study concerning the compromised welfare situation of slaughter animals during transport, at lairage, and slaughter should be brought to the attention of stakeholders in the business. Further studies are recommended, for instance, to obtain more reliable scientific evidence to help guide legislation on animal welfare in Ghana.

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Author Contributions

All the authors plan the experiments. Data collection was done by Frimpong and Hamdu. Data, analysis and manuscript writing was done by Frimpong, Bobobee and Gebresenbet with revisions from the other authors.

Conflicts of Interest

The authors declare no conflict of interest.

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