

Effect of Handling Cattle During Transport and Marketing on Quality of Beef

Melkam Aleme* and Gubil Bekele

College of Agriculture and Veterinary Medicine Department, Animal Science Program, Ethiopia

Abstract

The review summarizes the effect of pre-slaughter handling of cattle, mainly during transport and marketing on quality of beef. During transportation animals suffer too many stress full conditions such as improper handling on loading and un-loading, heat stress, improper ventilation in truck, long distance transport either by trucking or on feet, feed and water deprivations and cattle with different age loaded on same trucker. In other hand effect of marketing were critical causes of stress due to condition variation for the cattle including temperature, cold, crowding, noise, fighting, lair age for time of recovery after long distance traveling to market. Meat quality affected by those pre-slaughter conditions which cause different physical and chemical changes that causes to loss the quality attributes which unacceptable by consumers those changes of beef quality related to the color, PH, tenderness, flavor, beef health and water holding capacity. Thus implies more research and policy maker's suggestions including other participants in the marketing system as well as stockholder need to improve beef quality arises from pre-slaughter conditions in terms of transport and marketing facilities critical issues in developing countries and further need of research technologies in developed countries.

Keywords: Transport; Marketing; Quality; Beef cattle

Introduction

Pre-slaughter transport and handling of animals are accompanied by many stressful events, which affect animal welfare and meat quality [1]. 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. Pre-slaughter conditions are of great importance for final meat quality; because short- and long-term stressors affect fresh meat color, water holding capacity, shelf-life and technological yield. Some of the common factors that produce stress when they act excessively within any animal production system include inadequate nutrition, deprivation of water and feed, heat, cold, overcrowding, and handling. The deprivation of food and water, fear, arousal, mixing of groups, physical exertion and injuries are all factors that contribute to stress during transport.

Likewise, transportation of animals to the abattoir is one of the topical issues in animal welfare because it involves a complex series of operations like handling, loading and off-loading and exposure of animals to unfamiliar environments. Animal transporters attempt to move animals under adverse weather conditions and this can be detrimental to the animals. Furthermore, transportation of animals especially those with Gregory (2007) and Grandin (2015) indicated that road transport becomes difficult to monitor and validate under practical conditions because of different speed limits, terrain of the road and stoppages within the process.

In addition to transporting, handling; loading at farm and/or market side and unloading of animals at lairage, can have substantial detrimental effects on their well-being by causing stress. Handling animals without the practice of using sticks results in better welfare and less risk of poor carcass quality [2].

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. The presence of bruises on ruminant carcasses directly affects meat quality because bruised tissues need to be trimmed off; because it shows that animals have been hit or handled in an

inappropriate way, resulting not only in animal fear but also pain.

When meat quality alterations are present postmortem it implies that animal welfare was impaired. Meat color and pH alterations are a reflection of stressful conditions due to inadequate handling of animals during pre-slaughter operations. PH is important parameter to estimate quality meat. The main problem of meat with PH above 24h is are dark red color, increased tenderness variation, increased water holding capacity, poor palatability and growth of pathogenic microorganisms to unacceptable level of human use with development of off- odors and often slime formation. Glycogen depletion depends on physical exhaustion and psychological pre-slaughter stress of cattle.

The marketing process is inherently stressful for specially meat animals because they are taken away from their environment and loaded, and transported unloaded. When selling through a livestock market additional stress can be occurred due to events associated to transport and vehicle happen more than once, or they walk on foot for long distances, as they go to and from the market; animals are kept confined in an unknown environment and are often mixed with unfamiliar animals and facing fight, and prolonged time without food and water.

By improving productivity and product quality, particularly beef, in livestock production through better animal welfare, that is appropriate pre- slaughter handling, the provision of appropriate amounts of good quality food for human consumption can be assured and the welfare of people can be also improved. The objective of this review is to identify potential risk factors; effect of handling, transportation and marketing on quality of beef.

***Corresponding author:** Melkam Aleme, College of Agriculture and Veterinary Medicine Department, Animal Science Program, Ethiopia, Tel : +251 914625627, E-mail: melekamaleme@gmail.com

Received June 22, 2021; **Accepted** July 15, 2021; **Published** July 22, 2021

Citation: Aleme M, Bekele G (2021) Effect of Handling Cattle During Transport and Marketing on Quality of Beef. J Fisheries Livest Prod 9: 305.

Copyright: © 2021 Aleme M, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Literature Review

The Effect of Transportation on Beef Quality

Animals are reared on farms which may be situated far away from other farms, markets and slaughter plant. Transportation and the associated management are the most stressful experiences cattle undergo in their lifetime [3]. Transportation often coincides with a change in ownership whereby responsibility for the animal's welfare may be compromised. During transportation, animals are exposed to environmental stress such as heat, cold, humidity, noise motion and social regrouping, and overcrowding.

Transportation by its nature is an unfamiliar and threatening event in the life of an animal, and involves a series of handling and confinement situations which are unavoidably stressful and can lead to distress, injury or even death of the animal unless properly planned and carried out. The most obvious indicators that an animal is having difficulty coping with handling and transport are changes in behavior, which show that some aspect of the situation is aversive. There are also many risk factors that are thought to contribute to low quality carcass yield, one of which is transportation. Several factors, alone or in combination, can determine whether welfare outcomes during transport are either positive or negative. These include animal handling, loading and unloading, loading density, transport duration, trailer design and ventilation, driving and handling quality, road and environmental conditions, and fitness of the animals. Since transportation is a necessary part of the beef production chain, it is in the industry's best interest to ensure that stress is minimized when transporting cattle.

Animal handling

An integral part of the transport process start with animal handling which have been reported to be more stressful such as; elevated heart rate and stress-related hormones (cortisol) than the effect of transport itself [4]. Currently, science-based information regarding the relationships between animal type (age, size, and condition), temperament, and animal and handler experience as they relate to transport are limited. Therefore, it is recommended that handling during these events be conducted slowly, gently, and quietly. This is especially important when handling cull cows that are susceptible to bruising due to their decreased fat cover and higher incidence of lameness. It is suggested that all cattle should be handled as little as possible before slaughter to decrease bruising, especially after long distance (>480 km) transport, because shrink can magnify this effect.

Loading and unloading

Transportation begins with loading and ends with unloading. Both ought to be done in a gentle manner and under a quieter environmental condition. Careful loading and unloading conditions has been suggested by Adzitey and Nurul (2011). According to Mendon (2018), loading facilities and cattle-handling assessments behaved similarly, with the occurrence of animal bruising increasing when handling practices drop from good to regular, and only in the loading-facility assessment decreasing when compared with poor conditions. This behavior was not expected, as handling and loading facilities are a proven cause of bruises on cattle [5]. The chance of bruising occurring increases when handling and loading facilities worsen from good to regular, by 37% and 29% respectively. Any animal which is injured or frightened by people during loading can show extreme responses; however, in most efficient loading procedures, sheep are not greatly affected, cattle are sometimes affected, pigs are always affected, and poultry which are

handled by humans are always severely affected.

The correlation between the time loading, unloading and the use of different devices is probably due to the fact that people, handling cattle, tended to start using devices if loading and unloading halted. Extended unloading time may cause a serious disturbance. At unloading, the greater the load capacity of the vehicle, the greater the chance of causing falls and bumps against animals. Hence, through a broad literature review regarding transport, that more information and scientific study are required regarding the effects of existing and new trailer designs on cattle welfare and meat quality in addition to the mitigation method by facility maintenance and by adopting personnel training for better cattle handling.

Vehicle preference and driver experience

When animals transported using vehicle the consequences that lead to poor quality are; the type of vehicle used, the distance from the farm to the slaughter or market, the experience of driver, the nature of road, & the weather condition. Our country experiences transporting cattle with vehicle which is not appropriate to the animal use and also loading and unloading near hilly road side, as result they may reach in breakage of leg and bruising skin, calm animals may take off slightly and some aggressive cattle may run off and get suffering.

Vehicles have structural differences, resulting in different risks of bruising to transported animals according to the different compartments. Trailer temperature and humidity during winter transport of cattle in Canada and evaluation of indicators used to assess the welfare of cull beef cows before and after transport [6]. Thus, Season is also a one challenging factor in trucking animals, that difference in summer and winter months would be the most logical as they represent the temperature extremes, snow and chilling and related factors lead to body weight loss, metabolic activity disturbance, and finally quality degradation at meat cut.

The dividing barriers between compartments are narrower than the cages, increasing the chances of bumps particularly in the hips of animals [7]. Also, more vibrations are noticed accompanying the increase in the length of the vehicle as a function of the greater distance between traction and truck body. It may also increase the movement of animals caused by the discomfort due to such vibrations on the floor.

Driving skill has significant and direct effects (e.g., falling, injury, stress, and bruising) on cattle and their welfare during transport. This suggests that they may be more conscientious at stopping, starting, and turning; have better cattle handling skills; or are better at recognizing risk factors during transport. Over speeding, sudden stops, rapid acceleration and long journey times without appropriate rest should be avoided as these will increase the spate of carcass and meat quality defects. The effects of unloading delays on welfare, showing that the risk of bruising was higher in loads of beef cattle that had a delay of 30 min or more before unloading at the lairage.

Loading density

Loading density, the space made available to an animal within a trailer compartment, is an important topic for the beef industry due to the fact that significant economic incentive exists to load animals in a dense manner to offset increasing transport costs. Animals transported at high densities (>401 kg/m³) showed, as expected, a higher mean for bruises to all carcass sites when compared with <400 kg/m³ densities. Regardless of the type of cattle transported, loading density has been found to be highly variable between trailer compartments. Stocking density is, therefore, an important factor when trucking animals. The

number of truck axles used for hauling can also affect loading density. For example, the greater the number of axles, the more BW (animals) that can be loaded. This increases the possibility that lightweight calves could be overloaded, whereas heavy cattle (e.g., cows, bulls, fed cattle) could be under loaded, particularly in the doghouse and nose compartments.

High stocking densities are commonly observed in Latin America countries and overloading trucks when transporting cattle has been observed to be a problem in the region, but no precise figures on actual stocking densities used are available [8]. However, it is well known that inappropriate loading densities (over- or under loading) may negatively affect animal welfare and meat quality outcomes.

Transportation duration

The effect of the length of transport time on animal behavior during transportation showed a pattern similar to that of the load density in that there was a significant drop (46%) in the occurrence of carcass bruising between 2 and 3h and a considerable increase (63%) after 6h of travel. Transportation time alone is not necessarily the only cause of bruises on cattle carcasses, as we discussed earlier that it is important, to take in to account with vehicle type, driver experience, road conditions, and features such as the presence of horns and animal behaviour during the journey.

Accordingly there are other factors associated with transport, with short trips in poor conditions more detrimental than long journeys in good road conditions. Thus, there was a risk of bruising with short journey times, which may be associated with animals' initial stress in the early transport stages and a lower ability to maintain their balance inside the cage, with a greater susceptibility to slipping and falling, causing carcass bruises. Transport durations ranging between 2 and 48h have resulted in shrink values about 8% of body weight. Although animal transport of long duration is more likely to compromise animal welfare than shorter journeys; it is important to recognize that it associated negative aspects, which are the cause of the observed welfare issues [9].

In general, association between decreased animal welfare and increased transport duration is well established and includes greater shrink, poor welfare outcomes such as lameness, incidence of non-ambulatory cattle, and death, as well as increased morbidity in the feedlot. Moreover, greater numbers of bruises with increased travel times are due to increased muscle fatigue, which makes animals more susceptible to falling, bumping into the sides of the cages, or even falling during unloading.

Weather and trailer environment

The effect of weather conditions (cold and hot season) is economic to take in to account before planning to truck animals. Temperature-humidity index was greater at animal level than at the ceiling level of each trailer compartment and during stationary periods compared with in-transit periods. The lower temperature-humidity index in the belly and back compartments compared with the nose, deck, and doghouse of the trailer could be explained by less exposure to solar radiation, whereas the highest temperature-humidity index, in the nose, was most likely related to decreased airflow directly behind the tractor. Animal death increased sharply when ambient temperatures fell below -15°C , whereas the likelihood of becoming non-ambulatory increased when temperatures rose above 30°C .

Although boards can be used on the entire surface of the trailer, boarding is only recommended on a portion of a trailer to facilitate

some air flow. That temperature within the trailer was always higher than outside regardless of the boarding pattern. Boarding was also found to have a positive effect on welfare by reducing dark cutting during winter transport. This suggests that producers and haulers/transporter should be careful when shipping fragile cattle under these conditions, and manage the trailer environment through the use of aids such as bedding, boarding, or other available means.

Cattle type and age

The type of cattle being transported defines how fit they will be for transport and ultimately and how well they cope with the stress of transport. Cattle type refers to an animal's age, condition, temperament and previous experience. Age and weight are among the most important factors contributing to the ability of an animal to manage transport stress. It is crystal clear that young calves are reported to be more susceptible to stress during transport than mature cattle.

Accordingly Calves were more likely to become non ambulatory or die compared with fed and feeder cattle during transport. Females and young animals-more susceptible to stress compared to males and older animals. Moreover, shrink increased the risk of bovine respiratory disease in lighter weight calves compared with heavier weight calves. Likewise older animals (i.e., cull cows) are also at greater risk of poor welfare during long-haul transport (>400 km) because they have the greatest probability of becoming lame, non-ambulatory, and dying during and at the end of the journey compared with other types of cattle. Cull cows were also most affected by long-haul transport, having greater shrink than fed cattle transported the same distance. Further, they concluded that fed cattle are less susceptible to poor welfare because they have more robust immune systems, better body condition, and therefore better health than cattle at older and younger ages.

Feed and water deprivation

The effect of food deprivation in cattle on blood variable indicators of stress differs according to duration (hours) and whether it occurs together with transport or not. In North American transport trailers are not equipped to hold feed and water, and therefore, by default, cattle are exposed to fasting periods at least as long as their time in transport. Studies have reported that cattle fasted for 12, 24, 48, and 96h had live weight losses of 6, 8, 12 and 14% respectively. This observed body weight loss includes both water and tissue loss depending on the length of the fast. Results of the effects of fasting for 3 and for 16h, in both cases with and without transport, show that fasting with transport has an additional effect compared with deprivation of food in pens, which reflects more stress.

Moreover, steers with 24h of fasting at the slaughterhouse showed 9.4 times a higher probability of having a muscle $\text{pH}>5.8$ in their carcasses than those with 3h fasting, independently of the previous transport time [10].

The Effect of Marketing on Beef Quality

Marketing is inherently stressful for animals because they are removed from their home environment, handled, loaded and transported, and unloaded, often long journeys and held in unfamiliar surroundings. Animals are either sold at the markets or sent directly from farms to abattoirs for slaughter. In the markets they may be kept in groups and in open pens, may exposed to physical stresses such as extremes of temperature, cold., vibration and changes in acceleration, noise, unfamiliar social regrouping, confinement and crowding. They can also be starved or dehydrated if feed and water is redrawn longer than recommended. There are also psychological stresses such as the

breakdown of social groups and mixing with unfamiliar animals, unfamiliar or noxious smells and novel environments. Various degrees of bruising can occur on their skin at the market depending on the way they are handled. Because animals are not usually fed before and during transport, and because water may not be available all the time, they may suffer from hunger, thirst and fatigue. Reports showed that prevalence of bruising varies between markets; it ranged from 2% to 8%.

The low level of infrastructure and facilitating are not conducive for efficient marketing. Transportation is often on hoof which leads to considerable weight loss of animal as well as physical injuries and illness. Trucking is also very limited and used only during holidays and festivals to move finished cattle and small stock to urban centers. Poor infrastructures development also hampers the flow of stock from pastoral area to consumption sites/slaughtering plant. Marketing strategies to reduce stress and consequently pale soft exudative (PSE) and dry firm dark (DFD) meat can be found.

Availability of market information will help producers, traders and exporters to plan production operations and marketing decisions. It would also a valuable contribution towards improving government planning and policy marketing for the livestock sector. But, lack of marketing information reduces the efficiency of the marketing system. They also do not respond to the price changes resulting from supply and demand variations. Lacks of market transparency also restrict the development of the livestock economy. This leads to wandering of the hauler/producer and suffering of animals in the market place.

Fighting

When strange animals are mixed together they will fight to determine the new social hierarchy. Fighting is the major cause of dark cutters in cattle and the major cause of death losses in stress susceptible pigs. The cattle which were “dark cutters” were often either the lightest or the heaviest animals in the pen. This indicates that social order is related to stress since the heavier animals are usually dominant.

The low level of infrastructure and facilitating are not conducive for efficient marketing. Transportation is often on hoof which leads to considerable weight loss of animal as well as physical injuries and illness. Trucking is very limited and used only during holidays and festivals to move finished cattle and small stock to urban centers. Poor infrastructures development also hampers the flow of stock from pastoral area to consumption sites. Lack of marketing information reduces the efficiency of the marketing system. They also do not respond to the price changes resulting from supply and demand variations. Lacks of market transparency also restrict the development of the livestock economy. Availability of market information will help producers, traders and exporters to plan production operations and marketing decisions. It would also a valuable contribution towards improving government planning and policy marketing for the livestock sector.

Lair age

Lair age is a time of recovery from transport stress & should be observed for any injury or infection and major source bruise and injury when animal kept for longer period. The time animals spend without food and water is important from a welfare point of view, as they suffer from thirst and hunger, as well as from a meat quantity (carcass weight loss) and quality (high pH meat) point of view [11]. On the other hand, an increase in live and carcass weight can be observed in steers that were previously transported for over 12h, but not in those with short transport (<6h).

When the duration of lair age goes away from recommended time animals held fighting each other. Because strange animals are mixed together they will fight to determine the new social hierarchy. Fighting is the major cause of dark cutters in cattle and the major cause of death losses in stress susceptible pigs. In addition irresponsible/keeper man pricking with cattle sticks was commonly observed, usually during of such pen. The higher incidence of dark cutters in lighter weight cattle is probably due to aggressive small animals which continued to fight a losing battle with larger animals. The animals were in a large pen and were observed running at each other and butting at high rates of speeds. In most instances where the dark cutters were the heavier animals, the activity level in the pen was high and dominant animals expended a lot of energy. Therefore, more research is needed to determine the optimal space requirement.

Meat Quality Attributes

Meat quality can be defined in various ways from palatability to technological aspects to safety. They described beef quality as the ‘sum of all quality factors of meat in terms of the sensoric, nutritive, hygienic and toxicological and technological properties. Technological factors include such parameters as water holding capacity, pH, colour and meat health.

The balance among meat availability, wholesomeness, and intrinsic and extrinsic factors varies from country to country, depending on local customs and on the state of the local economy. In some developing countries, the price of meat and its availability or continuity of supply are the most important factors for consumers. Above and beyond these intrinsic parameters, a further set of extrinsic parameters gained a prominent position in the minds of current consumers of meat and meat products. They are termed extrinsic because they cannot immediately be detected by physical or sensory examination of the meat itself, but are associated with the way that the meat is produced. These extrinsic factors center around animal welfare, the nutritional values of meat in the human diet, and the ecological sustainability of production systems. In other words, the well-being of meat animals, the well-being of meat consumers, and the well-being of society as a whole are now principal attributes of meat production systems and the final product itself. These attributes are discussed fully [12].

Colour of meat

Colour is the first criterion used to evaluate meat quality by the consumer in the supermarket. Lean colour is also used as a point of discrimination within the current grading systems and the Canadian Beef Grading Agency, in consultation with industry, has developed grading colour chits to visually distinguish carcasses that have an unacceptably dark rib-eye colour.

Current research suggests NIRS has the potential to distinguish dark cutters from normal carcasses and further research would be required to determine if it can distinguish different classes of dark cutters. There are different ways determining meat color, which may vary with country to country according to countries codes & regulation and the level of technologies. In cubic color measurement systems, the degree to which colours differ from one another can be calculated with Euclidean distance. In the CIELAB color space, whole-unit values are chosen such that the minimum discernible color difference corresponds of 1. However, when colours are separated by time and space, colours with a higher Euclidean distance can be seen as either the same or very similar. Specific packaging strategies could be used to brighten the surface of dark-cutting meat such that it is almost indistinguishable from normal meat. They reported that within beef steaks of normal pH,

the Euclidean distance from the average bloomed colour can range as high as 30, and acceptable color lasts 3-5 days at 2°C.

Tenderness

Tenderness remains the main determinant of meat quality on which consumers can be satisfied and; is a function of inherent ante-mortem factors, combined with the effects of post-slaughter processes on rigor contraction, modified by the rate and extent of post-mortem proteolysis (protein breakdown) and the effects of meat cookery on the protein and connective tissue structures.

Accordingly they had demonstrated that post-mortem treatments contribute up to 70% to the variation in tenderness, with ageing having a predominant effect. The most recent Canadian Beef tenderness indicated there has been a significant improvement in tenderness at retail between 2001 and 2011, especially for strip loin and top sirloin steaks (CFIA, 2010). However, since not all cuts have improved to this extent and since consumers have indicated they are willing to pay more for guaranteed tenderness, industry interest in controlling this eating characteristic remains high. Palatability critical control points have been implemented in Australia and the USA is implementing a tenderness verification program (USDA Agricultural Marketing Services 2012) based on a sampling plan for manufacturing standards. While this may be a valid solution when individual carcass identification is unknown, an on-line system for tenderness testing of each carcass would be of significant value in the Canadian system, where individual animal identification is known and data collection through the BIXS system is already automated. Several camera or multispectral/hyperspectral systems for predicting tenderness are currently under development in the USA with promising results.

Meat flavour

According to them, flavour is a decisive sensory trait that affects consumer satisfaction in beef and it can be used as an additional strategy for market segmentation. Beef flavour is a sought after attribute but often remains elusive. Consumers concentrate on flavour to ultimately establish their satisfaction when beef tenderness is acceptable. Diets based on grassland forages plus their interaction with local environmental factors can influence beef flavor constituents, creating a desirable and unique beef flavor for discriminating consumers. Knowledge of these influences and the strict control of the determining factors are key elements in the granting of Protected Denomination of Origin (DMO). The DMO promotes the diversification and valuation of specific agricultural products, due either to origin, composition or production methods, to provide the consumer with greater information and knowledge on these products (for example Parma ham from Italy). At the same time, flavor intensity increases as animals increase in age and as marbling increases. Based on these considerations, the opportunity to develop a flavour niche market might be achieved utilizing cull cows due to their age and exposure to grass. Muscle profiling [13] indicates some muscles from the D-grade carcasses may have sufficient tenderness, intramuscular fat (marbling) and inherent flavour to be successfully marketed outside the ground meat trade. Other muscles from D-grade carcasses that lack tenderness could be used in value-added products with inclusion of tenderness interventions. However, in some studies, 30-40% of cow meat samples developed metallic and sour notes, and 10-20% had rancid, bloody, salty and bitter flavour notes due to a high iron content, which may need to be addressed.

Meat health

Meat is a nutrient-rich food long recognized as a source of high-quality protein, available minerals and many vitamins. The association between saturated fat consumption and cardiovascular disease has, however, led to recommendations for limited consumption of red meats. Emerging evidence from a number of reviews and Meta analyses, however, now suggest evidence linking saturated fatty acids to coronary heart disease is lacking. In addition, consumption of meat, including beef, is now being encouraged as a means to combat muscle wasting as people age.

Health conscious consumers supported by a growing body of scientific information have also begun to discriminate based on their understanding of "healthful fats". Hence, grass-finished beef is gaining in popularity, with a resulting shift in available dietary fatty acids (from predominantly linoleic, 18:2n-6, in grains to linolenic, 18:3n-3, in forages). Until now, however, grass-finished animals have been imprecisely and non-verifiably identified in the grading system through the presence of yellow fat (Canada Grade B 2) and the market potential is not being realized.

World Health Organization (2003) recommends a lower saturated fatty acid and a higher PUFA intake, especially of n-3 fatty acids to achieve an appropriate n-6/n-3 ratio (<5:1). Hence, strategies to improve the fatty acid composition of beef have been focused both on n-3 fatty acids and the natural enrichment of their beneficial biohydrogenation products while limiting total fat content and associated higher levels of saturated fatty acids.

At the same time, considerable effort is being directed to develop NIRS as a robust, on-line technology for predicting/discriminating the content of healthful fatty acids. The future incorporation of this technology into automated grading and data collection systems will allow the possibility of health conscious labeling/marketing, beyond grass finishing value chains.

Ultimate PH of meat

The pH that is attained after the muscle is in rigor has an influence on the water-holding capacity (drip loss) of meat. Meat that has a very high ultimate pH (i.e.>6.3) tends to be dark in color and the surface of the meat appears relatively dry. This dark, firm and dry product has a very high water-holding capacity. This product is produced when the animal experienced long-term pre-harvest stress and was harvested before it could rest and replenish these stores. This long-term stress results in depletion of glycogen in the muscle. Since glycogen is the substrate for lactate production in muscle, the less glycogen that is present at harvest, the less lactate is produced after harvest, and subsequently the less the pH will decline in postmortem muscle.

On the other end of the spectrum, very low ultimate pH (5.4-5.3) can result in meat that has relatively greater drip loss than product with a normal ultimate pH (5.6-5.8). One explanation for this low pH can be the presence of a high level of glycogen in the muscle. An estimate of the amount of glycogen can be made by measuring the amount of glycogen and its major metabolites in muscle immediately prior to or soon after slaughter. The value that is obtained is referred to as glycolytic potential. A high glycolytic potential indicates that the muscle had a relatively large amount of glycogen at slaughter and/or had a genetic abnormality that resulted in dysfunction of an enzyme pathway involved in glucose metabolism. An example of a genetic condition that can be one cause of high glycolytic potential in pigs is the RN gene.

Water holding capacity of meat

Looking at meat appearance, especially pork, but not excluding beef and veal, WHC is a critical factor. Meat presenting defects tied to texture, color, and firmness (consistency), such as pale-soft-exudative (PSE) meat or dark-firm-dry (DFD) meat, correlate to low WHC and high WHC, respectively. Traditional measurements of WHC, such as drip, absorption by paper strip, filter pair, and centrifugation, are still in widespread use despite all their intrinsic known defaults. Fortunately, recently developed physical methods are providing deeper insight into the biological and mechanical events induced (postmortem myofibrillar shrinkage, water exchange in extracellular/intracellular compartment water exchange, and, finally, water expulsion) as a step toward curtailing the incidence of PSE or DFD defects. Extending beyond a handful of techniques based on Imaging, X-ray diffraction, IR spectroscopy, and even Raman spectroscopy, which look for structural changes at cellular scale, low-field NMR remains the technique with the brightest future [14].

Water is a dipolar molecule and as such is attracted to charged species like proteins. In fact, some of the water in muscle cells is very closely bound to protein. By definition, bound water is water that exists in the vicinity of non-aqueous constituents (like proteins) and has reduced mobility, i.e. does not easily move to other compartments. This water is very resistant to freezing and to being driven off by conventional heating [15]. Another fraction of water that can be found in muscles and in meat is termed entrapped (also referred to as immobilized) water.

Conclusion and Recommendation

The quality of beef at pre-slaughter handling and marketing can be accompanied by different stressful factors. This starts from handling of animal at farm gate up to bleeding/stunning at the slaughter house; such as loading, transportation/foot or vehicle/unloading, duration of recovery/lair age and finally marketing system. Transportation was a primary factor contributing to quality that animal suffering stress from the duration of transport both short & long time, the status & design of vehicle used, training of hauler, driver experience, loading density, the season/weather condition that animals has been transported, road factor, deprivation of feed and water for prolonged time have infinite effect and significantly influenced the occurrence of bruises. Transporting different species, sex and aged animal together had also led to bruise and even reached on early death of animal. Marketing also exposed animals to physical stresses such as extremes of temperature, cold, fighting, noise, unfamiliar social regrouping, confinement and crowding. Thus, unwanted wandering and fighting at market place as well as un-recommended duration at lair age caused bruising, weight loss of animals, and pathogenic effect on carcass.

Therefore, the attributes of meat quality, such as tenderness, flavor, color, PH & water holding capacity could be closely subjected animal handling at transportation and marketing.

Nevertheless, the review strongly suggests that:

1. The preliminary results from this review concerning possible management practices for specific problems during the pre-slaughter period to minimize losses by bruising to different carcass regions, special handling operations, and personnel training measures should be undertaken.
2. Changing public opinion about the importance of good animal handling and applying legislative actions will be important.
3. The compromised welfare situation of slaughter animals handling during transport, at lair age, market and slaughter should be brought to the attention of stakeholders.

References

1. Burdick NC, Carroll JA, Hulbert LE, Dailey JW, Willard ST, et al. (2010) Relationships between temperament and transportation with rectal temperature and serum concentrations of cortisol and epinephrine in bulls. *Livest. Sci* 129: 166-172.
2. Cernicchiaro N, White BJ, Renter DG, Babcock AH, Kelly L, et al. (2012) Effects of body weight loss during transit from sale barns to commercial feedlots on health and performance in feeder cattle cohorts arriving to feedlots from 2000 to 2008. *J Anim Sci* 90: 1940-1947.
3. Cernicchiaro N, White BJ, Renter DG, Babcock AH, Kelly L, et al. (2012) Associations between the distance traveled from sale barns to commercial feedlots in the United States and overall performance, risk of respiratory disease, and cumulative mortality in feeder cattle during 1997 to 2009. *J Anim Sci* 90: 1929-1939.
4. Coffey KP, Coblenz WK, Humphry JB, Brazle FK (2001) Review: Basic principles and economics of transportation shrink in beef cattle. *Prof Anim Sci* 17: 247-255.
5. Cole NA, Camp TH, Rowe LD, Stevens DG, Hutcheson DP (1988) Effect of transport on feeder calves. *Am J Vet Res* 49: 178-183.
6. Chulayo A, Muchenje V (2017) Activities of some stress enzymes as indicators of slaughter cattle welfare and their relationship with physico-chemical characteristics of beef. *Animal* 11: 1645-1652.
7. Daley C, Abbott A, Doyle P, Nader G, Larson S (2010) A review of fatty acid profiles and antioxidant content in grass-fed and grain-fed beef. *Nutr J* 9: 10.
8. Deiss V, Temple D, Ligout S, Racine C, Bouix, J, et al. (2009) Can emotional reactivity predict stress responses at slaughter in sheep? *Appl Anim Behav Sci* 119: 193-202.
9. Eldridge GA, Winfield CG (1988) The behaviour and bruising of cattle during transport at different space allowances. *Aust J Exp Agric* 28: 695-698.
10. Ferguson D, Warner R (2008) Have we underestimated the impact of pre-slaughter stress on meat quality in ruminants? *Meat Sci*, 80: 12-19.
11. Fike K, Spire MF (2006) Transportation of Cattle. *Vet Clin North Am Food Anim Pract* 22: 305-320
12. Fraser D (2006) Animal welfare assurance programs in food production: A framework for assessing the options. *Anim Welf* 15: 93-104.
13. Frimpong S (2014) Effect of Transportation and Pre-Slaughter Handling on Welfare and Meat Quality of Cattle: Case Study of Kumasi Abattoir, Ghana. *Vet Sci* 1: 174-191.
14. Gallo CB, Huertas SM (2016) Main animal welfare problems in ruminant livestock during preslaughter operations : a South American view 10: 357-364.
15. Gebresenbet G, Ljunberg D, Geers, R, van de Water G (2004) Effective logistics to improve animal welfare in the production chain, with special emphasis on farm-abattoir system. *Int Soc Anim Hyg* 1: 370-38.