EFFECTS OF MARKETING CHANNEL ON BRUISING, ULTIMATE pH AND COLOUR OF BEEF, AND STAKEHOLDER PERCEPTIONS ON THE QUALITY OF BEEF FROM CATTLE SLAUGHTERED AT A SMALLHOLDER ABATTOIR

by

PETER VIMISO

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Supervised by:

Prof. V. Muchenje

Declaration

I, **Peter Vimiso**, vow that this dissertation has not been submitted to any University and that it is my original work conducted under the supervision of Prof. V. Muchenje. All assistance towards the production of this work and all the references contained herein have been duly accredited.

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Peter Vimiso **Date**

Approved as to style and content by:

_____

Prof. V. Muchenje (Supervisor)

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Abstract

Effects of marketing channel on bruising, Ultimate pH and colour of beef, and stakeholder perceptions on the quality of beef from cattle slaughtered at a smallholder abattoir

by

Peter Vimiso

The objective of the study was to determine the effects of marketing channel on bruising, pH_u, and colour of beef and to assess the perceptions of livestock farmers, meat traders and consumers on the welfare of slaughter cattle and its effects on meat quality. Ninety-six farmers were sampled on the basis that they were regular suppliers of slaughter cattle at an abattoir. Their perceptions on a total of 45 aspects were probed (5-point Likert scale) using a structured questionnaire. The effect of marketing channel on bruising, ultimate beef pH_u and colour (L*, a* and b*) was determined. Thirty-one meat traders from the nine butcheries that receive beef from cattle supplied by the 96 farmers were also used. A total of 102 consumers conveniently sampled at point of purchase in the nine butcheries were used. The farmers perceived human-animal relationships as not important to slaughter animal welfare and meat quality, but perceived transportation aspects, farm to abattoir distance, stocking density, farm animal handling aspects and loading method and choice of marking channel as important. They also perceived flavour, tenderness and colour as important meat quality attributes. Marketing channel had significant effects on bruise score, bruise age, pH and L* values ($p < 0.05$) but did not have an effect ($p >$

0.05) on a* and b* values. Animal class and distance were significantly associated with bruise scores. Bruise age was significantly associated with marketing channel. Bruising was significantly associated with pH_u and L* values. There were significant correlations between pH_u and L* (-0.90, $P < 0.05$), pH_u and bruise score (0.34, $P < 0.05$) and L* and bruise score (-0.24, $P < 0.05$). There were positive relationships between distance and pH_u and between distance and bruise score, while the relationship between L* and distance was negative. About 30% of the carcasses had pH_u values > 5.8 and L* values less than 33 and were classified as DFD. There were differences in meat quality due to marketing channels with cattle transported direct from farms having the highest bruise scores, pH_u and the lowest L* values. There was some general disagreement between meat traders and consumers on the use of quality attributes to predict beef quality. Consumers used the intrinsic cue of colour (for quality) and price to make a purchasing decision while traders used freshness to make a purchasing decision. Farmers perceived animal welfare as affecting meat quality; marketing channel had an effect on beef quality while consumers and meat traders perceived slaughter animal welfare as not affecting meat quality and differed on their perceptions of meat quality.

Key words: Pre-slaughter handling, Ultimate pH, bruise score, perception, farmer, meat trader, consumer

List of abbreviations

pH_u – Ultimate pH

a* - Redness

b*- Yellowness

L*- Lightness

SAS- Statistical Analysis System

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Chapter 1: Introduction

1.1 Background

Beef is one of the widely consumed protein sources in the world (Muchenje et al., 2009a). Furthermore, today's consumer and meat trader is increasingly becoming more concerned with the rearing, handling, transportation and slaughter of meat animals (Appleby & Hughes, 1997). With more consumers and traders becoming concerned with welfare of slaughter animals, there is scope in studying the perception of farmers, meat traders and consumers on welfare of slaughter cattle and how it affects meat quality. Several pre-slaughter processes that affect beef eating quality are at play at the farm, during transportation of cattle to the abattoir, the immediate pre-slaughter period, the slaughtering process and meat handling after slaughter (Muchenje et al., 2009a). At farm level, the interaction between factors such as animal feeding, disease control, production systems, breed and age and pre-slaughter handling are linked to the intrinsic quality of meat (Beriain et al., 2000; Rosenvold & Anderson, 2003; Martinez-Cerezo et al., 2005; Olson & Pickova, 2005). However most studies on farmer and consumer perceptions on animal welfare have covered welfare of slaughter animals at the farm but have left out welfare during handling at loading and off-loading, transportation, and at the abattoir, and the effects of welfare on transformation of muscle into beef of acceptable quality.

Muscle transformation into beef is a chain, often of stressful events that includes restraint, handling and loading, deprivation of water or food and transportation to the slaughterhouse often in severe weather conditions, off-loading, lairage waiting, and finally slaughtering (Muchenje et al., 2009a; Maria et al., 2005; Grandin, 1997; Warris, 1992). These events can elicit some physiological processes that can lead to muscle glycogen depletion, resulting in meat with a higher ultimate pH (pH_u) which is not ideal for conversion of muscle to meat (Purchas et al.,

1999; Kannan et al., 2002; Muchenje et al., 2009a). Beef with pH_u values greater than 5.8 or 6 is rejected by consumers because it is visibly dark and is tough and unpalatable at consumption (Viljoen et al., 2002; Wulf et al., 2002; Pipek et al., 2003). Of all the pre-slaughter events mentioned above, transportation causes more stress and even predisposes animals to bruising (Knowles, 1999).

Transport conditions vary according to the way of marketing animals. Cattle can be transported by vehicles directly from the farm or from live auction markets to the abattoir. In many African countries hoofing/walking cattle to smallholder abattoirs is common, especially for distances less than 20 km. Although this transportation mode still exists in the communal areas, road vehicle is slowly replacing it due to long distances and more time it takes to reach the slaughterhouse (Grandin, 2000). Furthermore, cattle in the emerging slaughterhouses are supplied by many small producers/farmers, who are located some distances away and with limited infrastructure, unlike in the established slaughterhouses which are well-equipped (Aklilu, 2002). The main issue facing marketing of slaughter cattle through auctions is the perception that it is not conducive to the delivery of high quality beef (Ferguson et al., 2007), since cattle are likely to endure longer transport times, a lot of handling through (un) loading and mixing with strange potentially aggressive animals that can cause bruising (Knowles, 1999).

Bruises in cattle occur during the *ante-mortem* period but they can only be seen at slaughter due to the thickness of the bovine skin. Bruise assessment is therefore a *post mortem* function and it is a retrospective reflection of all physically damaging events that may have occurred prior to slaughter (Strappini et al., 2009). Bruising in cattle is not only an indication of poor animal welfare, but can cause heavy financial loses (Jarvis et al., 1995; Grandin, 2000; Gallo, 2008)

since bruised meat must be trimmed, downgraded or condemned depending on the severity of the bruises.

The severity and prevalence of bruises is also depended on the marketing channel and transportation mode (Strappini et al., 2010). Several visual bovine carcass scoring systems have been developed for use in slaughterhouses to assess bruises and these are based on extent, site of bruising, colour, appearance and severity of the bruise. Estimated age of the bruise, together with information on the timing of pre-slaughter events, may help in the identification of the risk factors for bruising and provide information where animal welfare is being breached (Strappini et al., 2009). Bruising in cattle affects the quality of the carcass and results in meat of poor keeping quality because the bruised sites offer an environment suitable for microbial growth and the meat is undesirable to consumers (FAO, 2001; Chambers et al., 2004; Gallo, 2008; Hoffman et al., 2010). The degree to which the pre-slaughter events mentioned above will affect beef quality and the severity of bruising depends on the knowledge the farmer has on their effects and this knowledge will influence perceptions.

Farmer perceptions on slaughter animal welfare are important since these perceptions define producer behaviour and willingness to produce animals with acceptable meat quality (Kauppinen et al., 2006). The interpretation of the concept of farm animal welfare tends to differ amongst farmers and is influenced by convictions, values, norms, knowledge and interests (Te Velde et al., 2002). The above frame work explains why farmers, meat traders and consumers tend to speak different languages when it comes to animal welfare (Vanhonacker et al., 2008). Farmers' norms are clearly related to factors important for optimizing production, and the need

to make a living (Vanhonacker et al., 2008) and this might influence perceptions on animal welfare (Te Velde et al., 2002; Lassen et al., 2006), while the farmer's behavior towards his animals can be modified by factors such as personality and demographic variables (e.g. age, gender, education) (Fishbein, 1980). Farmers play a crucial role at all the initial stages of the transport chain and perhaps contribute about 80% to the quality of the final product (Smith & Grandin, 1999).

Consumer perception of meat and meat products is a critical issue for the meat industry because it directly impacts on its profitability (Troy & Kerry, 2010). Beef acceptance and purchasing behaviour by consumers is affected by quality variables, such as beef colour, tenderness and flavour, which more often than not get affected by pH (Aklilu, 2002; Muchenje et al., 2009b). Therefore, a negative perception of beef by consumers regarding such encounters may result in losses to the beef industry (Muchenje et al., 2009a). Meat traders' perception of slaughter animal welfare and meat quality is important since they are responsible for selling the product to the consumer at the end of the chain. A difference in judgment of product quality among farmers, traders and consumers might mean supply of a wrong product along the chain (De Haes et al., 2004; Verbeke et al., 2005). It is important to know the intrinsic and extrinsic cues that consumers associate with product quality, as farmers and traders should focus their added value activities on those aspects that consumers value as most important (Brunso et al., 2002; Ottesen, 2006).

While some studies have been conducted on the effects of pre-slaughter animal welfare on meat quality (Mach, 2008; Muchenje et al., 2009b) in large and better-equipped abattoirs, very little has been done on rural-based small slaughterhouses. Furthermore, very little work has also been

done on the perceptions of farmers, meat traders and consumers on slaughter animal welfare and how it affects meat quality.

1.2 Justification

Very little has been done on the perceptions of livestock farmers on slaughter animal welfare and how it affects the quality of meat produced at smallholder abattoirs. Meat quality is adversely affected by poor animal welfare practices along the production chain and a study that will enlighten players in the chain will go a long way in the provision of quality beef on the market. Beef pH which affects other important beef characteristics such as colour, tenderness and palatability (Gracey et al., 1999), is important, and this variable can be manipulated through good animal welfare practices. Improvement of handling methods of animals destined for slaughter can be of assistance in reducing stress, bruising and injury. The farmer, slaughterhouses, meat traders/ retailers and the consumers can all thus be rewarded by improvement on the quality of beef produced. Furthermore, this research through characterization and aging of any bruises that are observed on the carcasses will help with the identification of risk factors for bruising and thus provide information on where animal welfare is lacking. It is also hoped that this study will enlighten the transporters and abattoir operators on the importance of meat quality through its association with bruising and meat pH.

Meat traders' correct perceptions of slaughter welfare are valuable since consumers depend on them for the provision of meat of acceptable quality. Consumers are the end users of meats and therefore their perceptions on slaughter welfare and meat quality should be valued by the meat industry. Since consumers base their purchase decisions on quality cues, it is important that the meat industry fully understand what these cues are and the most important ones. It is hoped that

knowing the most important cues will help producers, abattoir operators and retailers to maintain and enhance these cues in their beef products. A better perception on welfare of slaughter cattle and good knowledge in predicting beef quality at point of sale is expected from cattle farmers, meat traders and consumers. A positive perception will help farmers to manipulate meat quality attributes at production level so that visually acceptable meat can be produced to meet consumer expectations.

1.3 Objectives

The broad objective of the study was to determine the effects of marketing channel on bruises, pH_u and colour of beef slaughtered at a smallholder abattoir and to determine the perceptions of farmers, meat traders and consumers on welfare of slaughter cattle and how it affects the quality of beef.

The specific objectives were to:

1. Determine the perception of livestock farmers on the effect of welfare of slaughter cattle on beef quality;
2. Determine the effects of marketing channel and pre-slaughter cattle handling on bruising, beef pH_u and colour;
3. Determine the perception of meat traders and consumers on the effect of welfare of slaughter cattle on beef quality.

1.4 Hypotheses:

The hypotheses tested were:

1. Farmers perceive slaughter animal welfare as not affecting beef quality;

1. Marketing channel and pre-slaughter handling do not have effects on bruising, beef pH_u and colour; and
2. Consumers and meat traders perceive animal welfare as not affecting beef quality.

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Chapter 2: Literature review

2.1. Introduction

The welfare of slaughter animals is a major concern to many meat producers (Vanhonacker et al., 2008) and has become a priority in many European countries (European Commission, 2006). The pre-slaughter logistic chain from farm to abattoir involves many stressful steps (loading, transport, unloading, and slaughter), but transport is considered a major stressor with many unwanted effects on meat quality (Tarrant, 1990). The various marketing channels also exposes slaughter animals to many deleterious effects on meat quality, with bruising being the principal result (Strappini et al., 2010). This chapter reviews the effects of marketing channel, pre-slaughter handling and the effects of farmer, meat trader and consumer perceptions on defining beef of acceptable quality.

2.2. Farmer perception on animal welfare

The perception of the farmer to animal welfare is influenced by many factors, with farmers being more interested in economic and financial issues and the need to make a living. Farmers' wish to supply high quality products and to build a positive image of livestock production may also influence their perceptions of animal welfare. They also spend most of their time with their animals and have some practical knowledge on animal welfare (Vanhonacker et al., 2008). Te Velde et al. (2002) is of the opinion that farmers have the belief that animals are meant to serve humans and that meat is an important part of people's diet with slaughtering animals for meat being a legitimate process.

Farmers' attitudes towards animal welfare may be explained based on three factors by Kendall et al. (2006). These are place-based, social structural factors and individuals' unique animal-related

experiences. With regard to social structural factors, gender, socio-economic class, age and family status influence farmer perceptions on animal welfare. Women are regarded as having a higher concern with animal welfare as compared to men. This could be due to the task of women as primary caretakers, since they are more likely to engage in household tasks that give them more contact with animals, like caring for pets and food preparation (Burrel & Vrieze, 2003; Verhue & Verzeijden, 2003). The less educated farmers are considered as having more concern for animals and this is explained by the underdog hypothesis (Kendall et al., 2006). Results that are contrary to the underdog hypothesis were found by Burrel and Vrieze (2003) and Verhue and Verzeijden (2003) where highly educated people expressed better concern for animal welfare. With regard to age, it was hypothesized that age is inversely related to the concern for animal welfare and to be related to one's life-cycle stage. Verhue and Verzeijden (2003) supported this hypothesis by indication that younger people tend to have more concern for animal welfare than the aged. The farmer's perception on animal handling influences meat quality.

2.3. The farmer and meat quality.

In the meat chain, a lot of pre and post-slaughter factors influence the intrinsic quality of meat (Sepulveda et al., 2010). At the farm, some of the following factors may influence the intrinsic quality of meat: animal feeding, disease control, the production system (intensive or extensive), and the type of breed the farmer keeps and the age of the animals (Rosenvold & Anderson, 2003; Martinez-Cerezo et al., 2005; Olson & Pickova, 2005). The type of breed a farmer keeps may influence meat quality through responses to pre-slaughter handling (King et al., 2006; Muchenje et al., 2009b). Selection for improved temperament can facilitate not only human- animal welfare benefits at handling, but also helps in the reduction in stress mediated losses in bruising and meat quality (Ferguson & Warner, 2008). The farmer has the most influence on handling and

transportation strategies that affect meat quality at the end of the production chain. The farmer selects the cattle to be sold or to travel and prepares them for transportation. However the most important decision the farmer makes that has a lot of bearing on beef quality is the final destination of the cattle (i.e. journey duration and distance). Smith and Grandin (1999) estimated that 80% of the aspects that contribute to poor meat quality occur before the cattle reach the abattoir.

2.4. Production system, animal welfare and handling.

From an animal welfare perspective, livestock farming can be divided into three systems: intensive/ industrialized, subsistence and extensive livestock farming (Gregory, 2007). With intensive or industrialised livestock farming, animal welfare problems relate with trying to make animals conform to particular management systems, while with subsistence farming, underfeeding is the predominant welfare and production concern (Gregory, 2007). With extensive systems, animals are managed with minimal human conduct, and the welfare issues of concern are encountered during loading and handling as the slightest contact can elicit fear responses (Fisher et al., 2008). Handling and loading difficulties that many farmers often come across are thought to be responsible for the belief by many cattle farmers that early handling experiences have long-lasting experiences when cattle are handled in future and that cattle with previous experiences with gentle handling will be calmer and easier to handle in the future than cattle that have been handled roughly (Grandin, 2006). Different animals react differently to handling and restraint. This being the case, it is possible that animals from the same farm treated to the same adverse conditions during handling and transportation will produce beef that differs in quality.

2. 5. Human-animal relationship in meat production

Ever since domestication of our farm animals began, close contact between the farmer and the animals has always been more in intensive farming systems than in extensive farming systems (Lensink, 2002). Farm animal management practices such as transportation, medication, vaccination and dehorning, can lead to fear reactions, with possible negative effects on animal welfare (Seabrook & Bartle, 1992; Waterhouse, 1996). Most physical contacts induce fear, while the non-physical contacts reduce avoidance behavior of the animals towards the farmer (Gonyou et al., 1986; Dodzi 2010). Lensink et al. (2001), in their study on commercial veal calves found that calves originating from farmers behaving positively, had lower pH levels than calves from farmers behaving negatively. The calves from 'positive' farmers were easier to load and unload compared to calves from 'negative' farmers. Animals that are difficult to load or unload spend more energy, resulting in the depletion of pre-slaughter glycogen levels. Pre-slaughter glycogen depletion in muscle results in poor production of lactic acid during the maturation process, the pH fails to go down and meat that is dark and unpalatable is produced (Muchenje et al., 2009a). The relationship between the farmers' attitude, their behaviour towards animals in general, the welfare of the animals and the productivity of the animals is shown in Figure 2.1

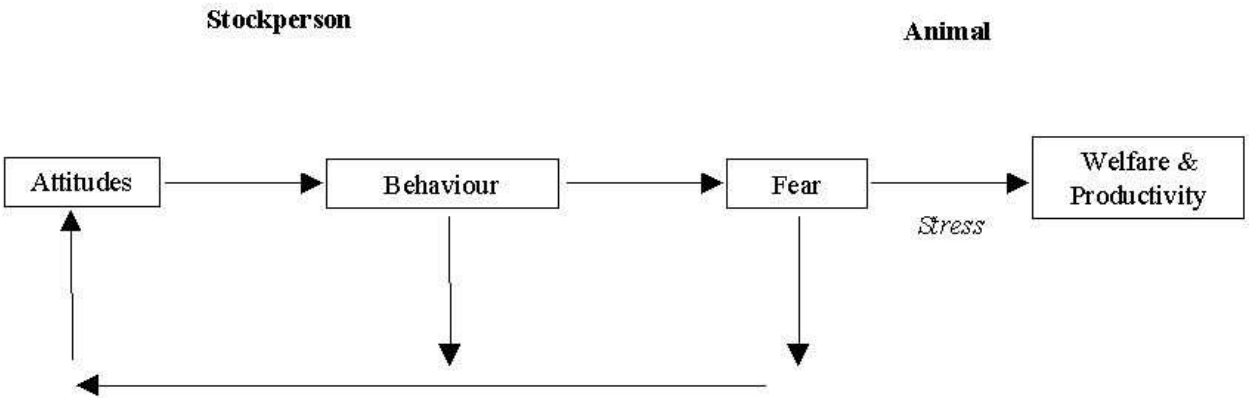


Figure 2. 1: Model explaining the farmer's influence on the welfare of the animals and their productivity

Source: Hemsworth et al. (1998)

2.6. Transportation factors that affect meat quality

Road transportation is associated with stress and several types of injuries (Minka & Ayo, 2007; Fergusson & Warner, 2008). The stress response to road transport in cattle will vary depending on the type of animal and the conditions during the journey (Fergusson & Warner, 2008). Increasing time from the farm to the abattoir usually has a negative effect on meat quality (Warris, 2000) with longer transport times increasing stress indicators such as cortisol, Creatine Kinase, and lactate (Grandin, 2000). Research has shown that cattle transported for distances less than 400 km are unlikely to have carcasses with above normal pH values, while cattle transported for distances greater than 2000 km or durations more than 24 hours are likely to show pH values

above normal (Eldridge & Winfield, 1988; Tarrant, 1989). Distance travelled by cattle to the abattoir and the occurrence of bruises seem to be positively correlated, with level of bruising increasing with distance travelled (McNally & Warriss, 1996; Hoffman et al., 1998).

Stocking density is also an important factor in meat quality and literature shows that it has an effect on bruising, with commonly used stocking densities ranging from low, medium to high (Table 2.1). High stocking density has more undesirable effects on meat than low or medium with the degree of bruising that occurs during transportation being high at high stocking density (Tarrant et al., 1992). The high bruise scores at high stocking densities are due to the fact that when animals go down, they are trapped on the floor by others wanting to 'close over' and occupy the available standing space. At high stocking densities, the room to move is limited and the animals fail to adopt their preferred standing positions.

Table 2. 1: The effect of stocking density on bruising in Friesian steers

	Stocking density			
	Low $200kg/m^2$	Medium $300kg/m^2$	High $600kg/m^2$	Author
Carcass bruise score	3.7	5.0	8.5	(Tarrant et al., 1992)
	3.1	3.6	11.9	(Tarrant et al., 1988)

2.7: Bruising

A bruise or “contusion” is described as a traumatic injury with rupture of the vascular supply and accumulation of blood and serum in the affected tissue (Gracey et al., 1999) without the skin being broken (Strappini et al., 2010). A bruise develops when force is applied to the skin by use of a blunt object, such as a stone, metal projection, a stick or when an animal falls (Strappinni et al., 2009). Critical areas in the meat production chain where bruising can occur include; the farm, during road transportation, at livestock markets, during loading and unloading, during penning and even during stunning procedures (Jarvis et al., 1995). Handling at livestock markets has a significant contribution to bruising (Knowles et al., 1999).

2.7.1: Livestock markets and handling

According to Knowles (1999), animals that are sold through auction markets undergo through a lot of handling, transportation, multiple loading and unloading procedures thus increasing the risk of bruising. Live auction markets are very popular in most countries including South Africa. According to Knowles (1999), livestock markets increase transport times, handling during loading and unloading and mixing with unfamiliar animals. All these increase the risk of physical damage and bruising. In a survey by McNally and Warriss (1996), it was found that cattle passing through auctions had higher bruises (7.8%) compared to those bought from dealers (6.3%) or direct from farms (4.8%). In a related study by Weeks et al. (2002), cattle passing through markets presented more bruises (71%) compared to cattle delivered by dealers (65%) or from farms (53.7%). However, Horder et al. (1982) found no significant difference between bruise scores of cattle from farms and those from livestock markets. The way cattle are handled is related to bruise development as shown by Lensink et al. (2001) in their experiment with veal calves. Animals that are well handled during loading develop fewer bruises than those that are roughly handled during loading and unloading. Apart from handling during marketing, the age and class of animal has an influence on the intensity of bruising they incur.

2.7.2: Animal class and age on bruising.

There is evidence that animal class and age of an animal has an effect on bruising (Jarvis et al., 1995; Gallo et al., 1999; Strappinni et al., 2010). Findings from these researchers show that cows bruise more than steers and bulls, while heifers bruise significantly more than steers. Mature and old animals also showed more bruising in comparison to younger animals. The differences in bruising between the different animal classes was linked to the differences in fat cover, skin or

hide thickness (Weeks et al., 2002), with cows bruising more due to their lack of fat cover (Grandin, 1998). Wythes and Shorthose (1991) determined the effect of age on bruising and found that bruising increased with the age of the animal. They found out that the mature and old cows were more prone to bruising compared to other classes in the same group. Although there could be differences in extent of bruising depending on age or animal class, the subjective determination of bruising using the Australian Carcass Bruise Scoring System (ACBSS) still remains a useful tool under abattoir conditions.

2.7.3: Determination of the occurrence of bruises

The site and extent of bruising can be assessed by using the Australian Carcass Bruises Scoring System (ACBSS) devised by Anderson and Horder (1979). Under this system, the carcasses are examined and the size, site and colour of every bruising are recorded on diagrams. The system classifies the severity of bruising according to the surface area of the lesion and three basic categories are used. The categories are 'slight' (S); from 2-8 cm, 'medium' (M); from 8-16 cm and 'heavy' H, from 16 cm. Three new categories Sd, Md and Hd have been developed, with the lower case'd' being used to indicate that the bruising comprises deeper tissues. The visual appraisal is also confined to seven areas; butt, rump, loin, rib, forequarter, back hip and pin. The information on the bruise scoring is recorded on sheets and calculated numerically. The system also enables each side, site or whole carcass to be allocated a numerical value that allows the amount of trimmed tissue to be estimated. Previous research has shown that 8 bruise points approximate to 8 kg of trimmed beef (Anderson, 1978). The visual assessment of bruising can be done in conjunction with estimation of the age of bruises. Though unreliable, bruise colour changes can be used to estimate the time of occurrence of bruising.

2.7. 4: Aging the bruises

Estimating the age of a bruise can provide for the identification of the place and time of livestock damage and provides information about the cause (Hamdy et al., 1957a, b). The protocol by Gracey and Collins (1992), though very subjective, can be used as a guide to determine the age of the bruises (Table 2.2). According to Grandin (2000), bruises in beef cattle can be separated into two classes: those that are regarded as fresh and those that are regarded as old, aged at several days or weeks, with the bilirubin being responsible for the yellow colour. Although aging bruises using color is regarded as inaccurate, the appearance of yellow colour in a bruise is considered to be more informative in bruise aging than other colours (Langlois & Gresham, 1991; Hughes et al., 2004; Langlois, 2007). Maguire et al. (2005) discounted the use of other colours like blue, green, purple, black, orange, brown or red in estimating the age of a bruise because a bruise can contain various colours at the same time. To compliment the work of Grandin (2000) and that of Gracey and Collins (1992), Langlios (2007) stated that if a bruise contains yellow colour, then it is not recent, but should be regarded as old, and its age should be estimated as older than 18 hours.

Table 2.2: Colour changes and bovine bruise aging

Observable colour of the bruise	Estimated age of the bruise in hours

Red and hemorrhagic (bright-red)	0-10 hours old
Dark- red colour	Approximately 24 hours old
Watery consistency	24-38 hours
Rusty orange colour, soapy to touch, clear yellow mucus	+72 hours (3 days old)

Source: Gracey & Collins (1992)

2.8. Colour and beef quality

Colour is one of the most important factors in consumer selection and decision to purchase meat and meat products, since it is the first quality attribute seen by the consumer and is an indicator of freshness and wholesomeness (Muchenje et al., 2009a; Troy & Kerry, 2010). Colour of meat depends upon several individual factors and their interactions. Differences in meat colour have been associated with variations in intramuscular fat and moisture content, age dependent changes in muscle myoglobin content and the pHu of the muscle (Muchenje et al., 2008). Myoglobin is

the basic pigment in fresh meat and its content varies with production factors such as species, animal age, sex, feeding system, type of muscle and muscular activity. Myoglobin is purplish in colour, is fixed in the tissues and is responsible for the majority of the red colour in meat. Haemoglobin a pigment that occurs in circulation accounts for the remaining colour of meat (Priolo et al., 2001). Pre-slaughter activities such as handling, transportation, loading and unloading can deplete muscle glycogen resulting in poor postmortem lactic acid production which results in DFD meat. It is important for meat traders or scientists to determine the colour of meat since meat colour can be used to predict its eating quality.

2.8.1. Determination of colour

It is important for retailers and researchers to objectively measure meat colour since there is a relationship among instrumental measures of fresh meat and colour and cooked meat palatability (Wulf et al., 1997; Wulf & Page, 2000; Liu et al., 2003). Several factors such as light source affect instrumental colour readings, with illuminant D_{65} which resembles daylight commonly used in meat colour measurements. Area of measurement which can vary from 8mm to 25 mm is also important and it should be as large as the instrument allows. Also important is the angle of observation and this can vary from 2^{o} to 10^{o} (Tapp et al., 2010).

Meat colour is defined in terms of the colorimetric co-ordinates, L *, a * and b*(Commission International De I' Eclairage, 1976). Reflectance (L*) is the lightness component and is a measure of the light reflected, it also indicates the black-whiteness of the meat and is measure of DFD beef. Its values ranges from 0 (all light absorbed) to 100 (all reflected), a* spans from -60 (green) to +60 (red) and is a measure of the oxygenation of myoglobin while b* spans from -60 (blue) to +60 (yellow).

2. 9: pH and quality of meat

A high ultimate pH is generally indicative of stress in animals (Dhanda et al., 2003; Muchenje et al., 2009a). It may result from transportation, rough handling, inclement temperatures, or anything that causes the animal to draw on its glycogen reserves before slaughter. Nutritional stress as can occur during cattle auctions can result in dehydration, electrolyte imbalances, negative energy balance, glycogen depletion in muscle, and catabolism of protein and fat, ultimately increasing the pHu (Dhanda et al., 2003; Mushi et al., 2009). It has been established by many authors that muscle colour is highly correlated with muscle pH (Wulf & Page, 2000 Page et al., 2001). Page et al. (2001) reported that a*and b* values were more highly correlated with muscle pH (r = -0.58 and -0.56, respectively) than L* values (r = - 0.40), and Muchenje et al. (2008) also reported weak correlations between pH_u and L*.

2.10. Consumer perception of animal welfare

In European countries, the issue of animal welfare is generally recognized (Martelli, 2009). In an internet consultation carried out by the European Commission in 2005, consumers were asked to list those factors they considered very important for animal welfare and protection (European Commission, 2005), space allowance was considered to be the most important farm animal welfare factor. Those factors that are important for slaughter animals were: humane transport (ranked second), presence of trained staff (ranked third) and humane slaughtering (ranked fourth). Other factors that were considered by the consumers to be very important were: access to outdoor areas, exposure to natural light, absence of movement restriction, absence of mutilation and social contact (European Commision, 2005).Consumers from different countries differ in what animal welfare factors they consider to be the most important. In a survey by Miele and Parisi (2001), Italian consumers considered the quality of the animal's feed as the most important

factor. Those factors important for slaughter animals were: the conditions of transportation and the conditions in which the animal is slaughtered (ranked fifth and sixth respectively).

2.11: Consumer perception of beef.

The perception of consumers on meat and meat products has a direct impact on the profitability of the meat industry. If consumers have a negative perception of any meat product, their purchasing behavior will be affected negatively (Troy & Kerry, 2010). Perception is defined as the act of apprehending by means of the senses and/ or the mind. Perception not only relates to basic senses such as visual, flavor and taste attributes, but also to formed learning or experiences. For consumers to willingly purchase and consume a particular beef product, their perceptions must be positive towards it. Consumer perception relates to beef quality in a broad sense (Troy & Kerry, 2010). Various models have been proposed to define food quality (Grunert et al., 1996; Peri, 2006). These models can be related to beef and can distinguish it as a food (safety, nutrition, sensory, ethical) and as an object of trade (certification, price) (Peri, 2006), or as a product before purchase (price, extrinsic quality cues, intrinsic quality cues) and as a product after purchase (beef preparation, after eating experience, sensory characteristics) (Grunert et al., 1996). The Total Food Quality Model with respect to meat is described by Grunert et al. (2004). In this model, various extrinsic and intrinsic quality cues perceived by the consumer are described. Extrinsic cues are described as those that are not physically part of the meat, (price, and place of slaughter/origin) while intrinsic cues as those that are physically part of the meat, (marbling, colour). Consumers base their purchase choices on the perceived quality cues.

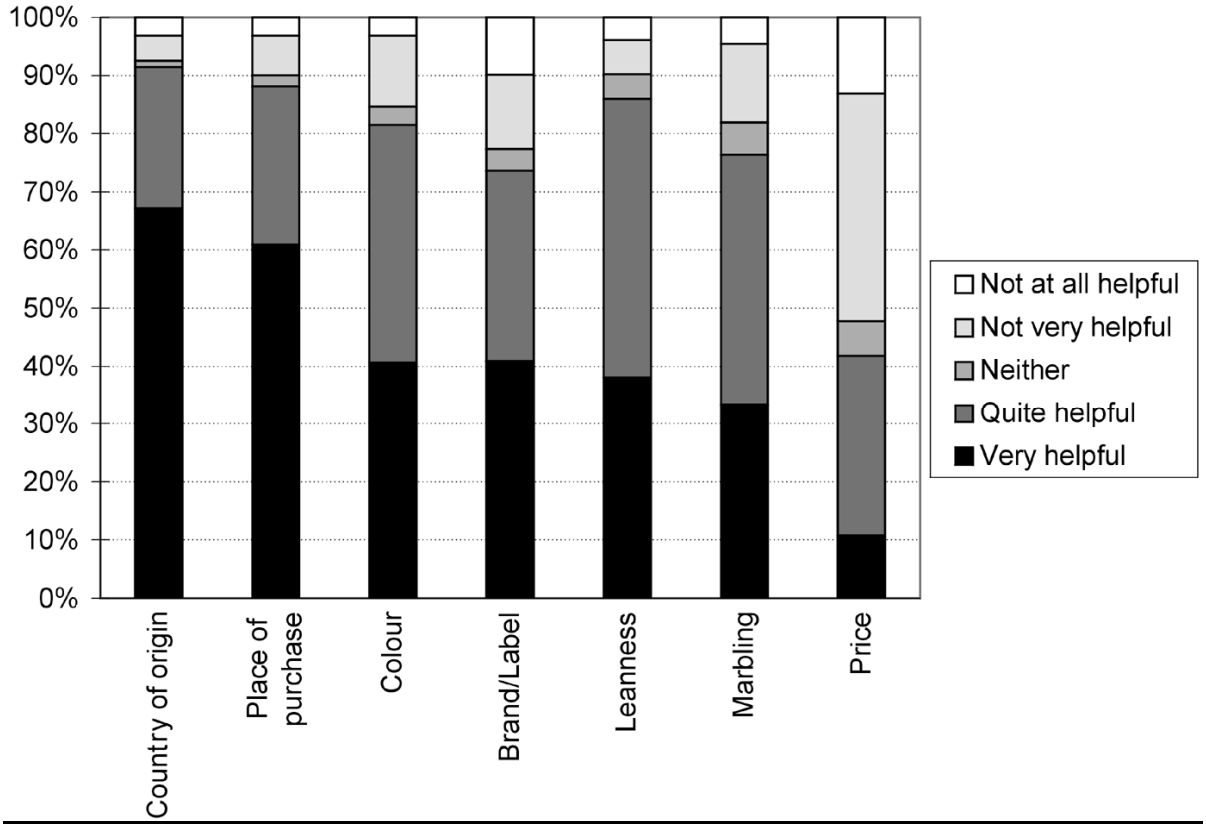
2.11. Quality cues

At point of purchase consumers use intrinsic cues: colour, leanness and marbling and extrinsic cues: quality assurance, place of purchase and price (Glitsch, 2000). After purchase, consumers tend to form eating quality expectations: tenderness, flavour and juiciness and the correctness of the production process (Glitsch, 2000; Grunert et al., 2004). Consumers prefer a light pink to bright red colour and they will strongly reject dark coloured meat, believing that it is from an old or sick animal or contaminated (Muchenje et al., 2009b). Marbling is the visible fat present in the interfascicular spaces of a muscle (Kauffman & Marsh, 1987). Marbling affects flavour, juiciness, tenderness and visual characteristics of meat (Miller, 2002). Some production factors such as animal breed, slaughter weight, feeding strategy, and growth rate affect marbling and consumer perception at point of sale (Keane, 1993; Blanchard et al., 1999; Candek-Potokar et al., 1999; Therkildsen et al., 2002).

2.11: Importance of quality cues at point of purchase.

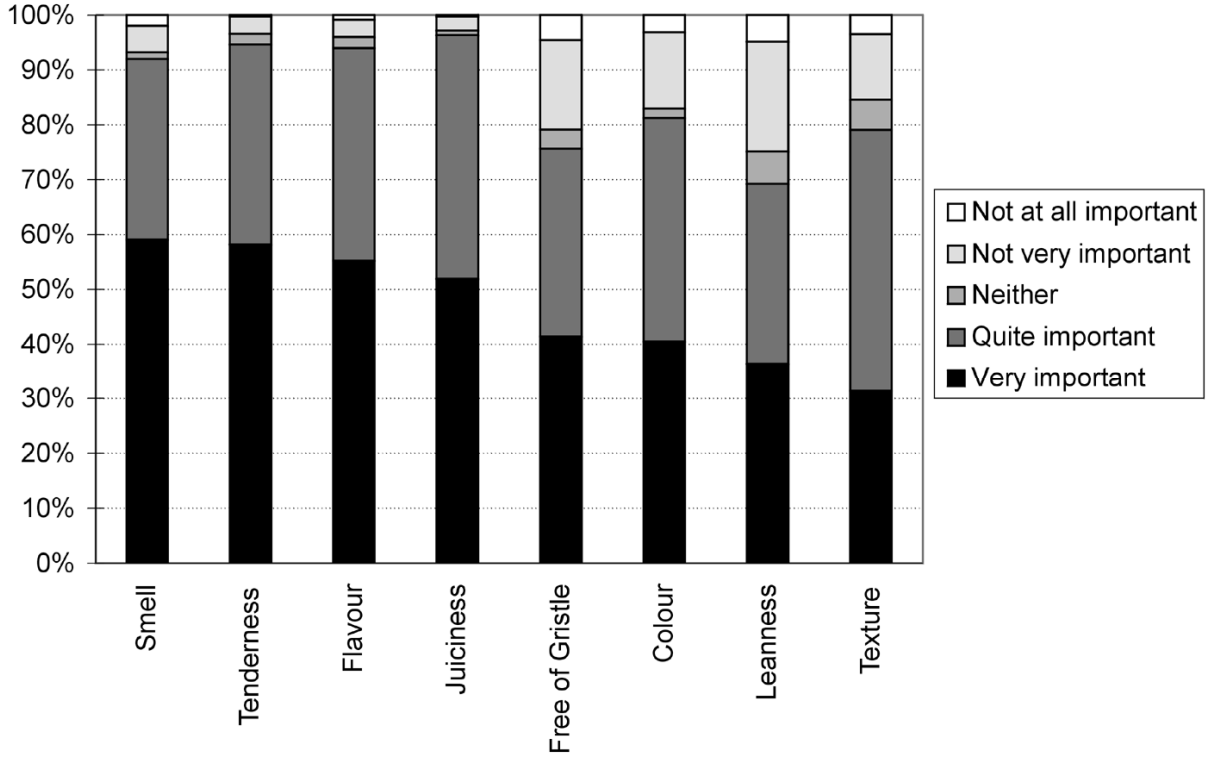
Jocumsen (2005) assessed Australian consumers on the use of intrinsic and extrinsic cues in predicting the eating quality of beef. Freshness was ranked first while marbling was ranked last. For extrinsic cues, presentation was ranked first and packaging was ranked last. Females rated colour, leanness, marbling, labels and presentation as significantly more helpful for predicting eating quality than did males. In a similar study in Germany (Becker et al., 2000), country of origin and place of purchase were ranked as most helpful in assessing beef quality in the shop (Figure 2.2) while smell and leanness were ranked as important eating quality attributes (Figure 2.3). Grunert (1997) found that consumers in Germany, France, Spain and the UK, perceived fat and place of purchase as crucial quality cues. Contrary to the expected norm where higher prices

would mean better quality, this study showed higher prices as having a negative effect on quality expectations. Acebro´n and Dopico (2000) found that Spanish consumers considered light coloured meat, expensive meat and meat packed in trays to be more indicative of quality. Steenkamp and van Trijp (1996) surveyed Dutch consumers and found meat colour, marbling and general appearance as the major quality cues while tenderness was identified as the primary determinant of experienced quality and flavour was insignificant.



Source: Becker et al. (2000)

Figure 2. 2: Helpfulness of Quality in the shop attributes for beef



Source: Becker et al. (2000)

Figure 2. 3: Importance of eating quality attributes in beef

2.12: Eating quality of beef

For beef of high eating quality to be produced, producers need to understand the factors that influence quality. Miller et al. (2001) revealed that the most sought after eating quality attributes of beef are tenderness, juiciness, flavour and overall palatability. Tenderness, though difficult to predict, is regarded as the most important eating quality attribute. It is based on ease of chewing and is influenced by many factors among them the fibrous nature of muscle, that contributes to chewing resistance (Gerrad & Grand, 2003). The way meat is treated after slaughter also affects tenderness since hasty refrigeration immediately after slaughter results in severe muscle contraction, leading to cold shortening (Muchenje et al., 2009a). Other factors that affect tenderness are: animal's age, sex, muscle location, live weight, breed and pre-slaughter stress (Muchenje et al., 2009a). Flavour of raw meat is blunt, slightly metallic and serum like, and the actual flavour only comes out after cooking (Mattram, 1988, Calikins & Hodgen, 2007). The flavour of cooked meat is affected by age, sex, amount and type of fat, animal diet as well as pre-slaughter stress levels (Troy & Kerry, 2010).

2.14: Summary

Farmer, meat trader and consumer perceptions of slaughter animal welfare and meat quality are important in meat production. Marketing channel, mode of transportation and handling of animals influences bruising and the quality of meat produced. Meat quality attributes such as colour and freshness are important at point of purchase since they affect consumers' purchasing decisions. Quality attributes such as colour, tenderness, leanness and marbling can be controlled at the farm or during pre-slaughter handling.

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Chapter 3: Farmers' perceptions of meat quality and how the quality of meat is affected by animal welfare practices.

(This manuscript has been submitted to *Food Quality and Preference)*

By Peter Vimiso

Abstract

The objective of the current study was to determine the perceptions of livestock farmers on meat quality and how it is affected by slaughter animal welfare. Farmer perceptions on a total of 45 aspects were probed (5-point Likert scale) using a structured questionnaire. Mean perceived importance scores were determined and mean scores above 2.5 (neutral point of the scale) were considered as important (positive perceptions) while mean scores below 2.5 were considered as not important (negative perception) by the farmers. The following aspects were found to be important: meat colour, carcass class, and freshness of meat, meat tenderness, flavour, animal handling facilities, marketing channel, and hunger during transports, and distance between the farm and the market/ abattoir, animal handling at loading and slaughter method. A chi-square test for association was done and the following were found significant ($P < 0.05$). Gender was associated with: meat colour and some animal welfare aspects. Age and educational qualification were associated with some animal welfare aspects. Farming system was associated with the presence of standard animal handling facilities. Animal welfare training was associated with respect for animals. It was concluded that livestock farmers perceive animal welfare as affecting meat quality.

Keywords: animal welfare; animal handling, South Africa; meat colour, meat tenderness; carcass class; meat freshness

3.1. Introduction

Production animal welfare is a major consideration in meat production and is based on the principle that animals can suffer, with consequences to meat quality (Manteca, 1998). Production animal welfare is valued by; scientists, governments, retailers, producers and consumers (Bracke et al., 2005), and their demands are always that animals be reared, handled, transported and slaughtered using humane practices (Appleby & Hughes, 1997). Animal welfare aspects that may affect meat quality in a negative way and often with economic losses are encountered during transportation (Warris, 2000; Perez et al., 2002; Maria et al., 2006) with journey length, if not properly planned weighing in significantly (Grandin, 2000; Gosàlvez et al., 2006). Other factors that can effect meat quality include; transportation time, loading and unloading (Nanni Costa et al., 1999; Buil et al., 2004), stocking density, weather conditions, vehicle characteristics, food and water deprivation and mixing of strange animals (Verga et al., 2009).

The concept of meat quality is not universally defined and varies considerably depending on the user. Producers and farmers tend to associate quality with technical use-attributes or with external aspects of the animals, they also tend to associate quality with attributes that can be measured and compared to set standards (Maza et al., 2008). Meat quality can refer to some of the following attributes: carcass characteristics and composition; meat characteristics such as colour, marbling, pH and eating quality characteristics including tenderness, juiciness and flavour (Bredahl et al., 1998, Muchenje et al., 2009a). These attributes, are considered to be the most important characteristics by which consumers judge meat quality (Grunert et al., 2004; Dyubele et al., 2010). In each stage from growth to slaughter, there are factors such as stress, ageing, pH and breed that may affect the quality of meat (Muchenje et al., 2009a). Meat colour

may be influenced by farmer related factors such as diet and slaughter age and animal related factors such as its activities (Muchenje et al., 2009a). Pre-slaughter factors that deplete muscle glycogen such as handling and transportation may affect meat pH_u and subsequently, meat quality parameters such as tenderness, juiciness, flavour and meat colour (Gregory, 2008; Ferguson & Warner, 2008; Muchenje et al., 2009a).

Farmers plays a crucial role at all the initial stages of the transport chain and perhaps contributes about 80% to the quality of the final product (Smith & Grandin, 1999), therefore their perceptions are important since they define their behaviour and willingness to produce animals with acceptable meat quality (Kauppinen et al., 2006). Research done to identify factors determining farmers' behaviour towards animals revealed that their behavoiur is closely related with the attitude they hold towards animals (Hemsworth & Coleman, 1998). A negative contact between a farmer and his animals not only induces avoidance behavior (Ndou et al., 2010), but also physiological stress responses (Hemsworth et al., 1986; Lensink et al., 2001) and changes in meat quality (Muchenje et al., 2009a, b). The farmer's perceptions and behavior towards his animals can be modified by factors such as personality and demographic variables (e.g. age, gender, education) and economic interests and his need to make a living (Vanhonacker et al., 2008).

Previous researches on animal welfare have either been approached from the consumer's perspective (Harper & Makatouni, 2002; Frewer et al., 2005; Maria, 2006) or focused on farmer perceptions on welfare at the farm (Boogaard et al., 2006; Kauppinen et al., 2006; Vanhonacker et al., 2008). Very little has been done on the perceptions of farmers on welfare of slaughter

animals from point of loading to point of slaughter and how it affects the quality of meat, yet they are at the first end of meat production and distribution, in addition to having a significant influence on the background of meat animals. The objective of the current study was therefore to determine the perceptions of livestock farmers on meat quality and how it is affected by slaughter animal welfare. The null hypothesis tested was that farmers perceive animal welfare as not having an effect on meat quality.

3.2. Materials and Methods

3.2.1. Description of the study sites

The study was conducted on 32 farms surrounding the rural town of Adelaide, Amatole District Municipality in the Eastern Cape Province of South Africa. The area is located 32.8^0 S and 26.9^0 E. It has vegetation that ranges from grasslands and thicket to forests and bush veld with *Acacia karroo, Themeda triandra and Digitaria eriantha* being the most dominant plant species. The place receives approximately 480 mm of rainfall per year, most of which falls during the summer months. It is situated in the semi-arid False Thornveld of the Eastern Cape. The mean temperature of the area is about 21.5^0 C and the topography of the area is generally flat with few steep slopes. The farms were of various sizes and those less than 200 hectares in size were classified as small scale commercial while those greater than 200 hectares were classified as large scale commercial. In this study, extensive farming referred to those situations where cattle spend a substantial part of each day outdoors, with minimal human contact and obtained most of their nutrients from pasture. Intensive farming was practiced by farmers who had less than 200 hectares of land, had more conduct with their cattle and practiced pen fattening e.g. feedlots.

3.2.2. Selection of the farmers

Selection of the farmers was done in two stages. The first stage involved selecting farmers using details that were provided by the management of Adelaide Municipal Abattoir. The farmers selected at this stage were directly involved in managing the farm and were also the principal decision makers. The selection was also on the basis that the farmers were regular suppliers of cattle and sheep to the abattoir. A total of 32 farmers were selected. The second stage involved use of the snowball sampling technique with the 32 farmers recommending other family members who usually assist in running the farm and are also decision makers. Each farmer recommended two family members, to make a total of 64 recommended farmers.

3.2.3. Data collection

Data was collected using a survey questionnaire. A total of 96 questionnaires were administered to 96 farmers. The questionnaires were administered with the help of the abattoir manager and employees in the Department of Agriculture. All the questionnaires were completed and returned. The structured questionnaire used in this study captured information such as farm characteristics, cattle breeds and numbers kept and reasons for keeping the breeds. The farmers' demographic information, such as educational qualifications and their link to farming and animal welfare were also captured. Aspects on animal welfare and meat quality were assigned to one of the following dimensions: human-animal relationships; selection and handling of animals for market or slaughter; transportation and slaughter and meat quality attributes. For each aspect, the farmers were requested to indicate its perceived importance for obtaining an acceptable level of slaughter welfare or meat quality (perceived importance) (Vanhonacker et al., 2008). All dimensions were probed on a five-point Likert scale: 1= totally unimportant to 5 = very

important (Vanhonacker et al., 2009). Perceived mean scores were determined and were used to determine importance of each aspect. Aspects with mean scores below 2.5 (neutral point of the scale) were considered as not important while those with mean scores above 2.5 were considered as important.

3.2.4. Statistical analyses

Frequencies for farmer profile and perceptions were determined using PROC FREQ procedures of the Statistical Analyses Systems (SAS) (2003). Mean perceived importance scores were determined using PROC MEAN procedure of SAS (2003). A chi-square test of SAS (2003) was computed to determine associations between age, gender, educational qualifications, farming training, animal welfare training, farm residence, reasons for keeping breeds, farming system and perceived dimensions.

3.3. Results

3.1. Farmer demography and farm characteristics

Most farmers owned large scale commercial farms and practiced extensive cattle farming as shown in Table 3.1. Most of the farmers were male and were over 51 years of age. The farmers had some basic education and more than 50% of them had gone through matriculation. Regarding training in livestock production or animal welfare after leaving school, the most common form of training was short courses, which was the highest level of training achieved by 20 and 18% of farmers respectively. The majority of the farmers (78%) resided at their farms. The farmers kept different cattle breeds at the farms and 56% of the farmers indicated meat quality related reasons (good temperament and production of tender meat) as the reasons for

Table: 3.1. Demographic characteristics of farmers

Characteristic	Frequency	Percentage
Age		
30-40	25	26.04
40-50	20	20.84
≥51	51	53.12
Gender		
Males	56	58.33
Females	40	41.67
Animal production training		
Yes	19	19.79
No	77	80.21
Animal welfare training		
Yes	17	17.71
No	79	82.29
Educational Background		
< Grade 12	4	4.2
Grade 12	49	51
Professional qualification	16	16.7
Degree	27	28.1
Farmer resident at farm		
Yes	75	78.1
No	21	21.9
Farm type		
Small scale commercial	11	34.4
Large scale commercial	21	65.6
Farming system		
Extensive	21	65.6
Intensive	11	34.4
Reasons for keeping their cattle breeds		
Good quality meat	29	30.2
Good temperament	25	26
Good mothering ability	42	43.8

making breed choices. Good mothering ability was given by 44% of the farmers as the reason for keeping the breeds they had.

3.3.2. Perceived importance on meat quality attributes

The farmers' perceptions on the importance of meat quality attributes that are important to consumers and producers are shown in Figure 3.1. The mean perceived importance scores ranged from 1.41 (marbling) to 3.5 (colour of the meat). The following aspects were regarded as important (in order of highest score to lowest score): meat colour, carcass class, freshness, tenderness, smell of meat, flavour, price, texture and juiciness of meat. The following aspects were considered not important: bruising, leanness and marbling.

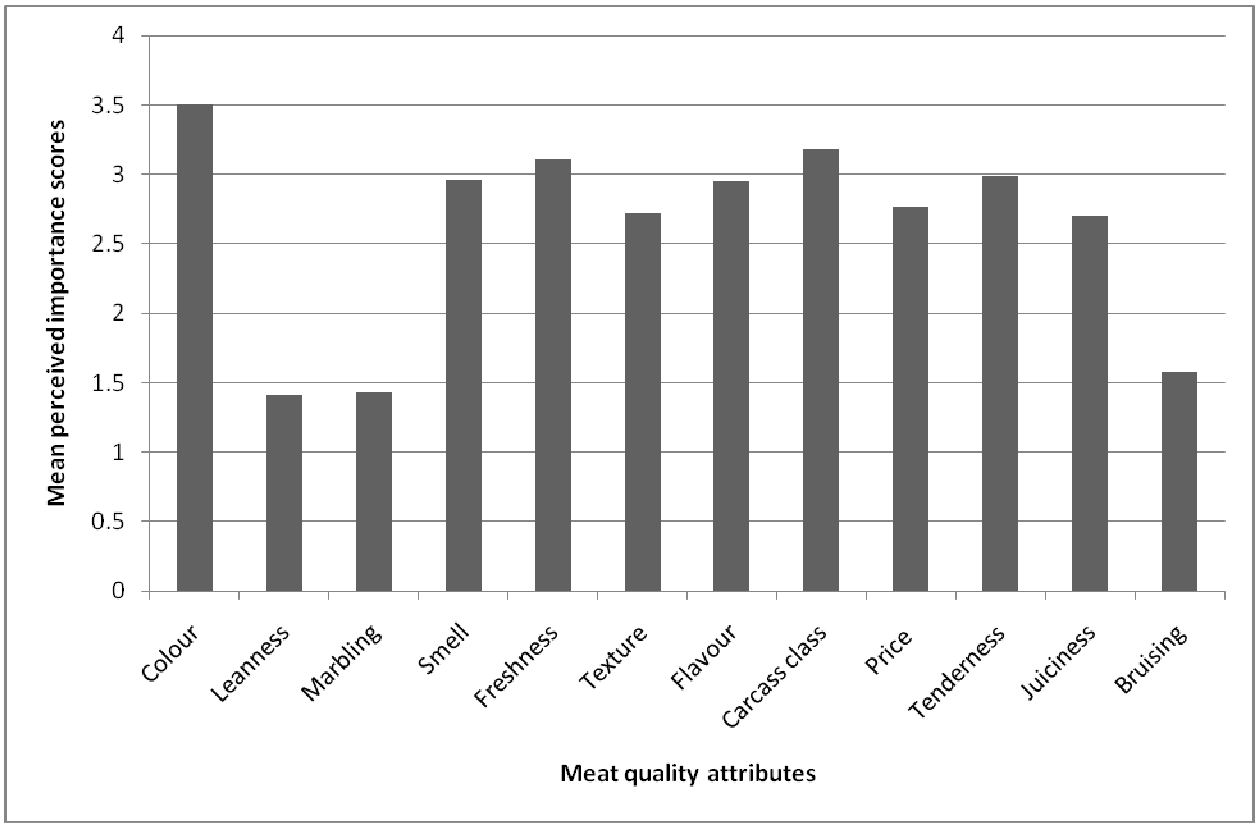

Figure 3. 1: Farmer perceptions on the importance of meat quality attributes

3.3.3. Perceived importance of human- animal relationships

The perceptions of farmers on the importance of human-animal relationships on animal welfare and how they affect meat quality are shown in Figure 3.2. The mean perceived importance scores for this dimension ranged from 1.43 (hand rearing of calves) to 2.5 (handler to animal ratio). The only aspect that was considered as important was the ratio of handlers to animals at the farm. Aspects that were considered as not important were: respect for animals, farmer animal bond, trained animal handlers, routine animal handling and hand rearing of calves.

3.3.4. Handling of slaughter animals at the farm

Farmers' perceptions on importance of animal handling on animal welfare and how it affects meat quality are shown in Figure 3.3. The mean perceived scores for this dimension ranged from 1.25 (time between selection and loading) to 3 (animal handling/ loading facilities). Aspects that were considered as important were: animal handling/ loading facilities, animal marketing channel, loading method, animal body condition at loading, experienced driver, farmer presence at loading and dehorning. The time taken between selection of slaughter animals and loading was the only aspect that was considered as not important.

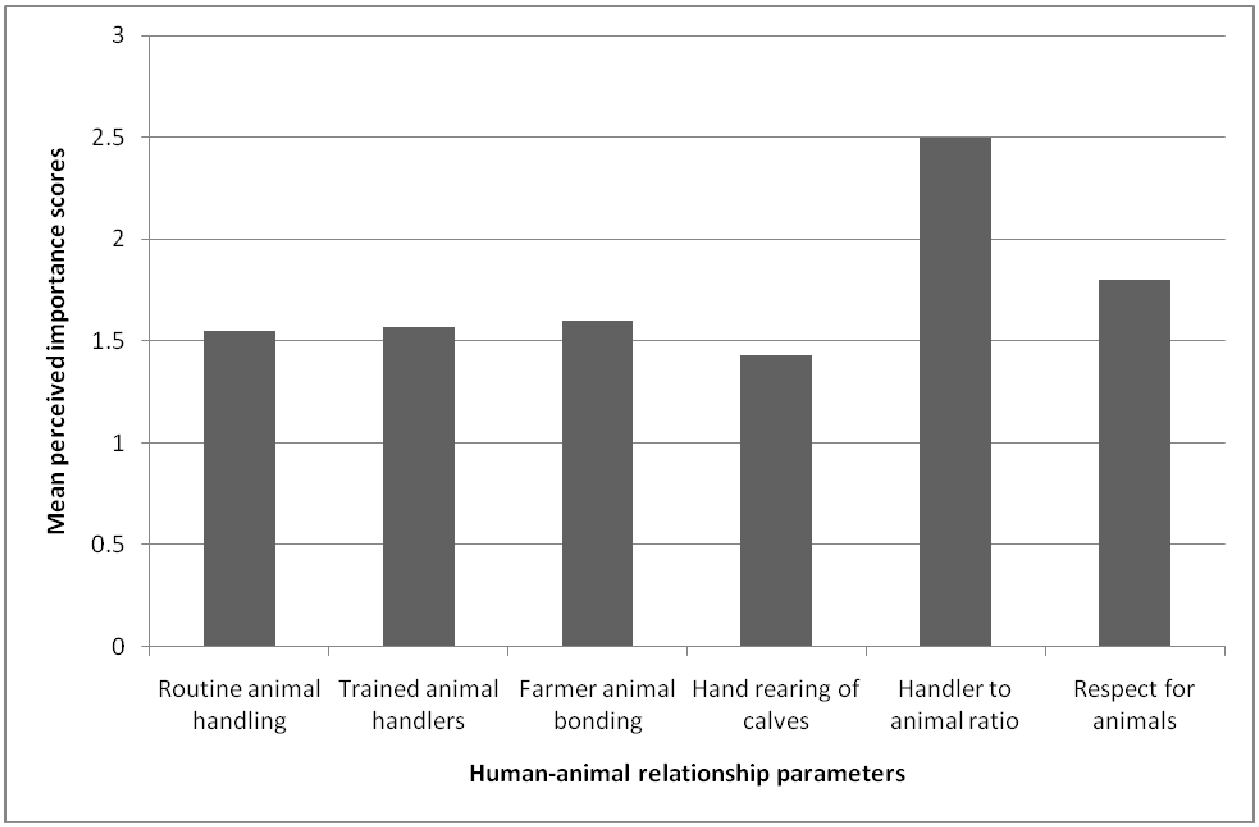

Figure 3. 2: Farmer perceptions on importance of human-animal relationships on animal welfare and meat quality

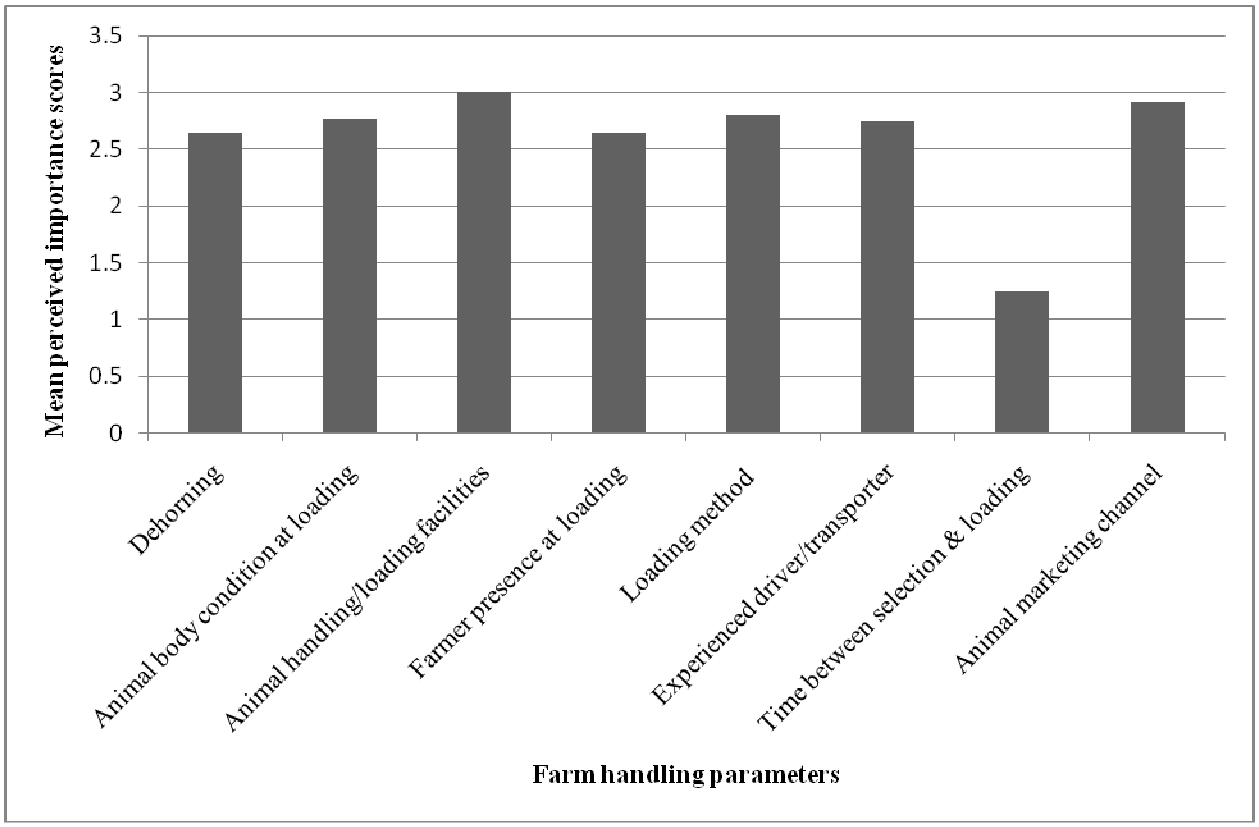

Figure 3. 3: Farmer perceptions on importance of handling of slaughter animals at the farm and their marketing

3.3.5. Perceived importance on transportation and slaughter

The mean perceived scores ranged from 1.28 (mode of transport) to 2.83 (farm to abattoir distance) (Figure 3.4) Aspects that were considered as important were: distance from farm to abattoir/market, number of transports, hunger during transport, thirst during transport, loading density, shock proof / calm transport, and vehicle condition. Aspects that were considered as not important were: mixing strange animals during transport, duration of transportation, condition/ road type, weather during transport and mode of transport.

Farmer perceptions on importance of slaughterhouse/abattoir practices on welfare of slaughter animals are shown in Figure 3.5. The mean perceived importance scores ranged from 1.41 (slaughterhouse design) to 2.89 (slaughter method). The aspects that were considered as important were: slaughter method, unloading method, lairage duration and stunning method while aspects that were considered as not important were: mixing of strange animals in the lairages, method of animal droving to stunning box or to loading trucks and slaughter house design.

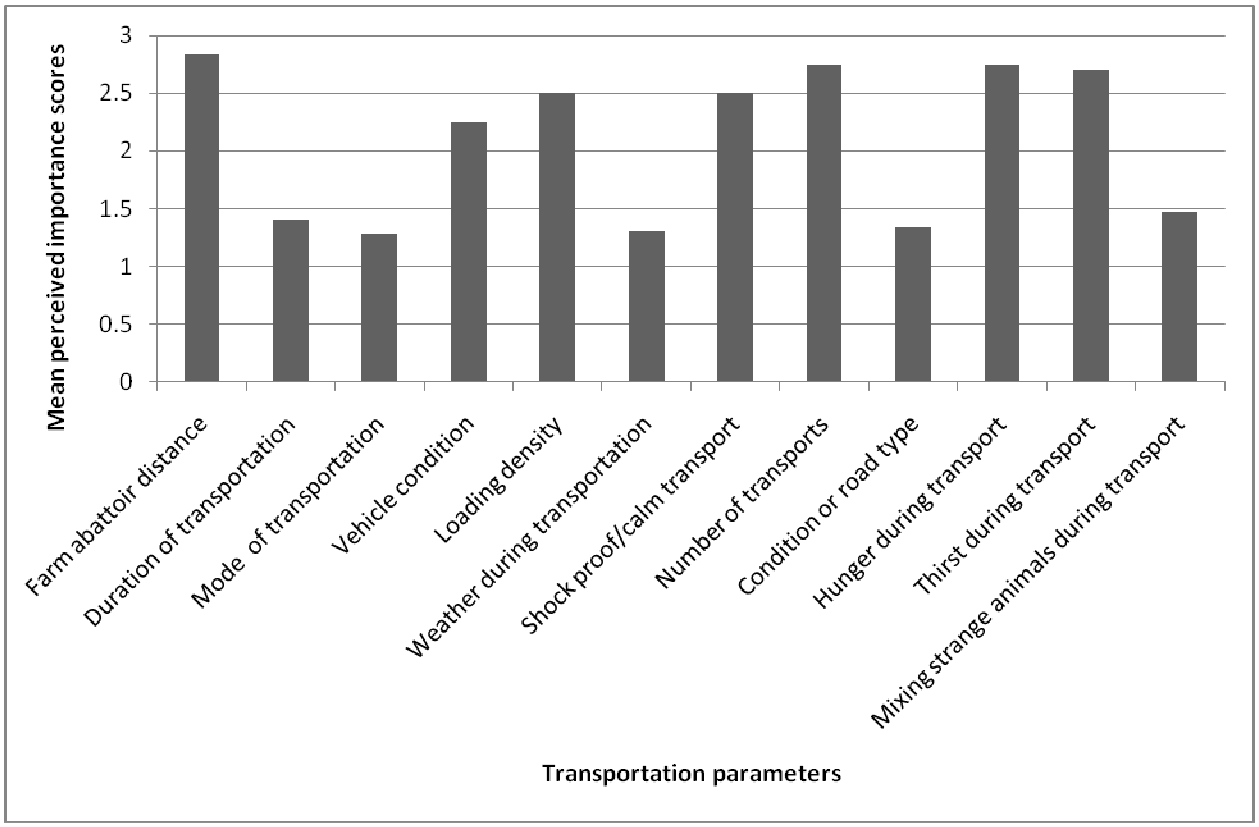

Figure 3. 4: Farmer perceptions on transportation and its effects on animal welfare and meat quality

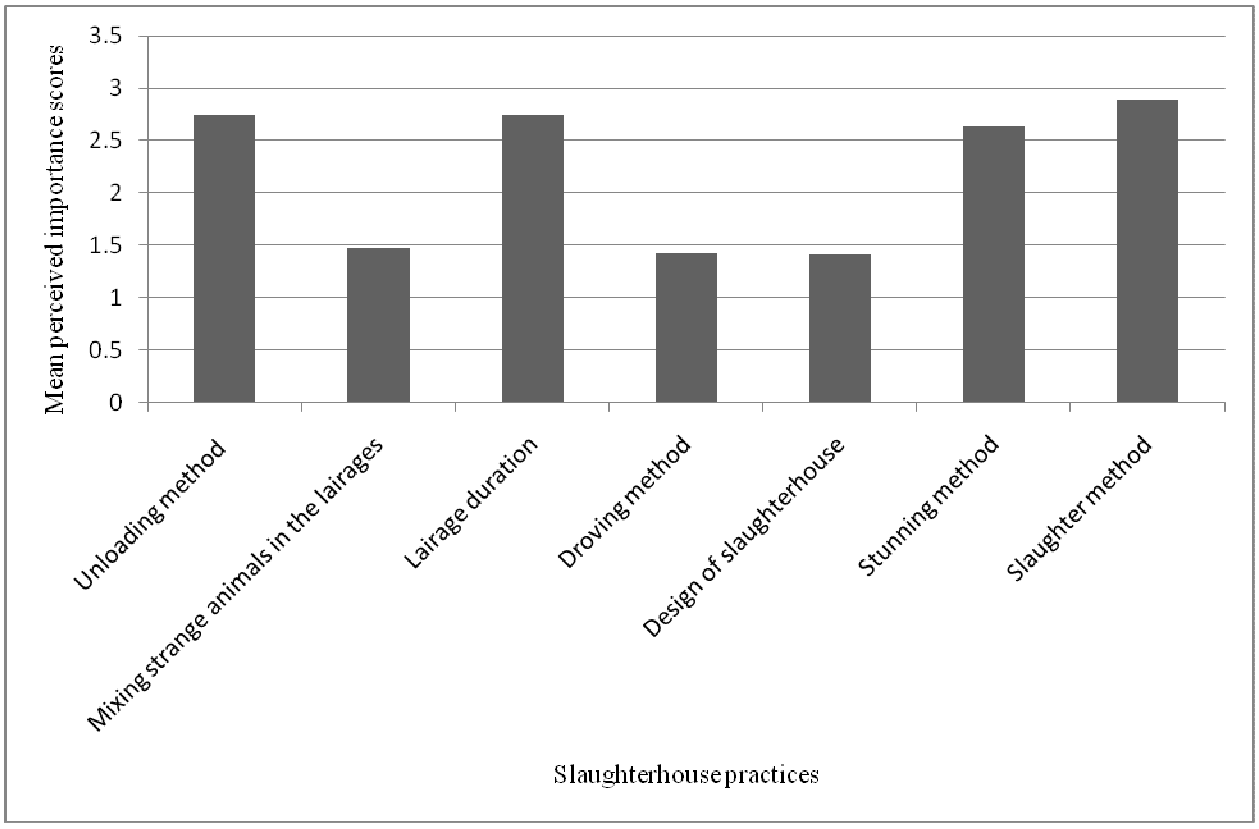

Figure 3. 5: Farmer perceptions on slaughterhouse practices and their effects on animal welfare and meat quality

3.3.6. Transportation and bruising

Almost all farmers agreed that transportation causes injury and bruising to animals. More than half of the farmers were not aware that bruising has negative effects on carcass class. Complains from the abattoir on bruising were received by 68% of the farmers while 65% of the farmers indicated they were aware that they can lose a lot of money through bruising.

3.3.7. Associations

There was an association ($P < 0.05$) between gender (female farmers) and the following aspects: farmer-animal bond, hand rearing of calves, animal respect and colour. Age was ($P< 0.05$) associated with the following aspects: farmer- animal bond (age category 30-40 years) and routine handling of animals (age category 30-40 years). Educational qualification was associated ($P < 0.05$) with the following aspects: loading method, farmer –animal bonding (grade 12), slaughterhouse design (degreed farmers). Animal welfare training was associated ($P < 0.05$) with respect for animals. Farm system was associated ($P < 0.05$) with presence of standard animal handling facilities (extensive farming/ large scale farms) and dehorning (intensive farming/ small scale farms)

3.4. Discussion

The finding that there were more male farmers concurs with an earlier finding (Rumosa Gwaze, et al., 2009) that reported that men are, by nature, heads of households or farms in many farming systems in Sub-Saharan countries. Decisions pertaining to agriculture, regardless of whether the farmer is resident at the farm or not, are made by men (Rumosa Gwaze et al., 2009). The presence of female farmers had a positive influence on animal welfare since women are

generally regarded as having more affection for animals than men (Kellert, 1996). The high proportion of farmers who were at least 50 years old could mean extensive experience and knowledge in livestock farming. Such aged farmers might also have problems in adapting to new changes or requirements in animal welfare (Rumosa Gwaze et al., 2009). Younger farmers are more likely to adapt to new changes faster than old farmers and their age may also influence their perceptions on animal welfare (Kendall et al., 2006). The lack of proper training in animal production or animal welfare may be compensated for by the fact that the majority of the farmers were brought up at the farms where they resided and had some experience on animal production and welfare. Since most of the farms were extensively farmed, cattle welfare at these farms was generally good since the animals have a greater freedom to express their normal behavior pattern (Mathews, 1996). However, the major meat production related disadvantage with the system is that of little conduct between the animals and the farmer. Extensively reared cattle, because of minimal conduct with humans, can react negatively to the slightest human conduct (Grandin, 1997) and may suffer more psychological fear during loading as compared to those intensively reared (Fisher et al, 2009). The major reasons cited by the farmers for keeping their breeds were related to meat quality and this may reflect the experience of the farmers in cattle farming.

The fact that the farmers correctly perceived meat quality attributes that are important in influencing purchasing decisions can be explained by the duality of roles, as consumers and as producers. The following attributes were perceived by the farmer as a consumer: colour, smell, tenderness, juiciness, freshness and texture while the following attributes might have been perceived at producer level: carcass class, price, and bruising. The finding that female farmers perceived colour to be significantly more important than did male farmers concurs with findings

by Jocumsen (2005). The colour of meat is an important factor since it is a visual measure of freshness and quality (Faustman & Cassens, 1990). Although the female farmers, in their role as consumers, might have perceived meat colour as important, it is also important to note that farmers play an important role in influencing meat colour. Factors that influence meat colour such as diet, slaughter age and pre-slaughter conditions (Muchenje et al., 2009a) can be controlled at farmer level if the later correctly perceives the importance of colour in meat quality. The fact that farmer age was significantly associated with some animal welfare aspects such as routine handling and farmer- animal bonding can be explained by the influence of basic animal production and animal welfare training that the young farmers have. This finding concurs with Nibert (1994) and Ohlendorf et al. (2002) who report that adults in their thirties or younger are most concerned with animal well-being. The experience in livestock farming that the older farmers have might be responsible for the significant association between this age group and the need for experienced drivers when transporting animals.

The fact that farmers generally had low perceptions of farmer- animal relationships can be explained by the fact that most farms are large scale and extensively farmed, with less need for contact with animals. This is not in agreement with Lensink et al. (2001) who found that livestock that are accustomed to close contact with people are calmer and less stressed by handling than livestock that seldom see people. It may therefore be beneficial to familiarise livestock with human handlers on a regular basis to reduce the stress of handling at (un) loading and in novel environments. As correctly perceived by the farmers, the presence of well designed and maintained facilities for handling and loading livestock is critical for promoting smooth animal flow, minimizing stress and reducing unwanted injuries. With proper handling facilities,

animals can become habituated to non-painful handling procedures such as weighing (Peischel et al.,1980; Grandin, 1989). However, animals do not habituate to severely aversive procedures (Ndou et al., 2010) as well as poor handling facilities (Hargreaves & Hutson, 1990; Coppinger et al., 1991). Dehorning of cattle, as correctly perceived by the farmers, is important. Dehorned cattle require less feeding space, are easier and less dangerous to handle and transport and cause less injury to other cattle (Vickers et al., 2005). Horns are the single major cause of carcass wastage due to bruising, thus causing serious financial losses to the farmers (Kihurani et al., 1989).

The farmers' general perceptions on animal handling and perceived as important their presence during loading and proper choice of marketing channel According to Smith and Grandin (1999), about 80% of the aspects that contribute to poor meat quality occur before the cattle reach the abattoir, and it is during this period that the farmer's input is greatest. It is important that the farmer selects animals that are physically fit for transport, and should not allow his animals to deteriorate in condition before transport. For beef cattle, timely marketing is important (Grandin 2000). The choice of market has a bearing on meat quality since the final destination of animals influences transportation distance, duration and amount of handling. According to Fergusson and Warner (2008), more handling, transportation and delays between farm and abattoir occur to animals sold through markets. Aspects such as waiting period between selection and transportation, choice of transporter and farm loading standards may have been considered as not important simply because the farmers lacked knowledge on their role in meat quality.

The fact that the farmers perceived distance between the farm and abattoir or market as important, may have been influenced, by financial reasons. The farmer's interests are more economically driven and centered on financial concerns and the need to make a living (Vanhonacker et al., 2008). However, according to Ibáñez et al. (2002), long transportation distance has negative effects on animal welfare and meat quality.

Farmers' experience on difficulties in loading extensively farmed cattle could have influenced their perceptions. Extensively farmed cattle are difficult to load, and according to Tennessen et al. (1984), loading such cattle is more stressful and disturbing than the truck ride itself. This is also supported by Maria et al. (2004) who say that loading is more stressful than unloading, with more adverse effects on animal welfare. Contrary to farmers' perceptions on weather, hot weather, humidity and cold winds are deadly to pigs during transportation while cattle and sheep are affected by temperatures near freezing (Grandin, 1981). The majority of the farmers in the study are cattle and sheep farmers, these species are not affected by high temperatures conditions like pigs, therefore the farmers may be having a knowledge deficit on effects of high temperatures.

3.5. Conclusion and recommendations

Based on perceived mean scores above the neutral point of the scale, it can be concluded that livestock farmers perceive slaughter animal welfare as affecting meat quality. Training in welfare of slaughter animals and farm animal welfare in general is needed, probably targeting the younger generations within the farming communities. The aspects used in this study may not have been exhaustive enough to determine the real level of perception of slaughter animal

welfare by the farmers, therefore further studies that separate farmers on the basis of farmed livestock species, size of farm and farming system are recommended. However it is important to evaluate the perceptions of the farmers by determining the effects of marketing channel on bruises, pH and colour of beef from the cattle they supply to a smallholder abattoir.

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Chapter 4: Effect of marketing channel on bruises, pH and colour of cattle slaughtered at a smallholder abattoir

(This manuscript has been submitted to *Tropical Animal Health and Production)*

By Peter Vimiso

Abstract

The effect of marketing channel on bruising, ultimate meat pH (pH_u) and colour in cattle was determined. Marketing channel had significant effects on bruise score, bruise age, pH and L* values ($p < 0.05$). Animal class and distance were significantly associated with bruise scores. Bruise age was significantly associated with marketing channel. Bruising was significantly associated with pH_u and L* values. There were significant ($P < 0.05$) correlations between pH_u and L*, a* and b*values, ($r = -0.45$) and ($r = -0.59$ and -0.55 respectively), pH_u and bruise score ($r = 0.34$) and L* and bruise score ($r = -0.24$). There were positive relationships between distance and pH_u and between distance and bruise score, while the relationship between L* and distance was negative. About 31% of the carcasses had pH_u values > 5.8 and L* values less than 33 and were classified as DFD. There were differences in meat quality due to marketing channels with cattle transported direct from farms having the highest bruise scores, pH_u and the lowest L* values. Cattle that passed through the market had a bruise prevalence of 63.1% while those transported directly from the farm had a bruise prevalence of 51.1% and those hoofed had a bruise prevalence of 41.1%

Key words: bruises, marketing channel, hoofing, ultimate meat pH, meat colour, animal welfare, smallholder abattoir

4.1. Introduction

The meat supply chain is an important aspect in the farming and meat industry that includes various critical stages such as transportation, (un) loading and slaughter of the animals (Ali et al., 2006; Ljunberg et al., 2007; Tadich et al., 2009). The farmers as concluded in Chapter 3 perceived slaughter animal welfare as not affecting beef quality. Furthermore, they perceived marketing channel as important in determining quality of beef at slaughter. There is however no information on the quality of beef from the cattle they supply to the smallholder abattoir. Many farmers have developed intermediate stages in the chain, thus making the process dynamic and often complicated. In South Africa, cattle are marketed through a number of channels, with selling through butcheries, auctions and abattoirs playing a leading role (Musemwa et al., 2007). The use of auction markets, holding farms or feedlots often exposes the animals to stressful conditions and a breach to animal welfare (Jarvis et al., 1996; Geesink et al., 2001; Wright et al., 2002; Ferguson & Warner, 2008), often resulting in bruises (Strappini et al., 2010).

A bruise can be defined as a tissue injury with rupture of the vascular supply and accumulation of blood and serum (Hoffman et al., 1998; Gracey et al., 1999) and can occur at the farm, during transportation, at the market or at the slaughter house (Jarvis et al., 1995). The distribution of the bruises and their frequency in certain sites is mainly indicative of transport, (un) loading and lairage practices since these are more likely to harm animals (Grandin, 1991; Jago et al., 1996).

Transportation of animals may vary depending on the source of the animals and in South Africa, cattle that are sold at auction markets can either be transported straight to the slaughterhouse for direct slaughter or they can be taken to farms or feedlots where they are held before release for

slaughter (Coetzee et al., 2004; Musemwa et al., 2008). The various transportation methods imparts different degrees of bruising and findings by McNally and Warris (1996); Weeks, McNally and Warriss (2002) showed higher bruises in cattle sourced directly from the auction markets than in cattle sourced directly from the farm. Eldridge et al. (1984) also reported that cattle transported directly from a farm to a slaughterhouse had significantly smaller and fewer bruises than cattle sourced through a livestock market. Contrary to these findings, Horder et al., (1982) reported no significant difference between the bruise scores of animals slaughtered after transport direct from farms and those from livestock markets, although bruise distribution was different.

Bruised cattle are stressed and are expected to produce abnormally high pH because of glycogen depletion and the subsequent lower production of lactic acid in the muscles (Kannan et al., 2002). The high pH apart from favours microbial growth, development of DFD beef and reduction of shelf life of meat (Chambers et al., 2004) and this condition is measured by L^* coordinates (Commission International De I' Eclairage, 1976). Beef with pH_u above 6.0 presents with many quality problems such as dark red colour, toughness, increased water holding capacity and poor palatability (Silva et al., 1999; Viljoen et al., 2002; Wulf et al., 2002; Apple et al., 2005; Mounier et al., 2006; Muchenje et al., 2009a).

The South African meat industry is serviced by slaughterhouses of various classes with low throughput/smallholder abattoirs playing a significant role. Information from smallholder abattoirs regarding effects of marketing channel and transportation mode on bruising and meat quality is limited. Also limited is the use of bruise aging to predict the time of occurrence of

bruises and the relationship between bruised carcasses and the development of pH, colour and DFD beef. The objective of the study was to determine carcass bruising based on data from observations at the abattoir and to quantify its relation with animal characteristics, seasonal conditions, marketing channel and mode of transportation. The association between presence of bruises and carcass pH was assessed, pH being a proxy for beef quality. Bruise colour changes were used to estimate the age of the bruise and relate it to mode of transport, source of the cattle and possible place of bruising along the transport chain. The null hypothesis tested was that marketing channel does not have effects on bruising, beef ultimate pH and colour.

4. 2. Materials and Methods

4.2.1. Site description

The study was conducted at Adelaide municipal abattoir (32.8^0 S and 26.9^0 E) in the rural town of Adelaide (Nxuba local municipality), Amatole District Municipality in the Eastern Cape Province of South Africa. The abattoir is classified as low throughput. The area has vegetation that ranges from grasslands and thicket to forests and bush veld with *Acacia Karroo, Themeda triandra and Digitaria eriantha* being the most dominant plant species. The place receives approximately 480 mm of rainfall per year of which most of it falls during the summer months. It is situated in the semi-arid False Thornveld of the Eastern Cape. The day temperature ranges for the period of study were 8º C to a high of 35º C with a mean temperature of about 21.5^0 C. The topography of the area is generally flat with few steep slopes.

4.2.2. Data collection

The study was based on data collected from the abattoir and therefore will not be considered as an experimental study. Data was collected from153 cattle between June 2009 and July 2010 from cattle that came for slaughter at the low throughput abattoir. Three groups of cattle were identified depending on their marketing history and mode of transport to the abattoir. Group 1 had cattle that were walked to the abattoir from feedlots or holding farms close to the abattoir. Their history included transportation by road from various farms to the auction markets and further transportation from the auction markets to holding farms for the farmer or meat trader's convenience. Group 2 had cattle that were transported by road from various farms to auction markets and then directly to the abattoir and Group 3 consisted of those cattle that were transported by road directly from the farms to the abattoir.

4.2.2.1. Transport

The truck carrying the cattle was identified, with the number of cattle loaded in the truck and trailer being counted. Dimensions of the truck or trailer were taken and the floor area calculated in m^2. The stocking density was then calculated by dividing the floor area by the number of cattle in the truck or trailer and the density was expressed as animal/ m^2. The departure times from the farms, feedlots/ holding farms or auction markets and arrival times at the abattoir for each of the three groups were recorded. Transportation durations for each group were then calculated as a difference between arrival time and departure time. The transportation distances from source to the abattoir for groups 1 and 2 were obtained from the transport vehicles while the distances walked/ hoofed from feedlots/holding farms were obtained by walking the cattle through routes

with predetermined distances. The average daily temperature during transportation was obtained from Adelaide town weather records. All these records were captured using a record sheet.

4.2.2.2. Cattle identification and treatment at the abattoir

Data on the source (farm, feedlot or auction market), breed and animal class was recorded on arrival. The majority of cattle that came for slaughter were Angus with other small numbers from Bonsmara, Nguni or crossbreeds. Data corresponding to breed was classified into two groups: Angus and other breeds. On arrival the cattle were put in holding pens with cattle from the same truck occupying the same pen and were rested for about an hour before slaughter. Cattle that came by walking arrived at the abattoir a day before and were housed overnight before slaughter. This was done by management for administrative purposes. During lairage, cattle received water but were not given any food and were kept in pens with standard conditions for slaughter houses: 2 m^2 per animal, under roofed pens with a concrete floor. The cattle were also identified by animal/sex class as either cows, oxen, bulls, heifers or steers. The cattle were slaughtered after stunning by a captive bolt, suspended by a hind leg, and exsanguinated and inspection was done by a qualified meat inspector. This procedure conforms to the commercial standard for cattle slaughter (Muchenje et al., 2008).

4.2.2.3. Measurements on carcasses

The dressed carcass included the body after removing the skin, the head at the occipito-atlantal joint, the fore-feet at the carpal-metacarpal joint, the hind feet at the tarsal-metatarsal joint and the viscera (Muchenje et al., 2008). Hot mass for each carcass was measured before meat inspection and carcass trimming was done, fat cover and age were measured using the SAMIC

standards (South African Meat Industry Company). The carcass classification system in South Africa considers age (A= 0 teeth, AB= 1 to 2 teeth, B= 3 to 6 teeth and C= more than 6 teeth) and fatness scale 0 to 5, with 0 = no visual fat cover, 1 = very lean, 2= lean, 3= medium, 4 = fat, 5 = over fat and 6 = excessively over fat) (South African Meat Industry Company (SAMIC), 2006).

4.2.2.4. Bruise measurements

Only carcasses that were presented with bruises were considered. The assessment was done using a method based on the Australian Carcass Bruise Score System (Anderson & Horder, 1979). After dressing, the carcasses were examined and the size and colour of every bruise was recorded. The maximum diameter was estimated as little (< 2cm), slight (2-8 cm), medium (8-16 cm) or heavy (> 16cm). Bruise scores were calculated for each load by multiplying the number of bruises in each size class by a weighting factor: slight 1, medium 3, and heavy 5, and adding these values (Anderson & Horder, 1979). These bruise scores were then divided by the number of cattle per load to give a mean bruise score per animal for each load. Bruise age was estimated using the method of Gracey et al. (1999) as described in Table 4.1.

Table 4. 1: Colour observations used to estimate the age of bruises.

Observable colour of the bruise	Estimated age of the bruise in hours
Red and hemorrhagic (bright-red)	0-10 hours old
Dark- red colour	Approximately 24 hours old
Watery consistency	24-38 hours
Rusty orange colour, soapy to touch, clear yellow mucus	+72 hours (3 days old)

Gracey et al. (1999)

4.2.2.5. pH measurements

Measurement of pH was done in the *Longissimus dorsi* muscle at the level of the 10th rib, approximately 24 hours after slaughter in carcasses that were refrigerated at 0 – 3 ^{o}C. The measurement was carried out using a portable pH meter (CRISON pH25, CRISON Instruments SA, Spain). The pH meter was calibrated using pH 4, pH 7 and pH 9 standard solutions (CRISON Instruments, SA, Spain) before each day's measurement. After measurements, the carcasses were classified as normal, pH < 5.8 or as DFD beef (pH ≥ 5.8) (Viljoen et al., 2002).

4.2.2.6. Determination of colour

Colour of the meat (L* = Lightness, a* = Redness and b* = Yellowness) was determined in the longissimus dorsi 24 hours after slaughter using a colour-guide 45/0 BYK-Gardener GmbH machine, with a 20 mm diameter measurement area and illuminant D65-day light, 10º standard observer. Three readings were taken by rotating the Colour Guide 90º between each measurement, in order to obtain a representative average value of the colour. The guide was calibrated before each day's measurements using the green standard.

4.3. Statistical analysis

The effect of marketing channel on bruises, pH and colour was analysed using the General Linear Model (PROC GLM; SAS, 2003). The proportion of carcasses with potentially DFD beef and the prevalence of bruises by channel were determined using the frequency procedure (PROC FREQ; SAS, 2003). A chi-square-test was conducted to test for association between marketing channels and bruise age. Significant differences between least- square group means were analysed using the PDIFF test of SAS (2003). A regression analysis was done to determine the relationship of varying distances, stocking density (groups 2 and 3), transportation duration and

day temperature on bruise score, bruise age, pH_u and colour (PROC REG; SAS, 2003), while correlations were done for the relationship between channel and other meat quality related data and between pH and Colour (PROC CORR; SAS, 2003).

4.4. Results

Main descriptive statistics for the variables studied are presented in Tables 4.2 and Table 4.3. All the carcasses that were evaluated were bruised, and all of them had been transported at some stage before slaughter. Cattle that were transported from the farm to the abattoir contributed 30.7 % while those walked from the farm to the abattoir were 42 % and those transported from market to abattoir were 26.8% of the total evaluated (Table 4.2). Cattle that were walked had the oldest bruises, 92.4 % were older than 10 hours, while cattle that came from the market had 66 % of the bruises aged less than 10 hours and those transported direct from the farm had 72 % of bruises less than 10 hours (Table 4.3). Bruise age was significantly associated with channel ($p < 0.05$). Meat pH_u was greater than 5.8 for 31 % of the carcasses, while 71% of the carcasses had L* greater than 33 and were classified as normal beef. Carcasses that were classified as DFD beef (L* < 33) were 31 % of the total evaluated (Table 4.2).

Several factors affected ($P < 0.05$) bruising and meat quality. Channel affected bruise score, pH_u and L*, (Table 4.4) while animal class affected bruise score (Table 4.5). From the regression analysis, a significant positive linear effect of distance, stocking density and transportation duration on bruise score and pH_u was observed, while a significant negative linear effect of distance, stocking density and transportation duration on L* was observed (Table 4.6). There was also a significant positive linear effect of transportation duration on bruise age (Table 4.6) .There

Table 4. 2: Frequencies for the categorical independent variables used in the analysis.

Item	Total observation	n	Frequency %
Animal	153		
Animal class			
Cows		76	49.7
Oxen		49	32.0
Bulls		13	8.5
Heifer		7	4.6
Steers		8	5.2
Breed type			
Angus		96	62.74
Any other		57	37.26
Carcass characteristic			
pH_u of longissimus dorsi			
$pH_{24} \geq 5.8$		47	30.7
$pH_{24} < 5.8$		106	69.3
Fatness			
Lean		2	1.3
Medium		33	21.6
Fat		69	45.1
Slightly over fat		43	28.1
Excessively over fat		6	3.9
Age			
1-2 Teeth		37	24.2
3-6 Teeth		91	59.5
More than 6 Teeth		25	16.3
Bruise age			
<10 hours		80	52.3
10-24 hours		31	20.3
24-38 hours		21	13.7
+ 72 hours		21	13.7
Colour (L^*)			
< 33.0		47	30.7
>33.0		106	69.3
Channel			
Channel 1		65	42.5
Channel 2		41	26.8
Channel 3		47	30.7

Table 4. 3: Distribution of bruise age by marketing channel.

	Channel 1	Channel 2	Channel 3
Bruise Age	%	%	%
< 10 hours	7.69	65.55	72.34
10- 24 hours	29.32	31.71	27.66
24-38 hours	30.77	2.44	0
+ 72 hours	32.31	0	0

Table 4. 4: Least square means and standard errors of means of bruise score, pH and colour from the three different marketing channels

	Meat quality variables		
Channel	Bruise score	pH_u	Colour (L^*)
3	10.70 ± 1.045^a	5.90 ± 0.050^a	35.93 ± 0.970^b
2	8.60 ± 1.065^a	5.78 ± 0.050^b	38.16 ± 0.989^a
1	6.45 ± 0.793^b	5.77 ± 0.038^b	37.50 ± 0.737^a

[ab]Means in the same column with different superscripts are significantly different at $p < 0.05$

Table 4. 5: Least square means and standard errors of means of bruise scores for the different animal classes

	Meat quality variables		
Animal class	Bruise score	pH_u	Colour (L^*)
Cow	11.01 ± 0.774^{a}	5.86 ± 0.037	36.22 ± 0.718
Ox	8.74 ± 0.886^{ab}	5.83 ± 0.042	36.38 ± 0.822
Bull	5.12 ± 1.482^{b}	5.70 ± 0.071	38.98 ± 1.376
Heifer	8.48 ± 1.722^{b}	5.84 ± 0.082	37.19 ± 1.599
Steer	9.53 ± 1.655^{a}	5.86 ± 0.079	37.22 ± 1.536

[ab]Means in the same column with different superscripts are significantly different at $p < 0.05$

Table 4. 6: Relationship between transportation variables and bruise score, pH_u, L*, and bruise age.

Parameter	Variable	Relationship	Regression equation	Significance
Bruise score	Distance	Linear	Y =7.16(0.422) + 0.05(0.007) X	*
	Stocking density	Linear	Y= 9.44(1.126) + 0.26(0.214) X	*
	Transport time	Linear	Y= 3.87(1.550) + 1.35(0.303) X	*
	Day temperature	NS		NS
pH_u	Distance	Linear	Y = 5.80(0.020) + 0.001(0.002) X	*
	Stocking density	Linear	Y = 5.80(0.040) + 0.021(0.008) X	*
	Transport time	Linear	Y = 5.62(0.066) + 0.053(0.013) X	*
	Day temperature	NS		NS
L*	Distance	Linear	Y = 36.98(0.375) – 0.023(0.006) X	*
	Stocking density	Linear	Y = 37.03(0.787) - 0.30(0.150) X	*
	Transport time	Linear	Y = 40.11(1.271) – 1.02(0.248) X	*
	Day temperature	NS		NS
Bruise age	Transport time	Linear	Y = 2.99 (0.382) + 0.169(0.075) X	*

*Significant at $P < 0.05$; Values in parentheses show the standard error, NS – not

was an association ($P < 0.05$) between channel and bruise age (Table 4.3).The were significantly high correlations between a* and b* values and pH_u (r = - 0.59 and -0.55 respectively) (Table 5.7). The bruise scores were higher in those cattle transported from the farm or market to the abattoir than those hoofed (Table 4.4). Cattle transported from the farm direct to the abattoir had significantly higher pH_u values than those either transported from market to abattoir or hoofed (Table 4.4). The L* values for cattle transported from farm to abattoir were significantly lower than those either hoofed or transported from market to the abattoir (Table 4.4).

Most bruises were found in cows, steers and oxen. Bruise scores were also highest in cows and steers and lowest in bulls and heifers (Table 4.5). Significant correlations were found between pH_u and L* (negative), pH_u and bruise score (positive), L* and bruise score (negative) (Table 4.7).

Bruise prevalence depended on the channel, with cattle that passed through the market having a prevalence of 63.1% while those that were transported directly from the farm to the abattoir had a prevalence of 51.1% and those that were hoofed/ walked had a prevalence of 41.1%.

Table 4. 7: Correlations among pH_u, L^*, a*, b* bruise score, carcass weight

	pH	L^*	Bruise score	a*	b*
pH_u		-0.45384 ***	0.33890 ***	-0.5936 ***	-0.5535 ***
L^*			-0.23743 ***	0.02123 ns	-0.04660 ns
Bruise Score				0.21786 ns	0.06990 ns
Carcass weight					-0.00472 ns

*** P < 0.05 ns- not significant

4.5. Discussion

Hoofed cattle contributed the highest number that passed through the abattoir during the period. These cattle were transported by road from different farms to the markets where the meat traders purchased them and then transported them by road to the holding farms. Since auction markets are held monthly and the purchased cattle are only slaughtered when there is demand, the cattle were kept for various time periods before they were slaughtered. The holding farms were about five kilometers from the abattoir and hoofing was found to be the most appropriate mode of transport. These cattle had the greatest number of dark and yellowish bruises and this reflected the history of the animals. Dark bruising is likely to be around 24 hours old while yellowish bruising is more than 72 hours old (Gracey et al., 1999). Although interpretation of the age of bruises based only on visual assessment is not precise, bruise age was found to be significantly associated with marketing channel or route of transportation in this study. The fact that cattle from farms had bruises that were less than 10 hours old meant that the cattle had recently been injured. The finding that bruise prevalence was highest in cattle that passed through the market was expected. This could be due to the increased amount of handling these cattle are subjected to. Weeks et al. (2002) and Strappini et al. (2010) found similar results. According to Gregory (1996) bruising is evidence of poor animal handling.

Bruising age is dependent on time between occurrence of the injury and the time of assessment. Bruise age had a positive relationship with transpiration duration, meaning that the more time it takes before assessment; the older will be the bruise. Considering the time taken from the farms for each group, the bruising must have occurred either during loading, transportation or at the abattoir (Strappini et al., 2009; 2010). Bruising can also occur as a result of impacts on falling

out of the stunning box or before exsanguination (Jarvis et al., 1995). The bruise age categories for cattle that came from the markets were consistent with their history, half of the bruises were more than 24 hours old. This was expected since the minimum time the cattle took before reaching the abattoir was 36 hours. The presence of fresh bruises from hoofed cattle indicated recent injuries, most likely incurred at the abattoir (Jarvis et al., 1995).

The fact that there were no differences in bruise scores between cattle from farms and those from markets can be explained by the possible modifying effect of transportation distance. Distance was found to have an effect on bruise score and there was also a positive relationship between distance and bruise scores. These results concur with findings by Horder et al. (1982) who found no significant difference in bruise scores between the farm and market cattle. Cattle from farms were transported over longer distances compared to cattle from the markets. Although hoofed cattle had bruises, the bruise scores were lower than either market or farm cattle. The most likely explanation is differences in handling. Bruising is evidence of poor handling, the more the animal is handled, the greater the chance of bruising (Gregory, 1996). Cattle from farms and markets were more handled, thus exposing them to more bruising than hoofed cattle.

The fact that 31% of the evaluated carcasses were classified as DFD beef ($pH_u \geq 5.8$) and the positive relationship between pH_u and bruises shows the link between bruising and DFD beef. These results concur with McNally and Warris (1995) who reported that 48 % of bruised carcasses had pH_u values that were greater than 5.8. The presence of bruises is a reflection of transportation problems and when animals are stressed, glycogen reserves are depleted and higher pH can be obtained (McVeigh & Tarrant, 1982; Muchenje et al., 2009a,b). The

relationship between the pH_u and DFD beef is also supported by the colour values obtained (31 % of the carcasses had L* values less than 33). Beef L* values less than 33 indicate beef that is dark and translates to DFD beef (Muchenje et al., 2008). These findings therefore suggest a relationship between bruises, pH_u, L* values and DFD beef.

Although there was a positive linear relationship between distance and pH_u, the pH values obtained could have been due to other factors than distance. According to Eldridge and Winfield (1988) and Tarrant (1989), pH is only affected at transportation distances above 2000km. Moderate transportation distances do not have an effect on pH_u (Mach et al., 2008). The fact that distance had a positive relationship with bruise score might explain the high bruise scores in cattle that came directly from the farms. According to McNally and Warriss (1996) and Hoffman et al. (1998), distance is positively correlated with amount of bruising. The positive linear relationship between stocking density and amount of bruising explains the increase in bruising that occurred with increasing density. According to Tarrant et al. (1992; 1988), bruising increases with increase in stocking density. The reason being that cattle that fall down tend to be trampled by others as they try to occupy the available space. The finding that transportation time had positive linear relationships with bruising and pH but a negative one with L* was expected. Long transportation duration has negative effects on meat quality (Grandin, 2000; Warris 2000).

All the cattle that were walked/hoofed to the abattoir arrived a day before. The time spent in lairage probably allowed them to replenish muscle glycogen concentrations or they recovered adequately from the hoofing stress. According to Warris et al. (1984), glycogen reserves can be restored at lairage and cattle can recover from transportation stress even without feeding. The

fact that there was a positive relationship between distance and bruise score might explain why bruise scores were higher in farm cattle than those from markets. Regarding animal type, bruises were found to be most frequent in cows and oxen. These results are supported by findings by Strappini et al. (2010). Findings by Yeh et al. (1978) also support these results since they found that cows bruise more than steers and bulls. This could be due to the fact that animals with a lower economic value like cows and oxen are more likely to pass through a livestock market, which implies more handling procedures, thus increasing the chances for bruising.

Fat cover showed unexpected results as it did not have an effect on bruise scores. This contradicts findings by Strappini et al. (2010) whose findings were that fat cover had a significant relationship with bruising. Fat cover, skin or hide thickness can affect the susceptibility to bruising from impacts (Weeks et al., 2002). It is also hypothesised that thin animals bruise more easily than fat animals and this, according to Grandin (1998), may be the reason why cows may bruise more than other sexes. Fat cover also did not have an effect on $pH_{u,}$ concurring with findings by Mach et al. (2008). The fact that age did not have an effect on bruising and other dependent variables contradicts findings by Wythes and Shorthose (1991), who found bruising to be heaviest in the oldest groups of animals (more that 6 teeth). Their results were also supported by findings by Anderson (1973) who found that bruising was more in the older animals. The fact that breed did not have an effect on bruising score concurs with findings by Fordyce et al. (1985) and Wythes et al. (1985) who suggested that individual animal variation and temperament was more important than breed in explaining bruise variations across breeds. Earlier findings by other authors suggest breed influence; with Wythes et al. (1985) finding Zebu crossbreeds to have greater bruise scores compared with British breeds. Since

Angus cattle were the dominant breed in this study, the results can be explained by its relatively good temperament. The fact that day temperature did not have an effect on bruising and other dependent variables concurs with findings by Strappini et al. (2010). Results in this study contradict Eldridge & Winfield (1988) who found season, especially cold weather to have on effect on mean bruise scores per carcass.

4.6. Conclusion and recommendations

Marketing channel has an effect on bruising and meat quality. Bruising is more prevalent in cattle that pass through the market. Stocking density, distance and transportation duration have negative effects on beef quality. Cows are more susceptible to bruising than other cattle classes. Bruising is significantly associated with increased carcass pH and the development of DFD beef. However it is important to determine the perceptions of consumers and meat traders on animal welfare and the quality of beef from cattle supplied by the farmers.

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Chapter 5: Consumers' and meat traders' perceptions of meat quality and how the quality of meat is affected by animal welfare practices

(This manuscript has been submitted to *Food Quality and Preference)*

By Peter Vimiso

Abstract

The objective of this study was to determine the perception of rural meat consumers and traders on meat quality and how the welfare of slaughter cattle from the farms, at the markets and at the abattoirs affects beef quality. The study focused on the three stages: prior to purchase, at point of purchase and at point of consumption. A total of 102 rural consumers conveniently sampled at point of purchase were used. Thirty-one meat traders from nine butcheries in three rural towns were used. It was observed that both consumers and traders generally perceived welfare of slaughter cattle as having no effect on beef quality. There was some general disagreement between the two groups on the use of quality attributes to predict beef quality. Consumers used the intrinsic cue of colour (for quality) and price to make a purchasing decision while traders used freshness to make a purchasing decision. It was concluded that the consumers and meat traders have different perceptions of welfare of slaughter cattle and its effects on meat quality.

Key words: animal welfare, rural meat consumers, meat traders, meat quality cues; purchasing decision.

5.1. Introduction

The welfare of slaughter cattle can be compromised during pre-slaughter handling (farm handling, novelty of the pre-slaughter environment, adverse weather conditions, mixing, fasting, transport, lairage conditions) and slaughter methods (Grandin, 1997; Fazio & Ferlazzo, 2003 Apple et al., 2005; Chapters 3 and 4). Welfare problems can also arise if slaughter cattle are passed through markets where the cattle experience fatigue, fear and distress, fasting, dehydration and injuries (Gregory, 2008; Chapter 4). When an animal is stressed in the pre-slaughter environment, the physiological responses that occur result in glycogen depletion, causing high ultimate pH and production of beef that is dark in colour and unacceptable to the consumer (Muchenje et al., 2008).

Animal welfare is becoming important for consumers in developed countries (European Commission, 2005), with the meat industry in these countries now placing a lot of importance on animal welfare (Troy & Kerry, 2010). Consumer perception of meat and meat products is a crucial issue for the meat industry because it directly impacts on the profits of this industry (Troy & Kerry, 2010). The meat industry must, therefore, have knowledge on the perceptions of its consumers on the quality of the products it produces. Various food quality models that distinguish beef as a food, an object of trade, a product before purchase and a product after purchase have been developed (Grunert et al., 1996; Peri, 2006). All models use quality cues that contribute to the function of beliefs and therefore purchase choice. These cues could be intrinsic or extrinsic. Intrinsic cues (marbling, colour) are physical characteristics of the product, while extrinsic cues (price, origin) are not physically part of the product (Grunert et al., 2004).

Perceptions by any individual are influenced by opinions about the way things are and the ideal situation (Te Velde et al., 2002). Knowledge gained from experience, facts, stories, impressions and the interests an individual has can also influence perceptions (Te Velde et al., 2002; Chapter 3). It, therefore, is imperative for the meat industry to have knowledge on what quality cues consumers use when purchasing meat and how they can use this information to remain competitive. Unlike in many studies, the consumers in this study were of a rural background and their perceptions on how animal welfare affects meat quality have not been explored. It will be important for the meat industry to know the quality cues they use in purchasing beef. In Europe where information on meat is readily available, consumers select meat using characteristics such as tenderness, juiciness and the anticipated taste (Becker et al., 2000; Glitsch, 2000). These characteristics are related by consumers to meat freshness, leanness and bright red colour (Krystallis & Arvanitoyannis, 2006).

Research has been done on consumer perception of farm animal welfare in livestock breeding (Te Velde et al., 2002). It was reported that consumers view physical health, adequate feeding and drinking water, freedom of movement and fulfillment of natural desires, humane transport, presence of trained staff, humane slaughtering and social contact as farm animal welfare issues of importance (Te Velde et al., 2002; Lassen et al., 2006; Marie, 2006; Martelli, 2009). Previous studies in the developed world have mainly focused on meat consumers' perceptions on meat quality (Grunert et al., 1996; Becker et al., 2000; Glitsch et al., 2000; Verbeke et al., 2005) without considering animal welfare. These studies have been done without considering the perceptions of meat traders yet they are at the centre of meat distribution and having direct

contacts with consumers. Furthermore, no attempt has been made to jointly investigate the perceptions of both meat consumers and traders on animal welfare and how it affects meat quality. Information on these two groups is quite critical for the meat industry. This study focuses on both consumers' and meat traders' perceptions on animal welfare and how it affects meat in a rural set-up in the developing world where more than 50% of meat consumed is from small scale abattoirs. The Eastern Cape for example, has got 88 red meat abattoirs with 48 of them being smallholder abattoirs (low throughputs). This therefore means that smallholder abattoirs supply more meat to the local butcheries and consumers (National Department of Agriculture, South Africa).

This is the first study to jointly determine the perceptions of rural meat consumers and traders on animal welfare and its effects on meat quality in the developing world. The objective of the current study was to determine the perception of rural meat consumers and traders on meat quality and how the welfare of slaughter cattle affects meat quality. The null hypothesis tested was that consumer and meat trader perception on animal welfare and meat quality is the same.

5.2. Materials and Methods

5.2.1. Study site

The study was conducted in the towns of Adelaide (Nxuba local municipality), Alice and Fort Beaufort (Nkonkobe local municipality) in the Amatole District Municipality in the Eastern Cape Province of South Africa. A total of 11 butcheries were used in the study, three in Adelaide, three in Fort Beaufort and five in Alice. Selection of the butcheries was based on them receiving meat for resale from the Adelaide municipal abattoir.

5.2.2. Sampling of respondents

The respondents were divided into two major categories: meat traders and consumers. A total of 31 meat traders were used in the study. These were limited to those who were directly linked to purchasing and sales of beef for the butcheries, i.e. butcher owner, butcher manager and butcher sales supervisors or sales assistants. All consumers who came to purchase beef were initially targeted and subjected to screening questions. The screening questions were given to select respondents on the basis that they were the major buyers of beef or frequently bought beef at the outlets, consume beef, had beef as their preferred meat product and could predict beef quality by looking at it. A total of 102 consumers were conveniently sampled as they came to buy beef from the selected butcheries.

5.2.3. Data collection

A structured questionnaire was used to interview both traders and consumers. Trained enumerators administered the questionnaires. Data from the consumers was collected by butchery intercepts with the consumers being interviewed at the point of purchase or as they left the butchery. The traders were interviewed in the butcheries during working hours. Data collected included demographic information such as gender and age, employment status, education and race of the respondents. The education categories had Grade 12 as the lowest qualification below which one was considered as uneducated. Grade 12 is taken as the highest pre-tertiary qualification since it gives learners the entry to tertiary education and is the only certified examination between primary and tertiary education. Professional qualification meant being certified to do one's respective job such teaching, nursing or certified meat cutters.

The questionnaire covered aspects of welfare of slaughter cattle from the farm to the abattoir and how this affected meat quality. Questions pertaining to cattle welfare at the farm included cattle rearing methods, feeding management, handling methods and breed types. Questions pertaining to welfare at the markets covered all aspects of cattle treatment (loading, handling and penning). Transportation included aspects of loading and driving management. Questions on cattle welfare at the abattoir included humane treatment, slaughter methods and lairage management. The respondents' perceptions on meat quality attributes at point of sale (colour, leanness, marbling, price, beef class, source and label), during eating (smell, texture, juiciness, tenderness, leanness, colour and flavour) and the quality of beef they purchase (Tenderness, taste, keeping quality, bruising and colour) were solicited. The categories of meat attributes such as smell, tenderness, juiciness, colour, leanness and texture were adopted from (Becker et al., 2000).

5.2.4. Statistical analyses

Data was summarised as frequencies for each response and statistical differences were analysed using the chi-square statistical test (χ^2) when appropriate. Associations were tested between either respondent, gender, race, age, education and all the factors and attributes. The analysis was carried out with the SAS statistical package of (2003).

5.3. Results

5.3.1. Sample descriptions

The socio- demographic descriptions of the 102 consumers interviewed on slaughter animal welfare and its effects on meat quality are shown in Table 5.1

Most of the consumers in the study were relatively young (80.39%), aged between 26 and 31 years. The majority of the traders (74.19%) had a professional qualification with the least qualification being Grade 12 (Table 5.2). There were some associations between respondents and some attributes (Table 5.3), while some associations were also found between some demographic variables and some attributes (Table 5.4).

Table 5. 1: Characteristics of consumers interviewed.

Characteristics	Frequency	Percentage
Age		
20-30	51	50
31- 40	46	45.10
≥41	5	4.90
Gender		
Males	50	49.02
Females	52	50.98
Race		
Black	44	43.14
Coloured	29	28.43
White	29	28.43
Employment status		
Employed	53	51.96
Not employed	49	48.04
Educational Background		
< Grade 12	4	3.92
Grade 12	16	15.69
Professional qualification	54	52.94
Degree	28	27.45

Table 5. 2: Characteristics of the meat traders interviewed.

Characteristics	Frequency	Percentage
Age		
<30	5	16.13
30-50	22	70.97
>50	4	12.90
Gender		
Male	20	64.52
Female	11	35.48
Race		
Black	14	45.16
Coloured	11	35.48
White	6	19.35
Educational Background		
Grade 12	7	22.58
Professional training	23	74.19
University graduate	1	3.23
Type of establishment		
Butcher's shop	6	66.67
Supermarket	3	33.33

Table 5. 3: Associations between respondents and some attributes.

Factor	(p-values)
The way cattle are raised influences beef quality	0.0001
Type of feed and beef quality	0.0001
Breed and beef quality	0.0011
Loading density and beef quality	0.0005
Frequent handling of cattle at the farm results in cattle with a good temperament	0.0039
Cattle that are difficult to handle at the farm tend to produce poor quality beef	0.0188
Overstocking grazing areas results in production of poor quality beef	0.0022
The way cattle are handled during cattle sales influences beef quality	0.0209
Colour	0.0001
Leanness	0.0019
Smell	0.0001
Type of packaging/wrapping	0.0001
Quality stamp	0.0001
Place of slaughter	0.0001
Juiciness	0.0002
Label	0.0001
Tenderness	0.0220
Price of beef is an indicator of beef quality	0.0456

Table 5. 4: Associations between race, education and gender some attributes.

Factor	Variable	Chi-square (p-value)
Cattle handling at sales and beef quality	Race	0.0489
Butchery reputation	Race	0.0454
Can you predict beef quality by looking at it	Education	0.0001
Purchasing decision	Education	0.0001
Lairage duration	Education	0.0001
Smell	Education	0.0294
Cattle difficult to handle and meat quality	Gender	0.0153
Overstocking results in production of poor quality beef	Gender	0.0068
Frequent handling of cattle and meat quality	Gender	0.0485

5.3.2. Factors relating to meat purchasing and consumption

The majority of the consumers preferred to consume beef, while other meat products, such as chicken and mutton, were less preferred (Figure 5.1). About 50% of the consumers interviewed actually consume beef at home. Meat types, such as mutton and chicken, were also consumed (Figure 5.2). Of all the consumers and meat traders interviewed, 96.24 % indicated that they were able to predict beef quality by just looking at it. Price influenced 70% of the consumers' purchasing decision while quality influenced the remaining 30% and all of them were not concerned with health (Figure 5.3). The primary factors that affect purchasing decision by the traders are shown in Figure 5.4. Quality was found to be the main factor and influenced 75% of the traders, while price influenced 25% and all were not concerned about health.

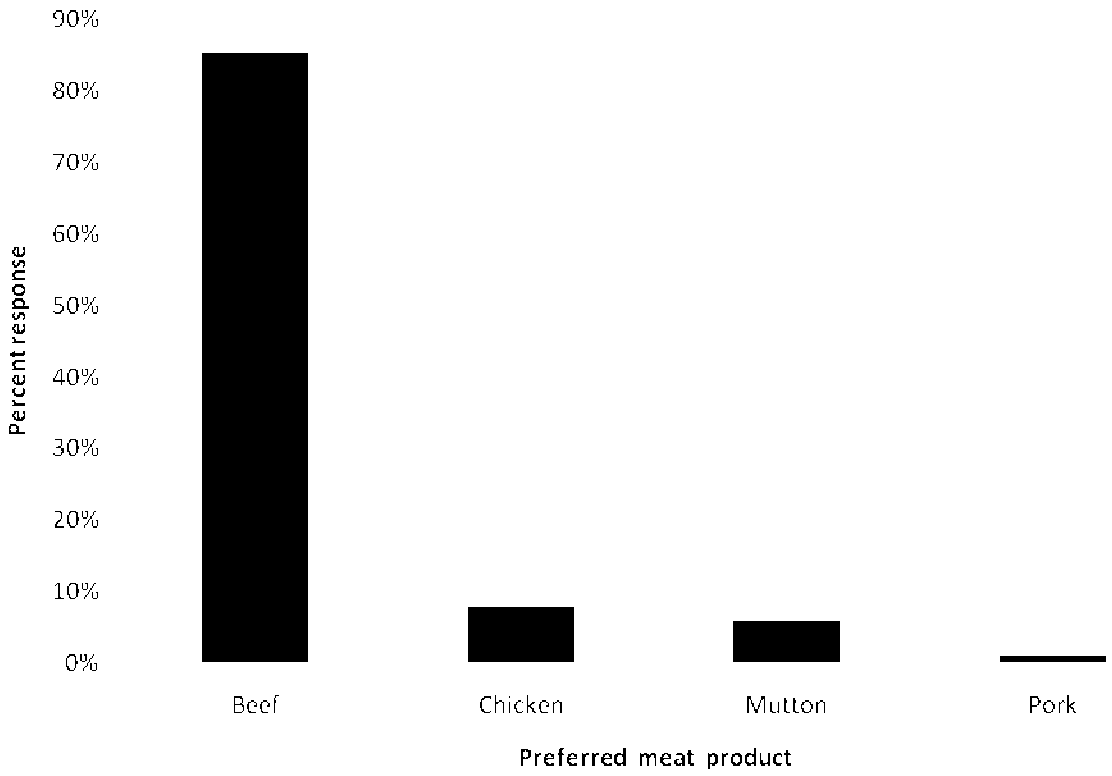

Figure 5. 1: Meat types preferred by the consumers in towns studied.

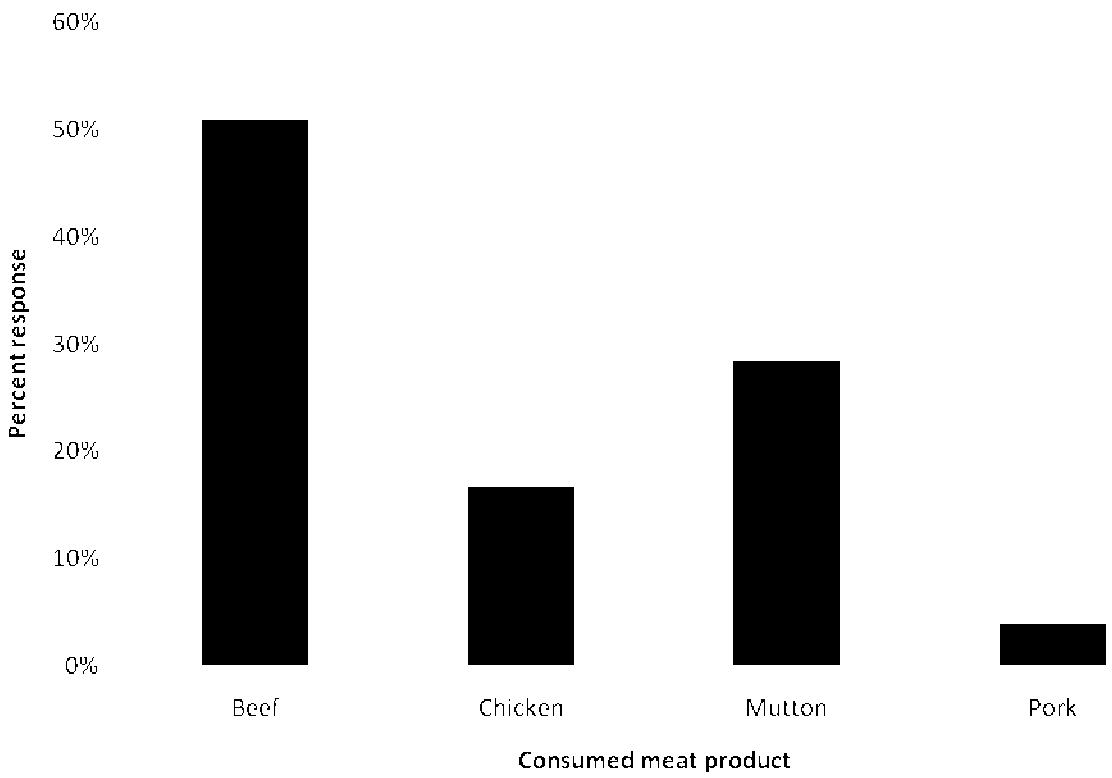

Figure 5. 2: Meat type actually consumed at home in towns studied.

Figure 5. 3: Primary factors in beef purchasing decision for the consumers.

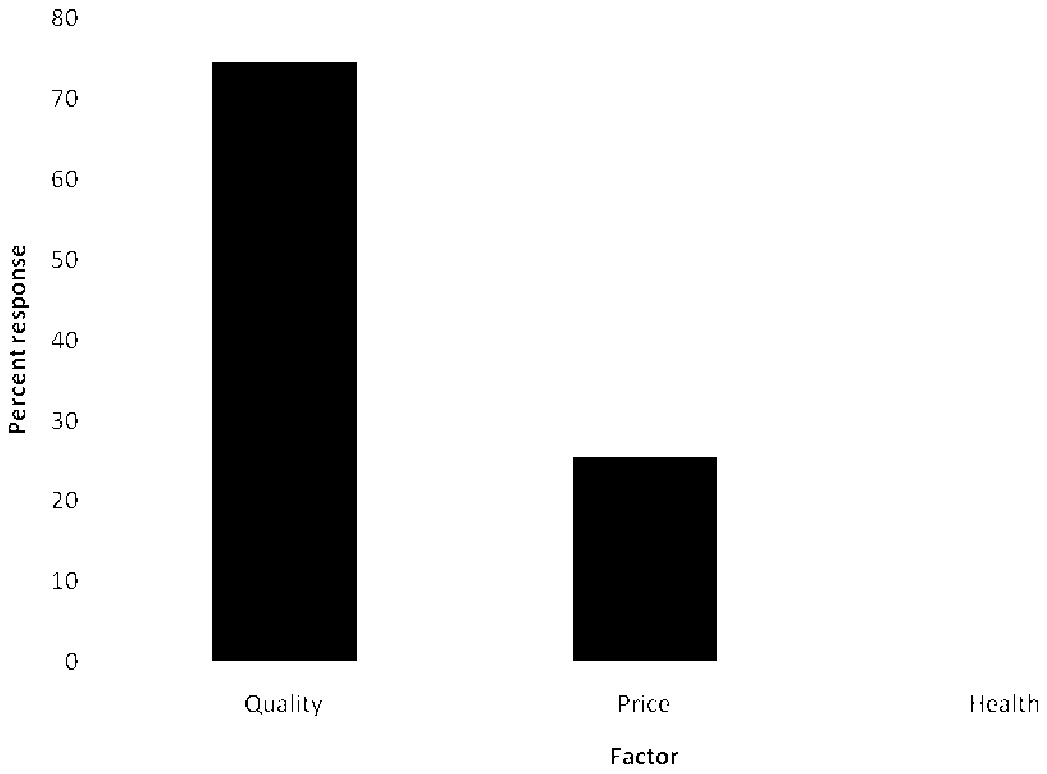

Figure 5. 4: Primary factors in beef purchasing decision by the traders.

5.4. Consumers' and traders' perceptions on beef quality attributes

For the consumer, the order of importance for use in predicting beef quality was colour > price > leanness > class (Figure 5.5), other attributes like label/information on the beef, source/ place of slaughter and marbling were perceived as not important in predicting the quality of beef at point of purchase. For the traders, the attributes of value were in this order; price > colour > class > label > source > marbling > leanness. To the consumer, the most important eating quality attributes were colour of the beef, smell, tenderness and leanness (Figure 5.6). The least important attribute was juiciness. The meat trader had tenderness as the most important attribute with the least important being leanness. In relation to quality of beef they purchase, some disagreements emerged between the two groups on taste, tenderness, keeping quality, and effects of bruising on beef quality. However the two groups agreed that the colour of the beef they purchase was not always good (Figure 5.7).

5.5. Perceptions of consumers and meat traders on welfare of slaughter cattle and its effects on meat quality

These results indicate that more than 75% of the consumers perceived all the farm welfare aspects not to affect beef quality no matter how adverse they could be (Figure 5.8). More than 60% of the meat traders perceived the way cattle were raised and feed type as factors that affect beef quality. Both consumers and meat traders did not consider frequent handling, poor temperament, overstocking and breed as factors that affect beef quality. The majority of the consumers and meat traders perceived events at the cattle markets as not affecting the quality of beef (Figure 5.9). The majority of the consumers and meat traders felt that welfare during transportation does not affect beef quality at slaughter (Figure 5.10). More than 50 % of

consumers and meat traders perceived abattoir events as not of any influence to beef quality at slaughter (Figure 5.11).

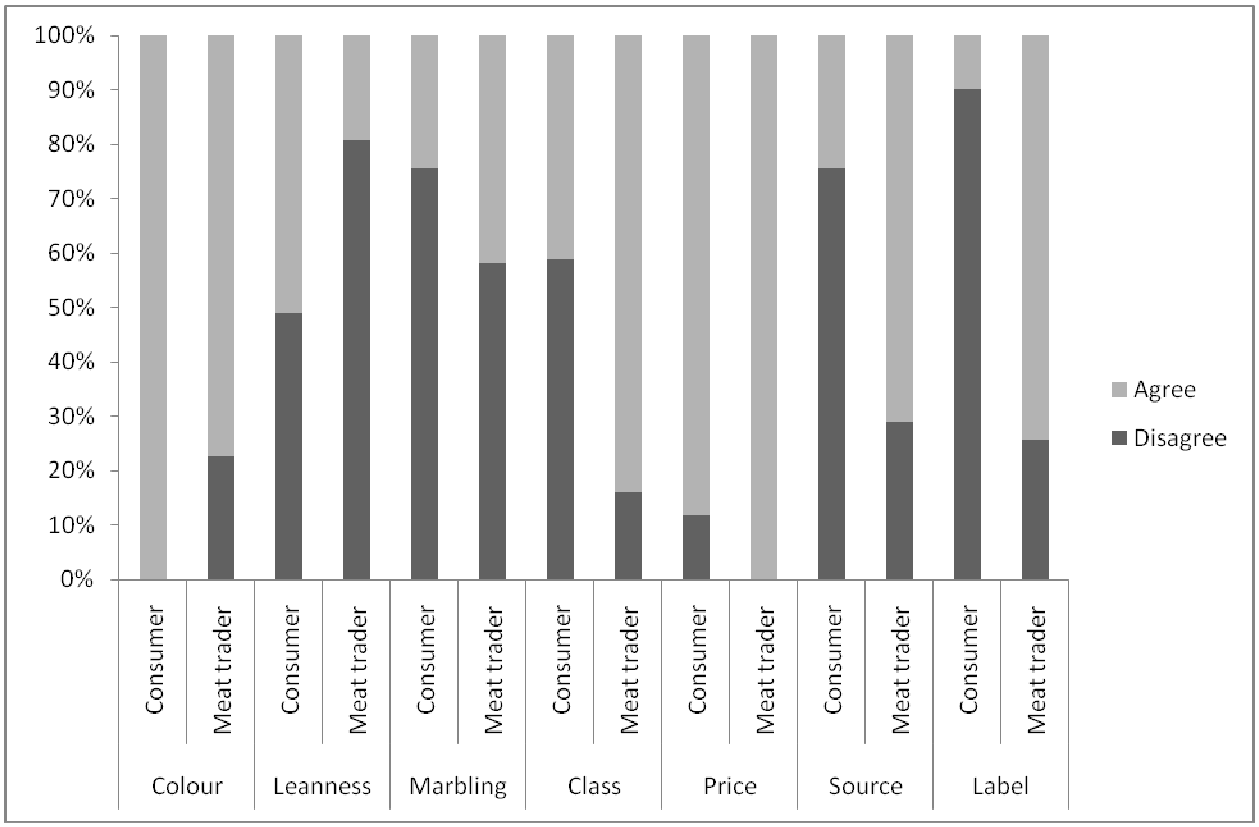

Figure 5. 5: Consumer and meat trader perceptions on beef quality in the shop attributes.

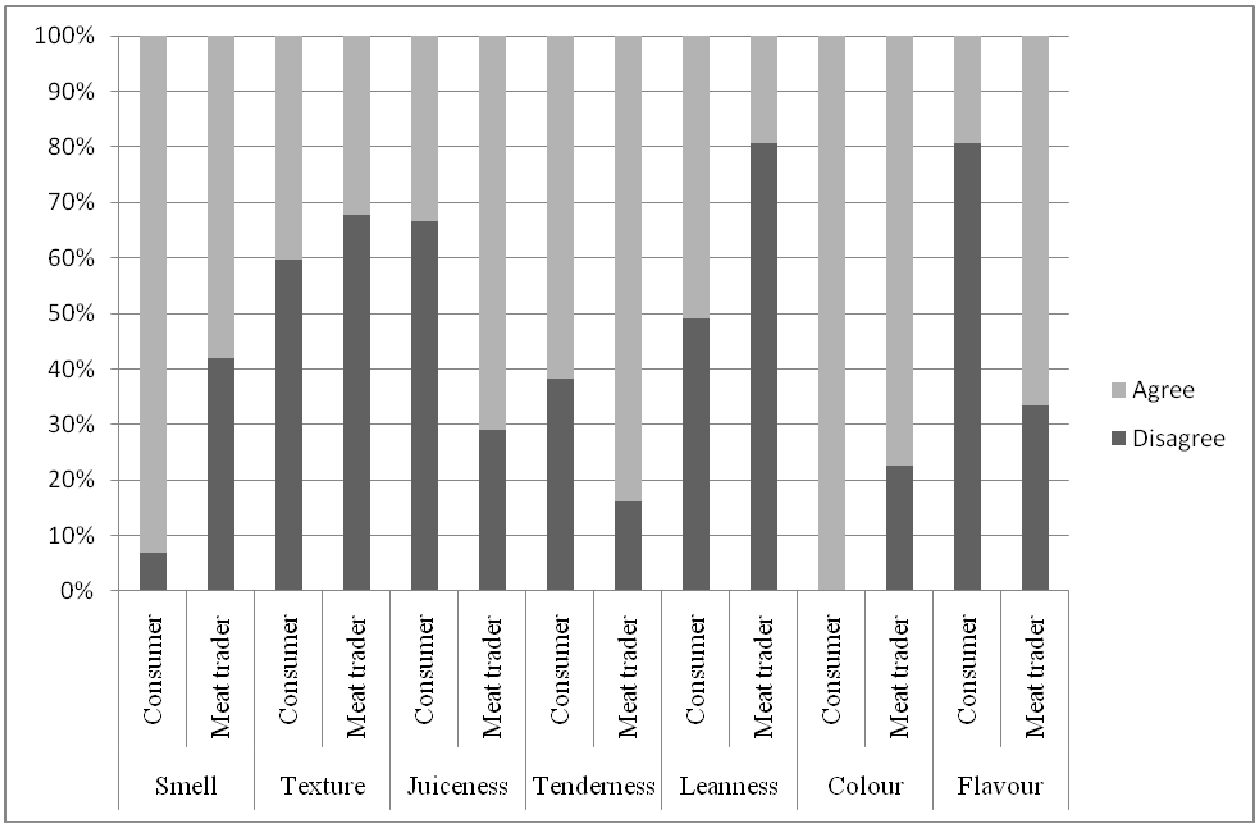

Figure 5. 6: Consumer and meat trader perceptions on eating quality attributes.

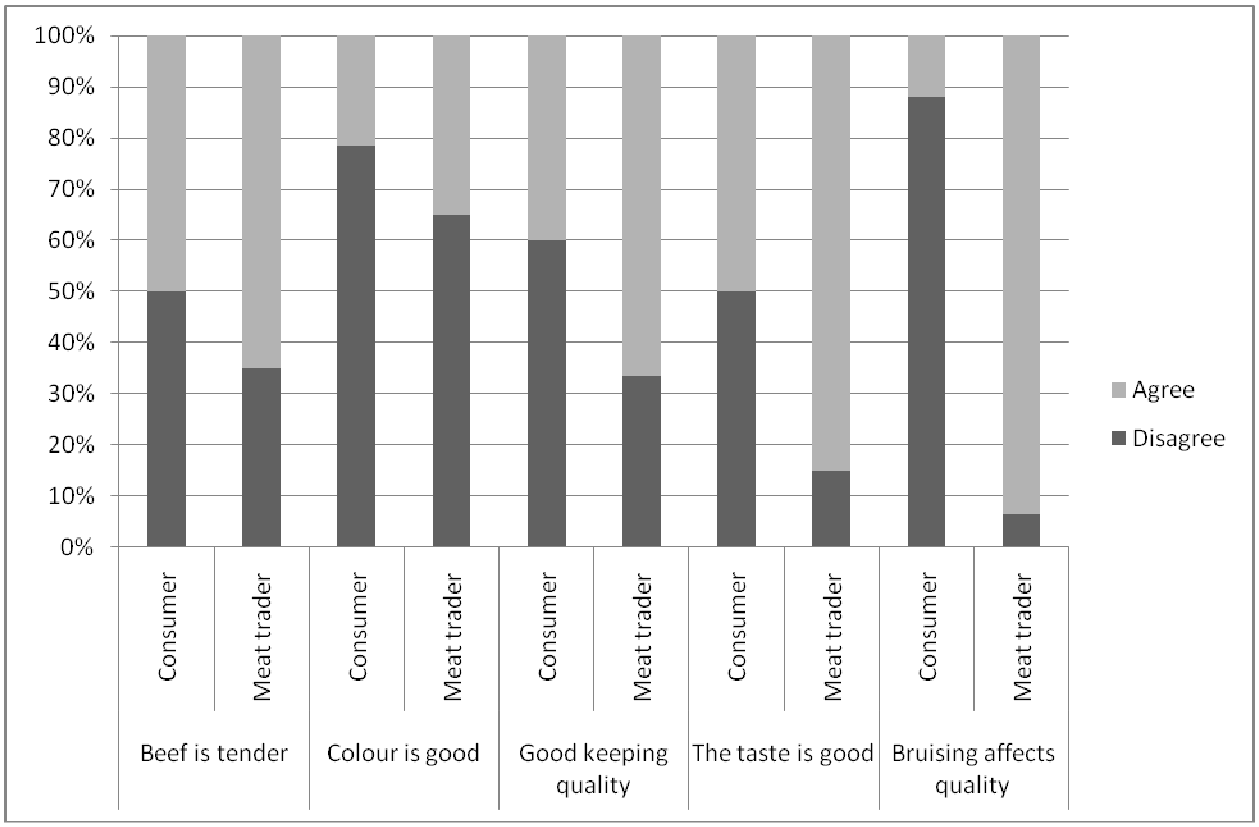

Figure 5. 7: Consumer and meat traders' perceptions on quality of beef they purchase

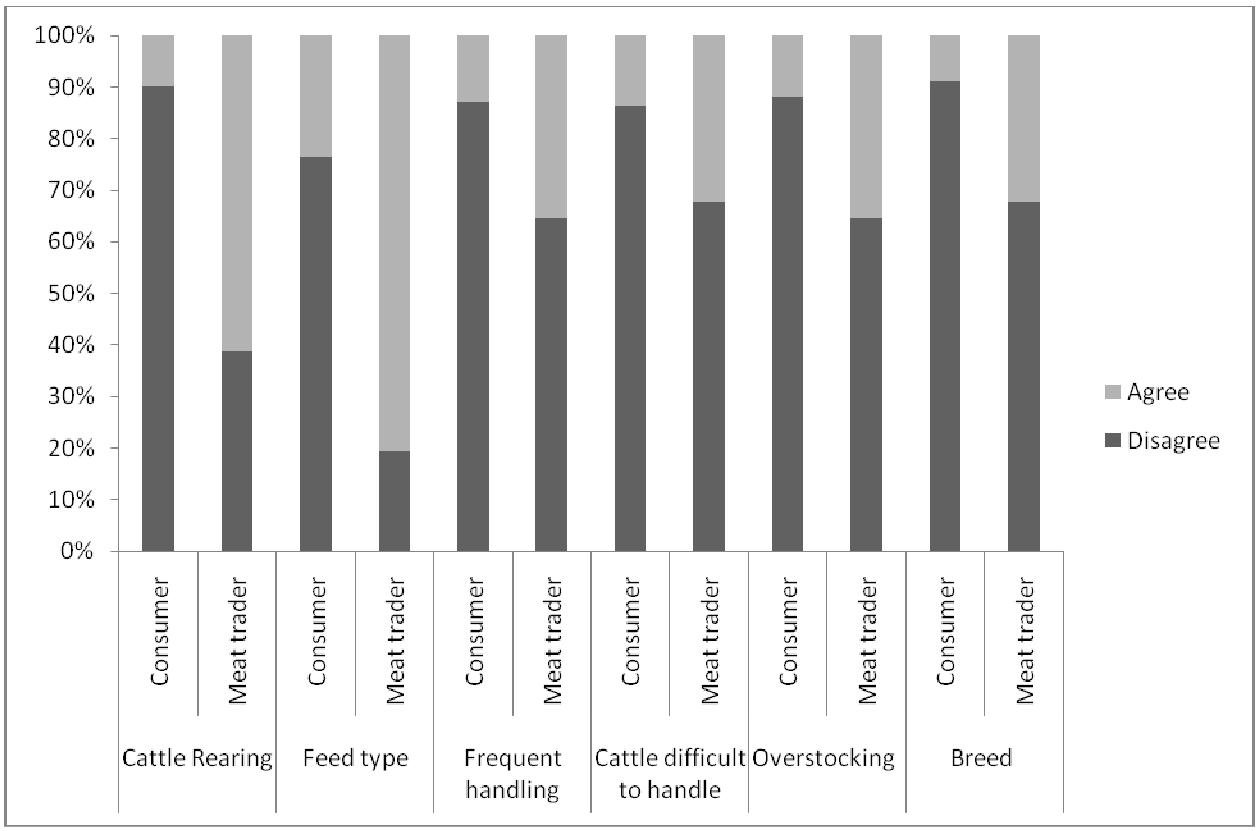

Figure 5. 8: Perceptions of consumers and meat traders on welfare of slaughter cattle at the farm and how it affects beef quality.

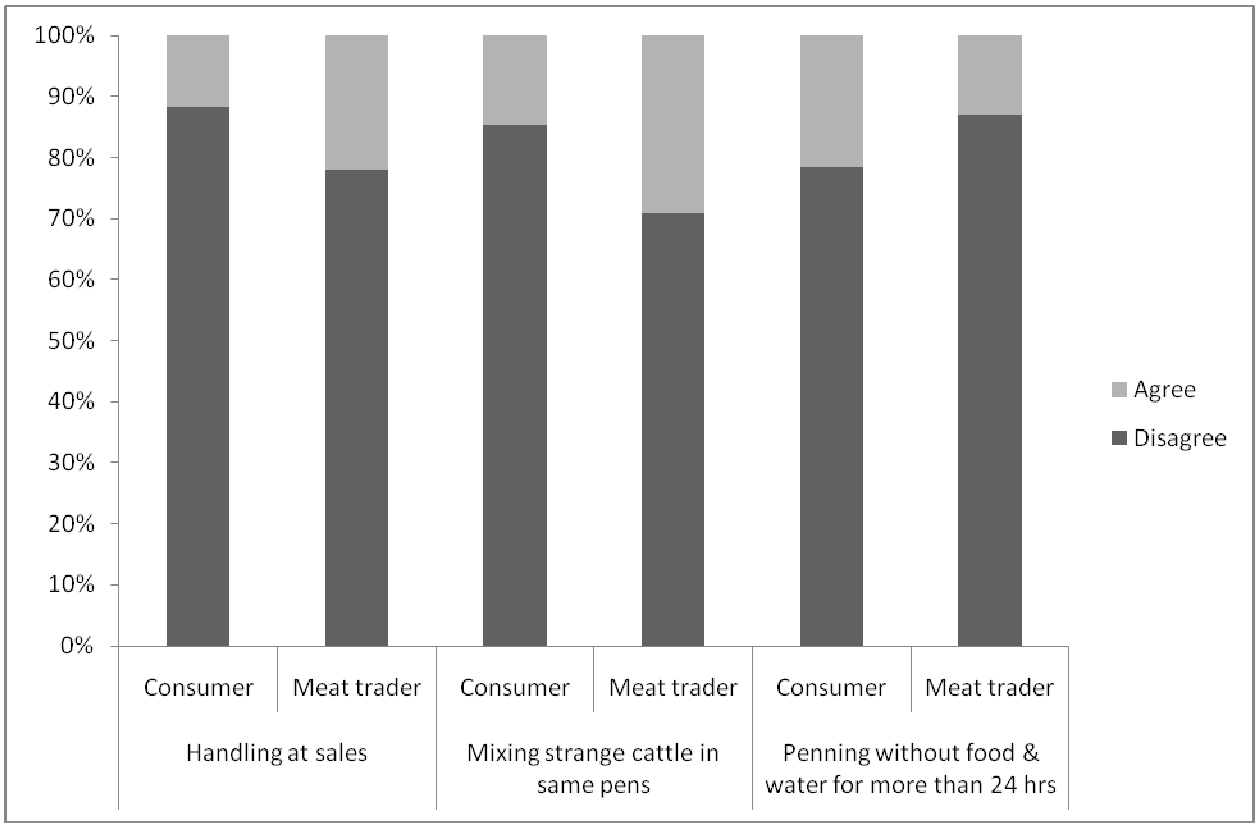

Figure 5. 9: Consumer and meat trader perceptions on welfare of slaughter cattle at the markets and how it affects beef quality.

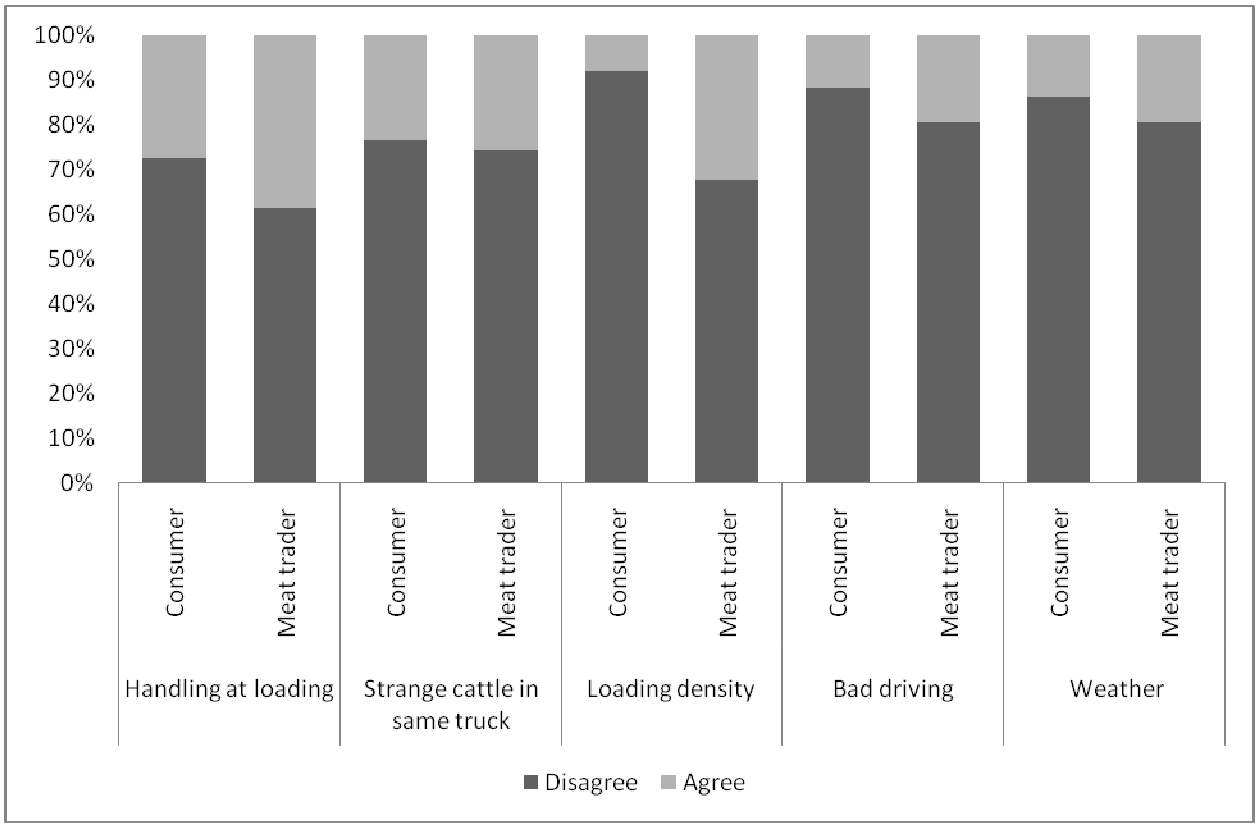

Figure 5. 10: Consumer and meat trader perception on welfare of slaughter cattle during transportation and how it affects beef quality.

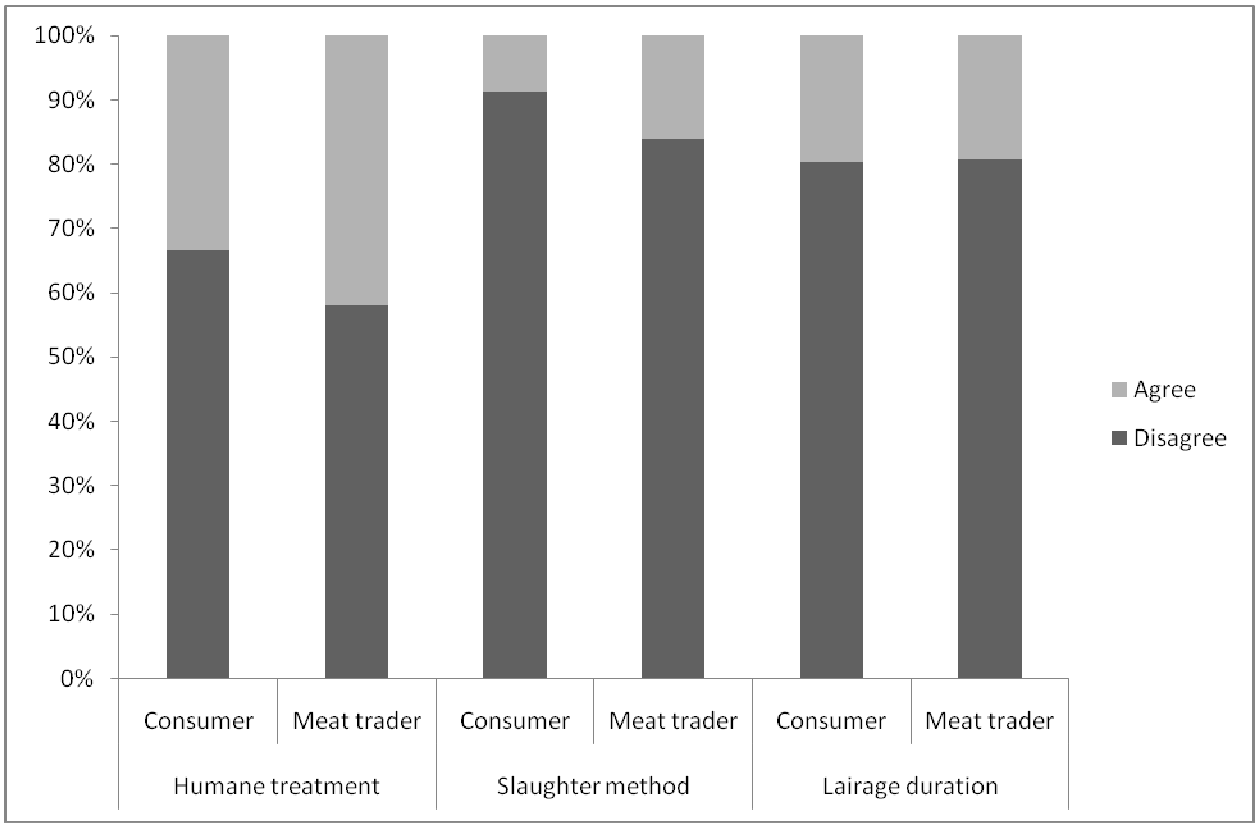

Figure 5. 11: Consumer and meat trader perceptions on slaughter cattle welfare at the abattoir and how it affects beef quality.

5.6: Discussion

Although most consumers preferred beef, the number that actually consumed beef at home was less due to its price relative to other products, such as chicken. The fact that mutton is consumed more than chicken may be due to the fact that some of the respondents interviewed keep sheep at their rural homes and mutton is a delicacy and a popular source of protein for them (Mapiliyao, 2010). The fact that price was chosen as the primary factor affecting purchasing decision may have been due to the fact that the respondents are from a rural and poor background where most purchases are determined by the amount of disposable cash available and quality of a product is secondary (Ballantine et al., 2008).

The fact that colour was regarded by the consumers as the most important quality in the shop attribute while the traders placed it second in importance was due to the fact colour of beef is the first attribute that consumers use when selecting beef. Meat colour is the most important factor affecting consumer acceptance, purchasing decisions, and satisfaction of meat products (Muchenje et al., 2009b). It is also important in meat marketing since it is the first quality attribute that a consumer uses to predict freshness and wholesomeness. The presentation of beef with the correct colour is the most important aspect in the marketing of beef since consumers tend to discriminate negatively against beef that is discoloured (Troy & Kerry, 2010). Our results concur with findings by Carpenter et al., (2001) who observed that consumer preference for beef colour was sufficient to influence their likelihood to purchase. Although the colour of fresh meat does not always mean good eating quality, the consumer still expects to purchase beef that is bright cherry red in colour (Taylor, 1996). The bright cherry-red colour of beef is due to oxymyoglobin which forms after exposure of the muscle pigment myoglobin to oxygen. In beef oxymyoglobin is responsible for the colour that consumers associate with freshness (Faustman &

Cassens, 1990). These findings tend to differ from those by Becker et al. (2000) who found country of origin and place of purchase as the most important attributes for quality in the shop. Jocumsen (2005), using Australian consumers, showed freshness as the most important attribute at point of sale.

The fact that the meat traders indicated price as the most important quality in the shop attribute is not surprising since they are in business. For consumers price was second in importance for predicting meat quality. This is not surprising as most of the ordinary consumer will associate an expensive item with good quality. This perception contradicts findings by Becker et al. (2000) who found that Germany consumers considered price to be of least importance as an indicator of quality. Price can be a cost factor as well as a quality indicator. As an indicator of quality, a beef buyer can have two price limits in mind, an upper limit, beyond which s/he would find the beef two expensive and indicating high quality and a lower price limit below which the quality would be suspect (Issanchou, 1996).

The finding that source or place of slaughter was important to the traders yet unimportant to the consumers was not surprising. This might be attributed to the fact that most consumers are not worried about place of slaughter at point of purchase except those consumers that only eat halaal certified meat (Heiman et al., 2001). To the consumers, their source of meat is the trader.

The finding that the class of beef as a quality in the shop attribute was not important to the consumer, yet important to the trader might be due to the fact that most consumers are not concerned about class of beef at point of purchase. However, class of beef is a good indicator of eating quality. Meat that is classified as Class A is tender and from a young animal, meat classified as Class B is less tender and from an adult animal while meat classified as Class C is

least tender and from an old animal (The Afrikaner Cattle Breeders' Society of South Africa, 2008). These classes are important to the trader as they use them for purchasing wholesale beef and pricing beef in the shop.

The fact that marbling was indicated as an unimportant quality in the shop attribute by both traders and consumers is not surprising. According to Verbeke et al. (2005), one requires good knowledge and a good background to appreciate marbling. Marbling, defined as the visible fat present in the interfascicular spaces of a muscle (Kauffman & Marsh, 1987), affects flavour, juiciness and tenderness of meat and hence increases its palatability (Miller et al., 2001). Even in those countries where consumers are regarded as knowledgeable in meat quality, marbling is not appreciated. In Germany for example, consumers ranked it third in its importance as a quality in the shop attribute (Becker et al., 2000) and in Belgium, consumers face difficulties when evaluating it (Verbeke et al., 2005). The fact that the respondents showed lack of knowledge in interpreting the importance of marbling in meat quality could have been as a result of their rural background.

The fact that leanness was regarded by half of the consumers as an important eating quality attribute might mean that there were some consumers who are health conscious or that they did not quite understand the meaning of the term. On the other hand, traders may not have attached any importance to leanness due to the fact that lean carcasses are generally light in weight compared to fat carcasses and the presence of fat might contribute to the weight of the beef they sell (Strydom, 2005). The finding that label was important to the trader but not to the consumer was not surprising. For a label to be effective, the information on the label must be read,

understood and accepted. Labels play only a minor role in signaling quality (Becker et al., 2000), although Verbeke et al. 2006, determined that information about beef quality through labels can be relevant for the consumers.

The findings for eating quality attributes for both respondents were as expected, although the response from the consumers showed some slight variation to findings by Becker et al. (2000) where consumers ranked tenderness as most important. The consumers might have ranked colour instead of tenderness as most important because they would rather try and eat tough beef than eat one that is discoloured. The consumers associate discoloured beef with a sick animal (Muchenje et al., 2009a). Beef that smells at point of consumption is repugnant and has to be thrown away. It is probably easy to negotiate through a tough piece of steak than one that smells. Consumers are also used to eating tough beef as they purchase it more often (Miller et al., 2001). Tenderness is affected by breed, sex, age, and live weight and most important by pre-slaughter or *ante-mortem* stress (Muchenje et al., 2009a). Contrary to consumer perception, tenderness is seen as the most important eating quality attribute (Miller et al., 2001). Tenderness can be attributed to a consumer's perception of meat, such as: softness to tongue, resistance to tooth pressure and adhesion (Muchenje et al., 2009b). Focused research data also show that tenderness, juiciness, flavor and overall palatability are sought most by consumers (Miller et al., 2001). The attribute texture did not mean much to the respondents, hence their perception of it.

The lack of significant differences associated with age, gender and most demographics in the perceived importance of quality cues suggests demographic differences are not markedly influencing consumers' perceptions of beef quality. These results contradict findings by

Jocumsen (2005), who found significant associations between gender and some quality parameters. Females found colour, marbling, leanness and labels to be more helpful than did males. This may be due to the fact that females are more health conscious than males (Kennedy et al., 2004).

Consumers' perceptions on welfare of slaughter cattle at the farm are a result of them not having visited cattle farms and therefore being less informed on animal welfare issues. There is some dissociation of consumers from farming practices as a result of their rural background and their knowledge of the circumstances in which meat livestock is produced becomes more limited (Frewer et al., 2005; Verbeke, 2005; Maria, 2006). The fact that the respondents perceived early and frequent cattle handling as not important in meat quality contradicts what has been reported in literature (Boissy & Bouissou, 1988; Boivin et al., 1994). It is generally accepted that early handling of cattle at the farm brings long lasting experiences when cattle are handled in future (Muchenje et al., 2009a). Cattle with previous experiences of gentle handling are calmer and easier to handle in future than cattle that have been handled roughly or were less handled when growing up (Boissy & Bouissou, 1988; Boivin et al., 1994). Breed, contrary to consumer perception, influences beef quality. Certain breeds are difficult to handle and it is recommended that they be familiarized with handling procedures as this makes it easier to manage during the pre-slaughter period (Minka & Ayo, 2007; Tompsett & Gregory, 2008). Breed type influences carcass and meat quality including the properties and structure of muscle and meat physiology (Muchenje et al., 2009b).

The fact that consumers in the study perceived overstocking of cattle at the farm as having no effect on meat quality is contrary to findings by Muchenje et al. (2008) who say that overstocking or poor feeding at the farm is an animal welfare issue and can affect meat yield and quality. Underfeeding at the farm can result in depletion of pre-loading glycogen levels in muscles of slaughter animals (Jacob et al., 2005). Pre-slaughter glycogen depletion in muscle may result in meat with high ultimate pH, which is dark in colour, has poor keeping quality and has poor palatability (Muchenje et al., 2009b).

Contrary to consumer perception that feeding management does not affect beef quality, the quality of meat, including its composition can be affected by type of feed (Muchenje et al., 2008). Forage –fed beef contains higher levels of beneficial n-6 and n-3 fatty acids (Baublits et al., 2006; Muchenje et al., 2009c). Baublits et al. (2004) report that beef from forage- fed cattle has less marbling and is darker in colour compared to beef from grain fed cattle. Beef from grass fed cattle is perceived to have differences in tenderness, color, juiciness and flavor (Baardseth et al., 1988; Hutchings & Illford, 1988; Chrystall, 1994) while beef from concentrate-fed cattle is said to be more tender and better flavoured (Larick et al., 1987; Mederos et al., 1987).

The perception by the respondents that welfare of cattle at markets does not affect meat quality contradicts Murray et al. (2000) whose findings were that welfare of animals sold through markets is poor compared with animals send directly to abattoirs. Cattle that are put through markets are subjected to fatigue, fear and distress, fasting, dehydration and injuries. Cattle that are sold through markets are handled more than those delivered to the abattoir and get more bruising as a result (Weeks et al., 2002).

Although the respondents perceived that transportation does not affect the welfare of slaughter cattle and meat quality, this is contrary to Grandin (2000) who found that transportation exposes cattle to stress from heat, cold, humidity, noise, motion and social regrouping resulting in production of poor quality beef. Transport even for short distances, results in the following: reduced live weight, increased morbidity and mortality, poor meat and skin quality, decreased glycogen reserves and economic losses due to bruises and rejected beef (Minka & Ayo, 2006; Agnes et al., 1990). The respondents felt that the (un)loading process does not affect meat quality. This is contrary to findings by Broom (2000) who found that loading and unloading of cattle into and out of transport vehicles can lead to severe effects on the animals if not properly planned. Even in very good loading procedures, animals can be frightened by people, resulting in stress and even injuries. Loading density, especially overloading increases the risk of animal injury and damage to carcass and meat quality (Tarrant, 1990). Although the respondents perceived that driving has no effect on animal welfare and meat quality, this contradicts other findings. Driving care and road conditions influences cattle welfare during transportation, with most events where cattle are floored caused by loss of balance during cornering (Tarrant, 1990). The complete set of transport events, especially loading and unloading phases are reported to determine stress and affect meat quality (Van de Water et al., 2003).

The results on abattoir practices and animal welfare are expected for the consumers but surprising for the traders. The backgrounds of the consumers play a major role in influencing their perception on abattoir practices. It is also common practice for rural people to slaughter their own livestock for meat, and often animal welfare is not a concern (Mapiliyao, 2010). The

way the rural people slaughter livestock may influence their perception of abattoir practices. Perceptions are often a result of knowledge on a subject (Te Velde et al., 2002). Unless a consumer has visited an abattoir, knowledge of abattoir practices will be poor, leading to wrong perceptions. Consumers generally believe that animals are meant to serve humans, keeping and slaughtering them for meat is legitimate and that farmers are there to provide food for the population (Te Velde et al., 2002). Traders are expected to have some knowledge of abattoir practices and animal welfare at slaughter. This knowledge helps them to make informed decisions when selecting the source of their meat since abattoir practices differ. Consumers depend on the trader for the provision of quality beef while the trader depends on the source /abattoir for meat that appeal to the consumer.

The perceptions of the consumers and meat traders on the beef they purchase were important because it gave an evaluation of the beef from the cattle the farmers supply and were slaughtered at the smallholder abattoir. The fact that both groups were at times not happy with the colour of the beef they purchase could have been as a result of the DFD beef that is often produced (Chapter 4). The fact that the two groups differed in their perceptions of tenderness and taste can be explained by the fact that these attributes are complex and difficult to predict and are influenced by many factors (Gerrad & Grand, 2003). Although the consumers indicated that the keeping quality of the beef was poor, this could be due to quality problems from the beef or storage problems at their homes. According to Muchenje et al. (2009a, b) beef with high pH has a poor keeping quality and is susceptible to spoilage. The finding that the consumers considered bruising as not affecting meat quality was not surprising. The consumers rarely come across bruised carcasses unlike the traders who feel the effects through trimming losses and often

condemnations of heavily bruised carcasses. According to Gallo (2008) bruising affects beef quality and can lead to heavy financial losses.

5.7: Conclusions and recommendations

The rural traders and consumers have the same perception that animal welfare does not affect meat quality although they differ on how they perceive beef quality. Both the consumers and meat traders are not satisfied with the colour of beef from cattle slaughtered at the smallholder abattoir. The implication of this to the meat industry in rural South Africa is that the traders may never improve on service provision if the much needed critical input does not come from the consumers. There is need to train the rural traders and consumers on welfare of slaughter cattle and how it affects meat quality. This implies that the rural traders may never supply the correct quality of beef to the market. Educational promotions that better inform rural consumers about the determinants of quality are needed.

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Chapter 6: General Discussion, Conclusions and Recommendations.

6.1. General discussion

The objective of the study was to determine the effects of marketing channel on bruising, pH and colour of beef and to determine the perceptions of farmers, meat traders and consumers on welfare of slaughter cattle and how it affects the quality of beef from cattle slaughtered at a small holder abattoir. The perceptions of the farmers on slaughter animal welfare and meat quality were determined in Chapter 3. In Chapter 4, the effects of farmers' choice of marketing channel and how they handled their cattle to the abattoir was determined through meat quality measurements. In Chapter 5, meat trader and consumer perceptions on the effects of slaughter animal welfare on meat quality in general and the quality of beef produced at the small holder abattoir were determined.

In Chapter 3, the farmers' general perception of slaughter animal welfare and meat quality was reported to be positive. Animal transportation aspects that the farmers considered as important and have an effect on meat quality were: distance between the farm and the abattoir, handling at loading, hunger and thirst during transports, number of transports and loading density. The fact that the farmers perceived these aspects as important means that they can positively contribute to the production of acceptable meat at the abattoir. Farmers' contribution to meat quality is immense considering that they can influence most the transportation factors that are deleterious to slaughter welfare and meat quality. Other aspects that the farmers are in direct control of are: animal body condition at loading, loading facilities at the farm, loading method, and choice of marketing channel. These aspects were all considered as important by the farmers, again an indication of their vital role in production of meat that is acceptable to the consumers.

However the fact that farmers had a negative perception of human-animal relationships might be related to the nature of their farming systems, since the majority of the farmers had extensive farms. Routine handling and close contact with meat animals result in animals with good temperament, that are easier to load and to handle in novel environments such as markets and abattoir (Lensink, 2002; Tarrant, 1990 Grandin, 2006). The fact that the farmers perceived colour, tenderness, flavour and carcass class as important is a positive indication to production of meat of acceptable quality. Meat tenderness and colour are affected by animal factors (sex, age, temperament) and animal production factors (diet, time on feed, handling stress and health) (Tatum et al., 1999; Sitz et al., 2005; Choat et al., 2006). Flavour is also affected by age, sex, stress level, amount and type of fat, as well as animal diet (Troy & Kerry, 2010). These factors and some animal factors that affect these attributes can be controlled at farm level with the farmer's input. The effects of farmers' choice of marketing channel and how they handled their cattle to the abattoir was determined in Chapter 4.

Marketing channel had significant effects on bruise score, bruise age, pH and L* values. There were positive relationships between distance, stocking density and transportation duration on bruise score and $pH_{u,}$ while a significant negative linear effect of distance, stocking density and transportation duration on L* was observed. Although the farmers' perceptions were positive on the effects of different marketing channels and pre-slaughter handling on beef quality, these results indicate that the farmers could not do much to prevent bruising. The fact that the incidence of bruising was high in cattle that were transported direct from the farm to the abattoir and also the significant effect of stocking density on bruise score indicates that the farmers were using high stocking densities. Bruise score increases with stocking density (Tarrant, 1989, 1988). Pre-slaughter handling of the cattle was also not good despite the positive perception by the

farmers on transport distance, stocking density and handling at loading. This is shown by the incidence of DFD meat (31%). This incidence is quite high compared to 13.89% (Mach et al., 2008), 1.7% (Kreikemeier & Unruh, 1993) and 2.79% (Mounier et al., 2006). DFD meat is dark, unpalatable, tough and unacceptable to the consumers (Priolo et al., 2001). Most of the cattle came from extensive farms and loading could have been difficult, resulting in glycogen depletion and high pH_u values. High pH_u results in DFD beef (Priolo et al., 2001). The perception of meat traders and consumers on effects of slaughter animal welfare on meat quality in general and the quality of beef produced at the abattoir was determined in Chapter 5.

There was some general disagreement between the two groups on the use of quality attributes to predict beef quality. Consumers used the intrinsic cue of colour (for quality) and price to make a purchasing decision while traders used freshness to make a purchasing decision. Although the consumers indicated that they use colour to predict quality, their major concern was the dark coloured beef that they often purchased. They also indicated that times they purchased beef with variations in tenderness. Variation in tenderness is characteristic of DFD beef (33% incidence in this study). According to Priolo et al. (2001), DFD beef often shows tenderness and colour variations. The meat trader by using freshness to predict beef quality is probably using a quality attribute that is not influenced by pre-slaughter beef production factors. Use of colour to predict quality could be useful in this case where DFD beef is often produced. Shelf life of beef is important for the meat trader and probably that explains their choice of this attribute to make a purchasing decision. The general lack of agreement among the three groups of stakeholders on the attributes to use for predicting beef quality is a major setback for the beef industry because the vital feedback from the consumer to the farmer will not be there.

6.2 Conclusions

Farmers had positive perceptions of the most important welfare aspects that directly affect meat quality but the quality of beef form cattle they supplied was negatively affected by some parameters they can control. Farmers can manipulate pre-slaughter parameters such as distance, stocking density and transportation duration to produce beef that is acceptable to the consumers. It was concluded that the consumers and meat traders have different perception of welfare of slaughter cattle and its effects on meat quality

6.3. Recommendations

Farmers, meat traders and consumers play an important role in meat production.

Areas that require further research include:

- The effect of handing animals on farms, transportation and the auction markets. The study should focus on observing loading and offloading of the animals as perceptions can be misleading. Pre-slaughter stress variables should also be measured before loading both at the farms and at the auction markets.
- The transporters' perceptions should also be sought because they also play a big role in meat production
- Abattoir activities should also be included since they also play a significant role in meat production and more smallholder abattoirs should be used in studies of this nature
- Tenderness of the beef should be measured in the laboratory so as to assess the effect of bruising on beef tenderness.
- More accurate methods for aging bruises other than use of colour changes have to be used.

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Appendix 1: – Farmers' perception on animal welfare of slaughter cattle and its effects on meat quality.

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1.0 **Demographic information**

1.1Age of respondent .....

1.2 Gender 1. Male □ 2. Female □

1.3.Educational qualifications.....

1.4 Are your qualifications linked to farming? 1. Yes □ 2. No □

1.5 Did you receive any training on Animal Welfare? 1. Yes □ 2. No □

1.5.1. If Yes, who provided the training?.....

1.6 Do you think farmers should receive training on Animal Welfare? Yes □ No □

1.7. Is the farmer resident on the farm? 1. Yes □ 2. No □

1.8 Farm type: 1. Small-scale commercial □, 2 .Large scale commercial □

1.9 Farming system:1. Intensive □, 2. Extensive □,

2.0 What is the composition of the cattle herd?

	Class					
	Bulls	Cows	Heifers	Oxen	Steers	**Total**
Number						

2.1 Which breeds are you keeping?----------

2.2 Reasons for breed preference?

Reason	**Tick**	**comment**
1. Good quality of meat		
2. Good Temperament		

3Good mothering ability		
4 No horns or easy to dehorn		

2.0 Human/ animal relationship

How important are the following aspects in obtaining an acceptable level of animal welfare and meat quality at slaughter? Each aspect should be ranked on a scale of 1-5: 1 Totally unimportant; 2 Not important; 3 Either important or unimportant; 4 Important; 5 Very important

2.1 Routine handling of your animals at the farm.....

2.2 Trained/skilled animal handlers.....

2.3 Farmer – animal bond.....

2.4 Hand rearing of calves from birth.....

2.5 Ratio of animal attendants/handlers to number of animals.....

2.6 Respect for animals.....

3. Handling of animals for market or slaughter

How important are the following aspects in obtaining an acceptable level of animal welfare and meat quality at slaughter? Each aspect should be ranked on a scale of 1-5: 1 Totally un important; 2 Not important; 3 Either important or unimportant; 4 Important; 5 Very important

3.1 Dehorning all animals at an early age …….....

3.2 Presence of animal handling/ loading facilities at the farm.....

3.3 Presence of the farmer when his animals are being loaded to the market/slaughter .....

3.4 Animal body condition at loading .....

3.5 Loading method.....

3.6 Experienced driver or transporter.....

3.7 Waiting period between selection & loading..... .....

3.8 Marketing channel for the animals.....

4.0 Transportation and slaughter

How important are the following aspects in obtaining an acceptable level of animal welfare during transport and slaughter? Each aspect should be ranked on a scale of 1-5: 1 Totally un-important; 2 Not important; 3 Either important or un-important; 4 Important; 5 Very important

4.1. Distance from farm to the abattoir/market (km):…….…….

4.2. Duration of transport …….....

4.3 Mode of transport to the abattoir or market.....

4.4 Condition of the transport vehicle.....

4.5 Thirst during transport.....

4.6 Hunger during transport.....

4.7 Loading density.....

4.8 Weather during transport.....

4.9 Shock proof & calm transport.....

4.10 Number of transports…….

4.11 Condition or type of the road during transport.....

4.12 Mixing of strange groups during transportation….....

4.13 Lairage duration (how long the animals stay before slaughter).....

4.14 Method of unloading animals.....

4.15 Method of droving animals to loading and stunning.....

4.16 Design of the slaughterhouse.....

4.17 Stunning method at the slaughterhouse.....

4.18 Slaughter without pain/ stress.....

4.19 Mixing strange groups in the lairages……

5.0 Meat quality attributes

How important are the following aspects in defining meat of an acceptable quality to consumers? Each aspect should be ranked on a scale of 1-5: Totally un- important; 2 Not important; 3 Either important or un-important; 4 Important; 5 Very important

5.1 Colour of the meat……

5.2 Leanness of the meat……

5.3 Presence of fat/ marbling……

5.4 Smell of the raw meat……

5.5 Freshness of the meat …….....

5.6 Texture of the meat …….....

5.7 Flavour…….

5.8 The quality stamp (Carcass class)……

5.9 The price of meat ……

5.10 Tenderness/softness of the meat……

5.11 Juiciness of the meat……..

5.12 Bruising……

6 Transportation and bruising

6.1 Are you aware that transportation can cause injury and bruising to cattle? 1. Yes □ 2. No □

6.2 Are you aware that you can have your cattle carcasses downgraded because of bruising? 1. Yes □ 2. No □

6.3 Have you ever received complaints from the abattoir about bruises on your cattle? 1. Yes □ 2. No □

6.4 Are you aware that you can loose a lot of money through bruising? 1. Yes □ 2. No □

Thank you for your time.

Appendix 2: Cattle transportation record sheet

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CATTLE TRANSPORT RECORD SHEET

Delivery Date	Loading/ departure time	Time of arrival	Slaughter date	Time of slaughter	Vehicle dimensions Length x Width	No. of cattle in vehicle	Day temp	Farm to Abattoir distance (km)	

Appendix 3: Carcass color & pH record sheet

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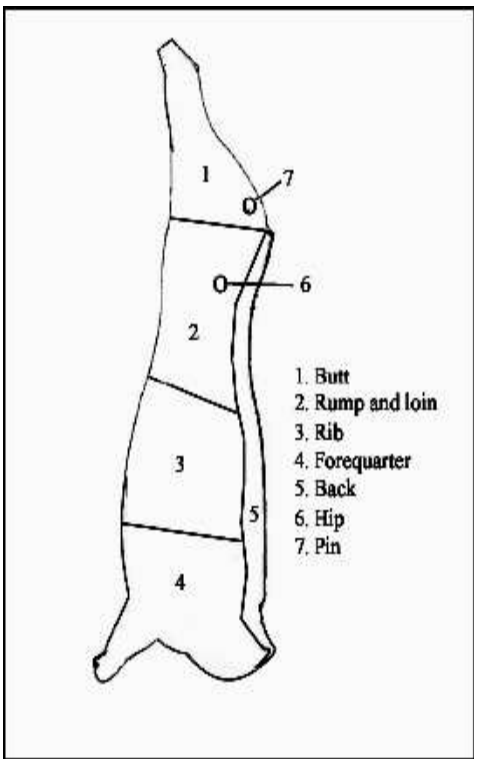
DATE……..

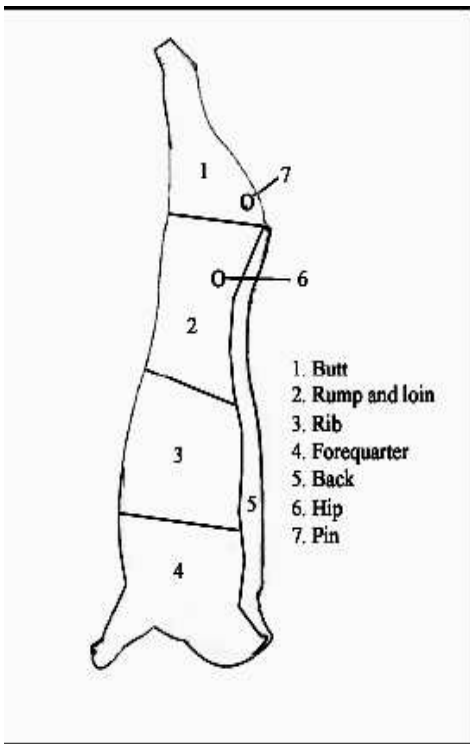
Carcas no.	Breed	Weight	Sex	Class	Age	pH 24	COLOUR AT pH 24		
							L*	a*	b*

Appendix 4: Bruise score record sheet

Carcass No…… Slaughter date……
Breed……..Sex……

Left side Right side





Left Side Right Side

S				
Sd				
M				
Md				
H				
Hd				

Appendix 5: Consumer and meat trader perception on animal welfare and its effects on meat quality

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Consumers and meat trader perception on animal welfare and its effects on meat quality

Name of Butchery/Shop:……..	Enumerator's name:…….....
Type of butchery:…….....	Municipality:…….....
District:…….....	Date:……
Butchery location: a. Communal □, b. Peri-urban □, c. Urban □	

1. Demographic information

1.1. Age of respondent?.....

1.2 Gender: Male □ Female □

1.3 Race ……...

1.4 Employment status? Student □ Part-time □ Full-time □ Not employed □

1.5 What is your highest level of education?.....

1.6 Primary factor in meat purchasing decision: Price □ Quality □ Health Other……...

1.7. Preferred meat product to eat and why: Beef □ Chicken □ Mutton □ Fish □ Goat meat □ Pork □ Other…….

1.8. Meat product most consumed at home and why: Beef □ Pork □ Chicken □ Mutton □ Goat meat □ Fish □ Other……..

1.9. Can you tell the quality of the beef just by looking at it? Yes □ No □

Indicate if you 1. Agree or 2. Disagree with the following statements on animal welfare and its effects on meat quality:

2.0 Cattle handling at the farm and its effects on beef quality

2.1 The way cattle are raised influences the quality of beef……..
2.2 The type of feed given to beef cattle affects meat quality after slaughter……...
2.3 Frequent handling of cattle at the farm results in cattle with a good temperament…….
2.4 Cattle that are difficult to handle at the farm are normally associated with poor quality beef ...
2.5 Overstocking grazing areas results in production of cattle with poor quality beef…….
2.6 Type of breed influences quality…….

3.0. Cattle handling at the markets and its effects on beef quality
3.1. The way cattle are handled during cattle sales influences the quality of beef……
3.2. Mixing strange cattle in the same pens results in poor quality beef after slaughter……....
3.3. Keeping cattle penned at the sales for more than 24 hrs without food and water affects meat quality……

4.0. Animal handling during transportation and its effects on meat quality
4.1 Animal handling during loading to the abattoir influences beef quality……
4.2 Mixing strange animals in the same truck during transportation affects meat quality……
4.3 Loading density affects meat quality……
4.4 Transporting cattle for very long distances affects meat quality……
4.5 Bad driving can result in injury to cattle and production of poor quality beef……

5.0 Abattoir practices and their effect on beef quality
5.2 Cattle are not always treated humanly at the abattoir…….

5.3 The way cattle are slaughtered influences the quality of beef……

5.4 Long lairage durations affects meat quality……

Indicate if you 1. Agree or 2. Disagree with the following statements on meat quality:

6.0. Meat quality cues

6.1. Colour of beef is an important indicator of quality ……

6.2. Leanness of beef is an important beef quality indicator ……

6.3. Presence of fat/ marbling is an indicator beef of quality…….

6.4. Carcass class indicates meat quality & influences my purchasing decision……...

6.5. Place of slaughter is a good indicator of beef quality……...
6.6. Information on the packaging/label is an indicator of quality……

6.7. Smell of the raw meat is an indicator of beef quality……

6.8. Juiciness is an indicator of eating quality…….

6.9. How fresh the meat looks is an indicator of beef quality……..

6.10. Texture of the raw meat is an indicator of eating quality……

6.11. The price of beef is a good indicator of its quality…….

Indicate if you 1. Agree or 2. Disagree with the following statements about the quality of beef you purchase:

7.0 Quality of beef slaughtered at the smallholder abattoir

7.1 The beef is tender at consumption……

7.2. The beef has good colour at point of purchase……

7.3. The beef is of good keeping quality……..

7.4 Bruising affects the quality of the beef……..

7.5. The beef has good taste at consumption……..