

**Investigating communal farmer's perceptions on production practices and evaluating
pre-slaughter responsiveness of extensively reared Boran and Nguni steers**

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Declaration

I, GUZI ANELISA, declare that this dissertation has not been submitted to any University and that it is my original work conducted under the supervision of Dr. Y.Z Njisane. The research was approved by the University of Fort Hare Research Ethics Committee (Certificate No.NJ1011SGUZ01). All assistance towards the production of this work and all the references contained herein have been duly credited.

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Investigating communal farmer's perceptions on production practices and evaluating pre-slaughter responsiveness of extensively reared Boran and Nguni steers

Abstract

This study's overall objective was to investigate communal farmers' perceptions on production practices and evaluate pre-slaughter responsiveness of extensively reared Boran and Nguni steers. On objective one farmers' knowledge and perceptions on cattle breeds, management, and marketing channels in selected villages of Alice, Eastern Cape, South Africa were evaluated. Interviews were conducted using a structured questionnaire divided into demographic information and relevant cattle production practices, following a snowball technique to select 101 cattle-keeping households from Gaga, Ntselamanzi, and Ncerha villages. Most of the interviewed cattle farmers were males (65%), in the age range of 40-60 years, with a primary-matric educational level. Among others, they highlighted financial security (47%) and traditional ceremonies (26%) as the reasons for keeping cattle. Most dominant in their herds were the Boran (49%) and crossbreds (23%) reared extensively with some supplementation (nutritional and medicinal). Their breed selection was based on disease and tick tolerance, temperament, and product (milk and meat) quality. It was noted that most of the interviewed cattle owners have the basic knowledge of good management practices, breed differences, and marketing chains. They related to low productivity to diseases, lack of knowledge, and poor resources. On the second objective pre-slaughter blood-based stress indicators and their subsequent effects were evaluated on beef quality of extensively reared Nguni and Boran steers. Twenty steers (10 Nguni and 10 Boran) aged 18 months were divided into two groups (with 5 of each breed per group) and transported from the University of Fort Hare Honeydale farm to the East London abattoir in the morning and afternoon trips. Upon arrival at the abattoir, the steers were held in lairage units for 24 hours (group 1) and 16 hours (group 2) until slaughter. Blood samples were drawn using a needle and vacutainer tubes from

each steer's jugular vein at the farm before transportation, upon arrival at the abattoir, and during slaughter to perform cortisol, glucose, and routine haematological analysis. *M. longissimus dorsi* samples were harvested on the left side of each carcass to measure the meat quality attributes. Interactions between the observed production-stage activities, breeds, and physiological changes of these steers were recognized; with cortisol and glucose increasing ($P \leq 0.05$) during transportation (4.15 ± 0.46 ng/mL and 5.35 ± 0.46 nmol/L respectively) and also with farm group 1 showing higher cortisol (42.62 ± 14.47 ng/mL) than the second group. Furthermore, all steers that were in slaughter group 1 showed less cortisol (101.49 ± 14.47 ng/mL) and glucose (6.50 ± 14.47 nmol/L) levels than those in group 2. In addition, Boran steers had higher packed cell volume, erythrocyte count, and haemoglobin values (33.27 ± 0.54 %, $7.66 \pm 0.19 \times 10^6$ μ L, and 11.15 ± 0.16 g/dl respectively) compared to Nguni steers in all production-stages. Later in the experiment, the effect of breed type, production stage activities (farm handling, transportation, and lairage duration), and stress responsiveness on some meat quality parameters (pH, lightness (L^*), redness (a^*), yellowness (b^*), hue, Chroma, thawing and cooking loss, and tenderness) collected from the steers were measured. It was observed that the group lairaged for 16 hours produced the highest L^* value (36.25 ± 0.88) compared to those lairaged for 24 hours. As for the b^* and hue of the meat, there were positive interactions between the breed type and the production stages ($p < 0.05$). Lastly, cooking loss and tenderness were significantly affected by the breed type in all groups, with Nguni having the most tender meat (24.06 ± 1.39 %) and less cooking loss (16.92 ± 1.33 %) than Boran breeds. Therefore, the production stage conditions and breed type influenced some physiological stress-indicators and meat quality of Boran and Nguni steers raised on natural pastures. However, there were not many differences observed between the groups and breeds.

KEYWORDS: Human-animal interactions, pre-slaughter stages, physiological stress, meat quality

Dedication

I dedicate the thesis to my parents (Mr. and Mrs. Guzi), sister (Thabisa), brother (Bongani), and nephew (Likhaka Bonita), who have always believed in me and only expected the best.

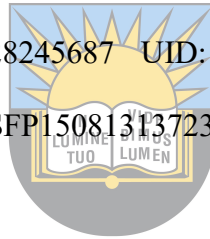


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List of symbols

N – Newton

n – Sample number

s – Seconds

Nmol/L – Nanomole per litre

U/L–Units per liter

ng/ml – nanogram per millilitre

g/dl – gram per decilitre

pg– picograms

% – percentage



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List of abbreviations

Ck- creatine kinase	a* – Redness b* – Yellowness
LDH- Lactate dehydrogenase	C – Chroma
HPA- Hypothalamic-pituitary adrenal	CL – Cooking loss
ATP- Adenosine Triphosphate	DFD – Dark firm and dry
PCV- Packed cell volume	HA - Hue angle
Hgb- Haemoglobin	L* – Lightness
MCV- Mean corpuscular	F- Farm
MCHC- Mean cell haemoglobin concentration	T- Transport
WBC- Leukocyte count	S- Slaughter
PLT- Platelet count	RBC- Erythrocyte count
HR- Heart rate	
h- hour	
ACP- Acid phosphatase	
ALP- Alkaline phosphatase	
EIA- Enzymatic immunoassay	
LTL- Longissimus thoracic lumborum,	



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Chapter 1: Background of the study

1.1 Introduction

Beef contributes about 14% of human diet in many households across developing nations, including South Africa and Turkey (FAO, 2015). In European countries, the contribution is estimated to be only 1.6 %. This implies that beef is mostly consumed in developing countries. On the other hand, the human population continues to grow faster, suggesting more possible future shortages of red meat and its products, particularly in the developing world (Godfray *et al.*, 2010). In an attempt to meet consumer demands, there is a high number of cattle sent to abattoirs for slaughter on a daily basis (Huertas *et al.*, 2010). This is where various pre-slaughter handling procedures are applied. This process involves the transfer of animals from the farm to the abattoir destination using different modes of transport (Hemsworth *et al.*, 2018), with road transport using a vehicle as the common method (Šimová *et al.*, 2016). Transportation of cattle is an unavoidable practice and is frequently regarded as one of the fundamental causes of stress (Miranda-de la Lama *et al.*, 2010). A series of stressors during transportation and slaughter of the cattle include handling at the farm, moving vehicle, weather conditions, and the novel environment with unfamiliar setup, smell, stock handlers, and other animals in lairage units (Adenkola and Ayo, 2010).

The welfare of farm animals as they undergo transportation and slaughter faces expanding examination from the general population, and incorporates worries about how animals are taken care of in the post-farm door. The connection between humans taking care of livestock and animals' welfare has been reliably shown under both exploratory and business conditions for various domesticated animal species (that is pigs, sheep, beef, and dairy cattle) (Losada-Espinosa *et al.*, 2018). However, handling methods have been identified to elicit fear and stress in livestock animals (Hemsworth *et al.*, 2018), thus activating the animals' physiological

response (Sandström, 2009). Response to these stress factors may result in variation in blood components such as creatine kinase (CK), lactate dehydrogenase (LDH), glucose, cortisol, and packed cell volume (PCV) (Petherick *et al.*, 2009; Ekizet *et al.*, 2012).

On the other hand, lairage is beneficial to the animals since it allows them to rest and recuperate from early stresses encountered throughout road transport (Zhen *et al.*, 2013). Recuperation of cattle in lairage units might be influenced by many factors such as lairage duration (Ferguson *et al.*, 2007; Ekizet *et al.*, 2012), environmental conditions (Lowe *et al.*, 2017), social mixing (Beery and Kaufer, 2015), and supply of food and water (Goddard, 2008). This implies that keeping animals in lairage units can be an added stressor, with some researchers claiming live weight losses. Other studies have identified multiple stress indicators (Dikeman, 2017), with cortisol being the most reliable and tested indicator of stress (Grandin *et al.*, 2007). In beef cattle, cortisol has been measured from blood, feces, urine, and saliva (Hagenmaier *et al.*, 2017; Faucitano, 2018). Increased stress responses had a deleterious influence on the welfare and quality of meat obtained from the cattle (Tekeet *et al.*, 2014). The impacts of various lairage duration on the physiological and behavioural state of the animals and their meat quality have been accounted for by several research gatherings, however, the outcomes are not all clarified.

1.2 Problem Statement

Some breeds of cattle fail to cope with the harsh environmental and socio-economic conditions common in the communal areas where, among other restraints, disease is rampant, feed is scarce, and management is poor. Lohakareet *et al.* (2013) reported that there is a good opportunity to improve the productivity of the livestock by bring together appropriate technologies and systems. However, it is a slow and difficult process for these communities to bringing about a change in the practices followed so far, due to traditional mindset and lack of infrastructure to develop the market chain (Hegde, 2019).

Handling of animals at the farm, transportation, lairage, and slaughter are important components of the meat production chain (Dikeman, 2017). Such factors have been reported to cause many production losses, including abnormal meat quality attributes such as pale soft exudative (PSE) and dark firm dry (DFD) meat, and increased stress levels associated with emotional reactivity. Stress is an unavoidable result in the process of taking animals from the farm to the abattoir. Although these are necessary procedures in the production chain and therefore cannot be completely discontinued, they have been previously reported to negatively impact slaughter animals of different species, thus resulting in poor animal welfare and reductions in meat quality. The reactions of animals to external difficulties are adjusted by a number of distinct animal components, for example, hereditary qualities (Boles *et al.*, 2015), sex, age, and physiological state (Munoz *et al.*, 2012), and by past encounters and obtained learning.

There is always a need to constantly evaluate the situation because all of these production chain stages are essential components of the meat industry. Recently production chains have been more arranged and modified, for example making pre-slaughter operations dynamic and complex by fixing their storage center, resting place, and health checkpoints. These changes can improve productivity but also increase the occurrences of pre-slaughter stress, resulting in poor welfare of the animals (Miranda-De La Lama *et al.*, 2014).

Presently, there are strict rules and regulations set on slaughter conditions regarding animal welfare but do not contain commendations concerning the ideal period for lairage and transportation time. However, among the researchers there are inconsistencies about the influence of various transportation and lairage duration on the physiology and beef meat quality. As for farm handling, little research has been done on the stress responsiveness of beef cattle. More observations are made during transportations and lairage. Therefore, current

literature does not offer proper guidelines and more knowledge about which production stage activities mostly affect the animal's physiological stress-indicators and meat traits. Other interrelated problems also evolve around which haematological parameters can be used to evaluate stress levels after farm handling, transportation, and lairage, especially in beef cattle.

1.3 Justification

An estimated 35 % of the South African people are at risk of food insecurity (Van Averbek and Khosa, 2007). This condition mostly occurs amongst black people who live on commercial farms and rural areas (Kirsten *et al.*, 1998; Mlambo, and Mapiye, 2015). Oluwatayo (2019) reported that income is the leading cause of household food insecurity. Accordingly, South African black rural households depend mostly on livestock farming for survival and monetary income (Tibesigwaet *al.*, 2018). However, more effort is required to improve livestock production for food security in these areas. The indigenous knowledge, socio-economic situation and attitudes of the rural farmers should be considered when planning strategies for rural livestock improvement. Most younger farmers do not use traditional veterinary medicine in their farming as they consider them outdated. Therefore there is a large possibility that these practices will become extinct with the older farmers and thus there is a need for them to be recognized and protected. Moreover, the livestock growth sector's modernization should also consider the traditional systems and introduce desired changes, involving the marketing values in the developing countries. It is considered that this knowledge will add value to researchers investigating the contribution of traditional farming on the livelihood of communal household farmers.

The measurement of changes in biological parameters such as hormonal and haematological components at slaughter can be used to monitor animal stress. It may be able to discover those responses that are not recognizable. Haematological parameters can also be used to assess pre-slaughter stress (Earley and O'Riordan, 2006; Bornezet *al.*, 2009; Čobanovićet *al.*, 2017),

however, initiating relationships between haematological responses and meat quality needs more work.

Measuring the effect of production stages including farm handling, transport, and lairage duration using plasma constituents such as haematological parameters and cortisol can be reliable and time-consuming since it can provide valuable information (Negrao *et al.*, 2004; Grandin, 2007). However, cortisol might not be the only hormonal constituent that can be used for stress detection, evaluation of haematic profiles can also be useful. Furthermore, animals' physiological reactions to production stages may give the chance to distinguish animals that might be under sufficient stress during transportation and lairage to compromise their welfare and meat quality.



1.4 Aim and research objectives

The broad objective of the current study was to firstly investigate the farmer perceptions and knowledge on cattle breeds and their management. Also, their physiological stress responsiveness after slaughter, as well as how the process compromise affects the meat quality harvested from the two breeds raised on natural pastures.

The specific objectives are:

1. To investigate farmer's knowledge and perceptions on cattle breeds, management and marketing channels in selected villages of Alice, Eastern Cape
2. To investigate pre-slaughter blood-based stress indicators and their subsequent effects on beef quality of extensively reared Nguni and Boran steers

1.5 Hypothesis

The null hypothesis states that:

1. Farmer's socio-demographic information does not affect the cattle breeds, management, and marketing channels
2. Pre-slaughter stages does not affect the blood-based physiological indices of Nguni and Boran steers , as well as stress responsiveness did not affect the quality attributes of beef harvested from both breeds reared on natural pastures.



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Chapter 2: Literature Review

2.1 Introduction

Livestock farming is an important part of agriculture, making a major contribution to the rural economy and socio-economic development in many developing countries. Livestock is fundamental to the livelihoods of the poor and is an important part of farming systems, to which livestock contribute by increasing the productivity of farms and providing a continuous flow of foods and income for households (Van Auerbeke and Khosa, 2007). In South Africa, cattle production is the most important livestock subsector (Museumwaet *et al.*, 2008); in traditional farming, draught power has been linked to poverty because farmers keeping fewer oxen manage to cultivate smaller areas. Cattle farming is also linked closely with the local culture and traditions, which are being followed ever since the domestication of livestock for economic benefits (Satyanarayan and Jagadeeswary, 2010; Lohakare *et al.*, 2013).

On the other hand, on-farm handling and pre-slaughter stress factors, including transportation, lairage, and slaughter, are the significant components of beef production (King *et al.*, 2006) that can influence equally animal welfare and its meat quality (Michael, 2017). Grandin and Shivley (2015) and Grandin (2017) report that an animal's previous experience on the farm can have an influence on how an animal responds to handling in the future. However, the hormonal variables commonly used to detect an animal's response to stressors are those representing variations in the movement of the hypothalamic-pituitary-adrenal (HPA) axis and cortisol levels (Muchenje *et al.*, 2009; Muchenje, 2013; Rey-Salgueiroa *et al.*, 2018). However, according to animal welfare, stress is biologically produced by an animal resulting from exposure to a situation or environment (Von Borell, 2001; Mormede *et al.*, 2007; Chulayo *et al.*, 2013).

Millions of animals are raised in farms in South Africa, and about 75% are transported by trucks to the abattoir (FAO, 2016). According to Ljungberg *et al.* (2007), an increase in animal transport is caused by the continuous structural alterations in slaughterhouses in relation to demands by markets. Road transport of farm animals involves the gathering and loading of animals from their original place and lairage at their final destination (Muchenje, 2009; Schwartzkopf-Genswein *et al.*, 2012; Chulayo and Muchenje, 2016). Generally, it is acknowledged that the time period of the journey is a part of the transportation process that can influence animals physiological response. Therefore, Perez *et al.* (2002) in a reviewing study found that behaviour, biological variations associated to the stress reaction and quality of the meat can produce very valuable information. After entry into the abattoir, there are two vital elements that might influence stress levels in cattle, and thus the quality of meat, which are lairaging and handling techniques immediately before slaughter.



According to Liotta *et al.* (2007), prior to slaughtering, the lairage has three imperative functions: it allows the animal's hygienic control ante-mortem and permits recuperation from physical and nervous stress encountered during transportation. It also ensures a continuous supply of animals to the slaughtering points. Dokmanovik *et al.* (2014) reported that lairage duration could be a significant foundation of differences determining the quality of meat. At slaughter stations, there are stressors and challenges that trouble homeostasis. Firstly, physiological reactions related to heart rate and respiratory frequency are activated, followed by changes in animal behaviour. At that point, the activation of the hypothalamic-pituitary-HPA and the discharge of hormones trigger the sympatho-adrenalelement of the autonomic reaction, rising cortisol and glucose concentrations (Ferguson and Warner, 2008; Romero *et al.*, 2017). In consequence, production and meat quality get affected when stress responsiveness is stronger (Grandin&Shivley, 2015), resulting in many financial losses to the

industry. In general, as long as knowledge in handling and controlling welfare of the animal lacks, the more the continuation of economic losses will be (Webster, 2001).

2.2. Livestock and cattle production and breed choice in Eastern Cape communal areas

Livestock farming is a basic component of South Africa's agricultural industry, producing more than 48% of total agricultural output, with cattle farming as the largest subsector with a share of 26.2% (Mapiyeet *al.*, 2018). The smallholder sector consists of subsistence and emerging farmers who mutually own close to 40% of the 13.4 million available cattle in South Africa (DAFF, 2017). In Southern Africa, over 90% of animal farmers are categorized as smallholders, and about 75% of the livestock, which largely consists of indigenous breeds, belong to the smallholder sector (Nyamushambaet *al.*, 2017; Table 2.1). For example, indigenous cattle breeds such as Nguni, Mashona, Tswana, and Tuli are critical components of smallholder beef production in Southern Africa. Presently South Africa has many indigenous beef cattle breeds such as the Afrikaner, Tuli, Tswana, Barotse, Boran, Mashona, Nkone, Angoni, and Nguni (Dovie *et al.*, 2006); though Nguni cattle numbers in South Africa declined from 1,800,000 in 1992 to 9,462 in 2003 (DAFF, 2015). The situation is intensified by a lack of records and uncontrolled mating systems practiced in the smallholder areas (Mngomezulu-Dube *et al.*, 2018), which, in most cases, promote inbreeding.

Cattle production has contributed to the global socio-economic and environmental status (DAFF, 2017). According to statistics, 1.3 billion people worldwide are directly or indirectly included, of which 600 million are smallholder farmers located in developed countries (Cisneros-Saguilán *et al.*, 2018). Therefore it is essential to introduce sustainable practices that authorize maintenance of milk and meat production to improve cattle production systems, as well as social and environmental benefits (Toro-Mújica *et al.*, 2011), which can suffer due to unsustainable technologies that demand high dependence on external inputs (Partridge, 2018).

There are other options for improving cattle production in the rural areas, such as introducing indigenous cattle breeds, including Nguni cattle bloodlines, and the formation of commercial benefits for subsistence farmers (DAFF, 2017).

Eastern Cape is enhanced with indigenous cattle with a mixture of genetic pools and is known for its expanded and different livestock production systems (Gushaet *al.*, 2018) This is because of the cultural and traditional variety and long-lasting agricultural practice. Out of the counted cattle population found in the country, 86.4 % are indigenous types, and the remaining are the exotic (4.2 %) and hybrids (9.4 %) breeds, respectively (Rowlands *et al.*, 2006; Fraseret *al.*, 2008; Barclay, 2016). Eastern Cape's beef sector includes both traditional and commercial sub-segments. However, traditional beef farming is a practice where mostly local breeds of cattle are kept integrated with crop farming (Mumba *et al.*, 2017). Traditional beef farmers are mostly found in rural areas, often practicing individual grazing on land owned by traditional leaders' trust (Ngubaneet *al.*, 2018). Whereas commercial beef farmers are demarcated as farmers who run large herds of mostly exotic breeds of cattle situated on large sections of titled land (Gushaet *al.*, 2018). DAFF (2017) reported that, during apartheid times, the local people of South Africa were evicted from their productive land, which was owed to the lesser white population.

The traditional and rural farmers are in ownership of adaptable, indigenous breeds which have the capability to cope under local environmental and climatic conditions (Mapiyeet *al.*, 2018). The owned breeds had required qualities for which they are chosen by the keepers and produced healthy calves and good quality meat within current challenges (Holt *et al.*, 2016; Gushaet *al.*, 2018). However, some of these breeds have failed to persist under the critical environmental and weather conditions of communal farms, such as parasite occurrences and disease, limited feeds and their resource, poor marketing channels, and dryness and heavy rains (Kunene-

Ngubaneet *et al.*, 2018). According to Muzzo and Provenza (2018), the motivation to select and keep specific breeds by communal famers is to use them to make money through many processes . Promoting the off-take rate on rural farms could be one way to modify the challenges of harsh conditions (Mugwabanaet *et al.*, 2018). Randhawa *et al.* (2016) reported that for the past 50 years, the population of cattle has expanded to about 50 %, while their products, including milk, meat, and hides, has improved up to 100% (Zhao *et al.*, 2015). However, this shows an improvement in both genomic value and animal welfare practices on beef breeds selection. The reason behind this practice is to secure the livelihood of the people.



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Table 2.1: Population of beef cattle in the African countries

Country	Population (millions)	Proportion in smallholder areas
South Africa	14.1	0.67
Botswana	2.3	0.88
Malawi	1.2	0.90
Mozambique	1.2	-
Namibia	2.4	-
Zambia	2.5	0.94
Zimbabwe	5.2	0.91



Source: Nyamushamba *et al.* (2017)

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2.3 Marketing Channels

2.3.1 Agricultural markets in communal sectors

Animal production is reported to be the most significant agriculture component as people mostly depend on livestock for many reasons, including nutritional consumption (milk, meat), transport, manure, cultural purposes and income generation through sales (Katikati and Fourie, 2019). Musemwaet *et al.* (2007) said that in meat production, cattle, pig, sheep, and goats are the main livestock species that produce meat in South Africa. It was stated that cattle production added 25% and 30% to the national agricultural Gross Domestic Product (GDP) (Scholtz *et al.*, 2008). The South African government introduced the Marketing of Agricultural Act of 1996 to stop the control boards (DAFF, 2012) and make sure that poor rural people gain access to marketing channels as a productive asset for agricultural reasons (Cheteni and Mokhele, 2019). Additionally, the Marketing Act was meant to increase free and wild agricultural service markets and allow smallholder farmers access (Grace *et al.*, 2015). However, in agricultural resources, the biggest financial investment in communal areas can be attributed to cattle (Ndoroet *et al.*, 2014).

The marketing channels practiced in the communal areas strengthen their household economy. Moreover, rural households still find it complicated to reach the mainstream markets, as most of them are still selling their livestock through informal markets (Gwiririet *et al.*, 2019). Market off-take is still observed to be low in societies that are benefiting from government projects (Shackleton *et al.*, 2019). It was found that communal farmers receive less profit from their livestock through this marketing channel. Hence, Ndoroet *et al.* (2014) reported that it should be a basic practice to consider the status of livestock to conserve them and promote their economic potential. Other factors that lead to lower prices for livestock have been recognized (Musemwaet *et al.*, 2007). Allsopp *et al.* (2007) and Mertz *et al.* (2009) reported that other

challenging factors included theft, poor livestock health, limited resources, and information. The influence can be improved if livestock, particularly beef cattle from the communal areas, are carried into the formal economy (Mapiyeet *et al.*, 2018).

Furthermore, some households mentioned economic, political, and social factors rather than limited information as the main reason to lose out in marketing and beef production (Pannell *et al.*, 2006). In southern Ethiopia, cattle keepers identified hunters, feed and water scarcity, drought, and diseases occurring in animals as the main constraints on cattle production (Scholtz *et al.*, 2008; Desta *et al.*, 2011; Letsoaloet *et al.*, 2016). This was accused of influencing the quality of livestock, production and their market value. Stress in farm animals is currently conceived as a reaction that happens ineluctably when cattle are unprotected from harsh environmental situations, which is the reason for some unfavorable consequences, ranging from discomfort to mortalities (Dolinska, 2017).

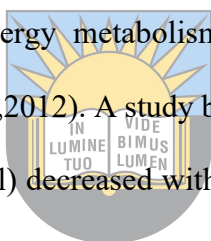


2.3.2 Challenges faced by the marketing channels: Transportation of farm animals

In Agricultural industries (farm and meat industry), the meat production network is an imperative aspect that incorporates different acute periods, including loading, transportation, and slaughtering of the farm animals (Čobanovićet *et al.*, 2017). Animal transportation may differ depending on the size and source of the animals, and in South Africa, steers that are traded at closeout markets can either be transported straight to the slaughterhouse for slaughter or can be taken to ranches or feedlots where they are held and fattened before discharged for slaughter (Vimiso and Muchenje, 2013). Transportation is also known to have a huge impact on animal production (Frimpong *et al.*, 2014). It is widely known and scientifically proven that pre-slaughter stress commences during occasional handling of animal and meat products. Nevertheless, Wighamet *al.* (2018) reported that reduction of muscle glycogen due to transportation had been found to have a strong impact on a few key meat quality characteristics,

for example, ultimate, tenderness, colour, water-holding capacity and sensory indicators (Mounieret *et al.*, 2006).

When animals are transported to an abattoir on arrival, they are offloaded and regularly held in lairage prior to slaughter (Chulayo *et al.*, 2016). Wigham *et al.* (2018) showed that animals develop means to adapt to the environmental changes that end up affecting even their physiology during the transportation period. Cattle react to stressful factors with high lactate, creatine kinase, and catecholamines activity (Terlouw, 2005; Chuyalo *et al.*, 2016). Besides, pre-slaughter stress factors such as transportation, ambient temperature, occasional poor handling, distance, and lairage duration cause animals to release hormones and enzymes (creatine kinase, cortisol, and catecholamine) into the bloodstream leading to a series of secondary processes that include energy metabolism (Beerda *et al.*, 1997; Ferguson and Werner, 2008; Chulayo and Muchenje, 2012). A study by Frimpong *et al.* (2014) indicated that the amount of stress hormone (cortisol) decreased with increased transport time while lactate and creatine kinase increased.



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Furthermore, it was also reported that long transportation hours in poor condition transporting vehicles are not suitable for animal welfare (Njisane, 2016). Mixing the animals during transportation might increase the exposure of animals to infections. This is because susceptibility to stressors during transportation is related to a decrease in the function of the immune system of animals (Hulbert *et al.*, 2011; Adenkola and Ayo, 2010), increasing the susceptibility to respiratory diseases in cattle (Grandin, 2017), which may result in the release of stress hormones (Llonchet *et al.*, 2015). Moreover, transportation at high stocking density was described to elevate plasma cortisol (Kadimet *et al.*, 2009). McKenna (2017) reported that the increase of stress hormones in animals during sampling might result from handling and the novel environment. Nevertheless, assuring great transportation does not just guarantee the good

welfare of animals and the quality of meat; it is likewise of economic significance (Anderson *et al.*, 1999; Bornezet *et al.*, 2009; Costa *et al.*, 2015).

Transportation is an intimidating event in the life of livestock animals; it involves a series of handling and limitation situations that can lead to distress, injury, or even death of the animal (Tarrant and Grandin, 2000). During transportation, animals have to cope with several multifactorial stressors (Miranda *et al.*, 2010). The transport and handling of animals are vital factors in meat production chains. According to Ljunberget *et al.* (2007), transport and handling of slaughter animals are one out of many events that cause an increase of cortisol stimulation and unfavourable conditions on beef steers, increasing the chances of spread of disease and also reducing the meat quality (Chulayo *et al.*, 2013). Many studies discovered that during transportation, animals use more energy (Grandin, 2010; Miranda *et al.*, 2014). Chulayo *et al.* (2016) stated that the use of energy during this dangerous production stage (transportation) is affected by the hypothalamic-pituitary-adrenal axis leading to a secretion of cortisol (Tarrant and Grandin, 2000; Chulayo *et al.*, 2016).



A common observation following transportation is a temporary increase in blood cortisol levels, and many causes may add to this stress reaction, including human-animal interactions before and after transportation (Chen *et al.*, 2015). The difficult combination of stressors linked with transportation proceedings has been related to a wide range of physiological reactions (Chen *et al.*, 2015), including changed immune function, behavioral response (Njisane, 2016), and muscle physiology (Chulayo *et al.*, 2016).

Table 2.2: Commonly used physiological indicators of stress during transportation

Stressor	Physiological variable
Measured in blood or other body fluids	
Food depreciation	↑ FFA, ↑ β -OHB, ↓ glucose, ↑ urea
Dehydration	↑ Osmolality, ↑ total protein, ↑ albumin, ↑ PCV
Physical exertion	↑ CK, ↑ lactate
Motion sickness	↑ Vasopressin
Fear or Arousal	↑ Cortisol, ↑ PCV
Other measures	
Fear/arousal and physical	↑ Heart rate, heart rate variability ↑, ↑ respiration rate
Hypothermia/ hyperthermia	Body temperature, skin temperature

Modified from: Broom (2003)

The transported animals are regularly introduced to a range of physical and psychological stimuli, many of which are new, and some are averse (Rajionet *et al.*, 2001). Physical and psychic efforts happening during the transportation of livestock animals disturb their homeostasis and digestion and subsequently increase the action of enzymes and hormones (Ayo and Oladele, 1996; Mostl and Palme, 2002; Adenkolaet *et al.*, 2009). Also, Bauer *et al.* (2001) and Saunders and Straub (2002) showed that numerous stressors prompted the actuation of the autonomic sensory system (Spencer *et al.*, 1984), with the pituitary-adreno-cortical system also assuming a vital role in the adjustment of stress reaction (Armario, 2006). Plyaschenko and Sidorov (1987) reported an increase in the adrenal cortical movement in pigs transported, showing an increase in the blood level of 11-hydroxycorticosteroids (11-oxy) 30 min the beginning of transport. Odoreet *et al.* (2004) discovered the initiation of the hypothalamic-pituitary-adrenal axis and the catecholaminergic system in calves' long transportation. They detected increased blood hormone levels, lymphocyte, glucocorticoid and adrenergic receptor, cortisol, and catecholamine fixations. Adenkolaet *et al.* (2009) showed that transportation actuated leucocytosis, neutrophilia, lymphocytosis, eosinophilia in control pigs that were not enhanced with ascorbic acid while the protein, basic phosphatase, aspartate aminotransferase, and neutrophil-lymphocyte proportion was found to decrease essentially in pigs regulated with ascorbic acid when contrasted with the control group after 4 hours of transportation during winter.

Knowles *et al.* (1999) investigated the impacts of transportation on cattle for up to 31 h. They observed that plasma creatine kinase increased extremely after 26 h, and the animals that took rests during the adventure had higher amounts of cortisol. Furthermore, plasma protein ascended with increasing venture duration, and plasma glucose initially increased yet decreased after 21 h of transport, and plasma urea increased with increasing venture time, yet packed cell volume (PCV) expanded amid the initial 12 h of recuperation, yet diminished after 31 h

(Natochin and Chernigovskaya, 1997). On the other hand, Galipalliet *al.* (2004) observed that Tasco seaweed (*Ascophyllum nodosum*) supplementation increased cell reinforcement movement and invulnerable reactions following road transportation in goats. They demonstrated that plasma cortisol and glucose increased because of transportation; however, they diminished essentially in the wake of holding and that plasma creatine kinase exercises and neutrophil check expanded (Barton *et al.*, 2003). In spite of the fact that lymphocyte counts diminished fundamentally amid the transport time, eosinophil and monocyte checks were barely impacted by transportation effects (Balcombe *et al.*, 2004).

2.4 The concept of animal stress

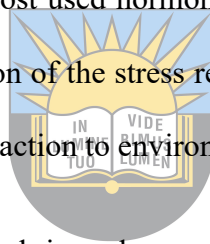
Past an expansive decent variety of ideas, welfare alludes chiefly to the animal's subjective psychological state, as identified with its internal and external condition. In the early nineties, stress was described by BernardClaude as an agitation of the ongoing state of the internal environment (milieu interieur). The term was differently defined by Canon (1929) using the modified term, homeostasis. On the other hand, Selye (1973) expanded its definition, redefining it as a certain reaction of the body to any demand. Stress in animal welfare has been widely observed by a series of plans and diverse perspectives such as biomedical and animal sciences (Ralph and Tilbrook, 2016). Stress significantly affects animal health and productivity, and an open impression of animal stress can have a negative impact on industrial practices. Understanding stress reactions in livestock may help diminish stressful management procedures and encourage the determination of stress-tolerant animals.

2.5 Methods of measuring stress

2.5.1 Biochemical and haematological measures

The most known sensitive biological conditions for measuring the well-being of farm animals such as heart rate and respiratory rate (Wigham *et al.*, 2018), are not enthusiastically practicable

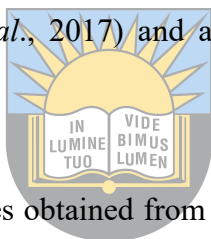
to be evaluated in the sensitive environment of the slaughter area. However, assessing behaviour and physiological responses in a commercial abattoir can be very difficult. Grandin (1980) reported that the easiest technique of measuring severe stress is relating baseline levels for heart and breathing rate and body temperature with those attained during stressful circumstances. However, this only worked for physical activities. It was discovered that blood catecholamines and glucocorticoids could also be used to determine stress levels since these hormones take part in the body's response and adaptation to stress (Kilgour, 1978 and Stermer, 1978). Recently, it has been scientifically proven that biochemical parameters are mostly used in livestock animals to assess stress under different conditions (Stafford and Mellor, 2005; Bristow and Holmes, 2007). One of these parameters is cortisol, and although there are different parameters, cortisol is the most used hormone in different species, including cattle. Other than being an animal's indication of the stress response, the hormone cortisol regulates the activities of different systems in reaction to environmental conditions (Corninet *et al.*, 2013).



Some individual factors such as epinephrine, glucose, creatine kinase, and lactate are related to pre-slaughter stressors and health in cattle. According to Grandin (1980), epinephrine levels are considered the most complex animal response to chronic stress, such as fear resulting from handling methods used in the slaughterhouse or stunning pen. However, according to Boissy and Neindre (1997), creatine kinase and lactate are muscle-specific and hormones, respectively which indicate levels of stress and can indicate leakage from the muscle as a result of suffering in critical conditions such as pre-slaughter stressors; especially during handling (human-interaction) and physical exercise (Grandin, 2000; Grigoret *et al.*, 2004). Moreover, lactate levels are also used to indicate physical stress and fatigue (Broom, 2003; Petherick *et al.*, 2009). During these critical conditions, creatine kinase regenerates Adenosine Triphosphate (ATP) to maintain energy homeostasis (Warrisset *et al.*, 1998), because in the process, hypothalamic-pituitary-adrenal corticoid becomes influenced by the use of energy and protein imbalances

(Bristow and Holmes, 2007). However, the production of glucocorticoid as the effect of stress can cause rapid glycolysis, resulting in elevated blood lactate (Probst *et al.*, 2012).

Measuring differences in biological factors such as haematological parameters can be used to provide relevant results as the proof of stress and may be able to indicate unrecognizable reactions (Wigham *et al.*, 2018). Haematology is the investigation of the numbers and structure of cell components of the blood, namely; the red cells (erythrocytes), white cells (leucocytes), and the platelets (thrombocytes) and the use of these results for treatment of the blood and analyzed diseases (Etimet *et al.*, 2014). However, for the physiological status of animals, haematological parameters are considered as good indicators; furthermore, haematological components help in observing feed poisonousness, particularly with feed ingredients that are in contact with the blood (Docanet *et al.*, 2017) and also the health status of farm animals (Chinekeet *et al.*, 2006).



NseAbasiet *et al.* (2014) stated that values obtained from the haematological factors could work as standard information for differences in conditions of physiological status and well-being of livestock animals (Table 2.3). In addition, during different management processes, stressed animals' outcomes can be estimated in plasma constituents of tested blood (Bornezet *et al.*, 2009 and Etimet *et al.*, 2014).

Table 2.3: Values of the haematological parameters for farm animals

		Cow	Sheep	Swine	Rabbit	Pig
Packed volume (%)	cell	24 – 48	24 – 45	32 – 50	30 – 50	37 – 48
Haemoglobin(g/dl)		8 – 15	8 – 16	10 – 16	10 – 15	11 – 15
Mean corpuscular (fl)		40 – 60	23 – 48	50 – 68	78 – 95	67 – 77
MCH(pg)		11 – 17	8 – 12	17 – 23	-	-
Mean haemoglobin concentration(g/dl)	cell	30 – 36	31 – 38	30 – 36	27 – 37	30 – 34
Leakocyte (*100)	count	4 – 12	4 – 12	7 – 20	4.5 – 11	5 – 8.9
Lymphocytes		40 – 70	40 – 70	40 – 60	40 – 80	39 – 72
Monocyte		1 – 6	0 – 6	2 – 10	1 – 4	2 – 6
Eosinophils		0 – 4	0 – 10	0 – 10	0 – 4	0 – 5
Basophils		0 – 2	0 – 3	0 – 2	1 – 7	0 – 3

Adopted from: Etimet *al.* (2014)

According to Isaac *et al.* (2013), animals with virtuous blood conformation are probably expected to behave well and show good performance. Moreover, laboratory tests in the animal or human body are commonly run on the blood as the vital tool in identifying any abnormalities (Webster, 2001).

2.5.2 Heart rate

Heart rate (HR) is one of the ways to measure cardiac activity. In cattle, heart rate can measure stress from physical and emotional origins (Borellet *et al.*, 2007). To measure heart rate in calves, they wear the heart rate monitors for an hour to facilitate them to become accustomed to the equipment (Borellet *et al.*, 2007) and get proper HR readings. Therefore, heart rate measurement has been used as a noninvasive method for assessing beef cattle's well-being (Quevedo *et al.*, 2019). To improve after-birth care and reduce the death rate of beef calves, heart rate parameters can be measured (Alfonso *et al.*, 2018). Heart rate is reported repeatedly as one the most factor that is used to measure fetal welfare in the final stages of pregnancy in livestock animals and humans (Quevedo *et al.*, 2019). However, there are limited studies suggesting heart rate variability as the used technique to measure beef cattle's well-being during pre-slaughter conditions.

2.6 Some stress-inducing factors

2.6.1 Sound

A study by Lyverset *et al.* (2013) shows that cattle have more sensitive hearing than humans, and noises lower to humans are quite loud to cattle. Ames (1974) also reported that cattle are known to have low-frequency hearing than any other mammal. Therefore, it was picked up that this increased sensitivity makes noises such as equipment rattling, metal on metal sounding, and noise created by humans prime areas for potential hearing stressors (Lyverset *et al.*, 2013).

Moreover, to livestock, unexpected loud or novel noises can be extremely stressful. Sheep exposed to exploding firecrackers or noises in a slaughter plant was found to have an increased thyroid hormone level and elevated cortisol (Pearson *et al.*, 1964).

Talling *et al.* (1996) reported that high-pitched sounds had a greater effect on an animal's heart rate than low-pitched sounds. Lainer (2000) also found that the most effective stimuli for causing a startle response in cattle were sporadic, high-pitched sounds and sudden movements. Domestic animals like pigs are most sensitive to noise at 500 Hz (Talling, 1996; Lyverset *et al.*, 2013). This current study suggests that novel sound is an affecting stimulus that primarily triggers the animals' defense mechanisms. The authors acknowledged that reducing all forms of noise during handling is needed to help decrease the level of fear in beef cattle.

2.6.2 Overcrowding

Overcrowding is an overpopulation of animals in one area of an environment. The high density of animals on the farm results in stress due to the fights and bullying in the crowd, and overcrowding reduces an individual's capability to avoid violence from others (Beery and Kaufer, 2015). Furthermore, crowding decreases access to important resources such as food or resting spaces and increases competition between animals (Beery and Kaufer, 2015; Kathryn and Gregory, 2015). Therefore, agonistic behavior during feeding increases for cattle when animal density per unit feeding space increases (Proudfoot *et al.*, 2009).

2.6.3 Fighting

When animals are handled, they are subjected to inevitable husbandry practices. Grandin (1990) reported that the strength of a cattle's response to a few stressors relies upon numerous variables, including the level of tameness and adaptation to the climate. The basic hormonal mechanisms underlying stress include the secretion of epinephrine, which activates the animal for the classic "fight or flight" response, and glucocorticoids' secretion (Grandin, 1990;

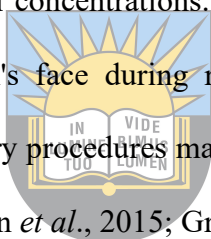
Moberg, 2001). According to Carreras *et al.* (2017), glucocorticoids are released later and help maintain energy supplies and resist stress. Furthermore, exposure to humans is one of the potentially most frightening events that many farm animals experience in their life. As shown by glucocorticoids and corticosteroids, it has been reported that human interaction with animals affects animal productivity and physiology (Carreras *et al.*, 2017).

At all times before slaughter, cattle may experience stress from a range of handling practices and some pre-slaughter stresses, such as fighting, fasting, loading and transport, mixing, and human interactions (Faucitano, 2018). In cattle, fighting has been reported as the key cause of dark cutters (Deesinga, 1997) and the major cause of death losses (Grandin, 1970). When different animals are mixed, they fight to determine the new group leader. Having different breeds in the same group, most especially between steers, is a major animal welfare issue. When mixing strange cattle, aggression occurs as they create a new social hierarchy. The cattle with dark cutting meat were often either the lightest or the heaviest animals in pen (Grandin, 1970). However, this indicates that social order is related to stress since the heavier animals are usually dominant. The higher occurrence of dark cutters in lighter-weight cattle is possibly due to aggressive small animals fighting with larger animals. Therefore the body size of an animal, age, size, and shape of the pens may also be considered a factor (Grandin, 1980).

Von Borell (2001) reported that animals were in a vast pen and were watched running at each other and butting at high-speed rates. Furthermore, in many occasions where the dark cutters were the heavier animals, the pen's movement level was high and dominant animals exhausted a great deal of vitality (Grant and Albright, 2001). However, in the gathering where the dark cutters were the lighter weight dairy cattle, perceptions showed that the docile lighter steers experienced issues staying away from the dominant animals in the little swarmed pen (Grandin, 1980; Broom, 2003). More research is expected to decide the ideal space necessity.

2.6.4 Restraining of animals

Restraint is a method used when handling cattle and many other species. There are many situations where farm animals have to be handled, restrained and or transported (Grandin and Shivley, 2015). Chen (2016) reported restraint as a stressor that causes behavioural changes. Restraint stress has negative effects on cattle's productivity and on the secretion of cortisol by the adrenal axis (Chen, 2016). There are contradictory studies based on the effects of restraining stress on cortisol levels. For example, Szenciet *al.* (2011) demonstrated that restraint increases Adrenocorticotrophic hormone (ACTH) response, elevates serum cortisol concentrations, and alerts the immune response in cattle. Similar findings were demonstrated by Grandin and Shivley (2015) that when some animals are restrained, they react with greater nervous behaviour and higher cortisol concentrations. Although, Chen *et al.* (2015) showed that placing a mask over an animal's face during restraint significantly reduces cortisol concentrations. Restraint for Veterinary procedures may be very stressful for one animal, and it may be relatively less stressful (Chen *et al.*, 2015; Grandin and Shivley, 2015).

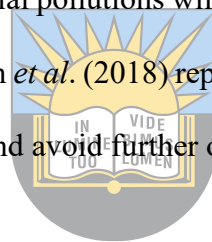


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2.6.5 Effect of lairage on meat quality

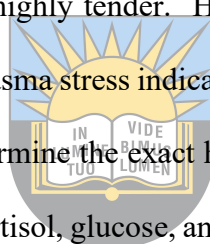
The well-being of beef cattle is very important after transportation and during lairage. Losada-Espinosa *et al.* (2018) reported that animals get challenged by stress-making situations during pre-slaughter processes, for example, when they find it difficult to adapt physiologically to physical challenges in the new environment (Strappiniet *al.*, 2010). In addition, the handling techniques used at the abattoir can be very stressful for cattle (Hemsworth *et al.*, 2018). These high levels of stress can perturb the homeostasis of animals, increase exposure to disease, default growth, damage life probability, and decrease meat quality. In beef cattle, interpretation of the physiological response to various conditions combined with history and recent findings provides animal handlers and farmers with valuable information.

Many animals are seen to be exposed to a series of stressors during the pre-slaughter period. Numerous elements identified with pre-slaughter handling, such as transportation and lairage, influence meat quality (Li *et al.*, 2018). Despite the fact that the purpose of lairage is to empower animals to rest and to recover from transportation stress, it can be a notable source of meat quality issues, Table 2.4 (Terrant, 1990). Animals may experience the ill effects of various bruising and injury levels because of attacking or overcrowding (Miranda *et al.*, 2014). Lairage can also act as repositories of disease by pathogenic bacteria, and there is proof that longer holding times increase the risk of carcass contamination (Adzitey, 2011). However, poor handling of animals in the lairage, for example, the utilization of electrical rods, abstracting the movement of animals through the race, beating and a firm grasp of the coat with the hand, and contact exposure of animals to microbial pollutions will antagonistically have an impact on the meat quality (Jarvis *et al.*, 1996). Akin *et al.* (2018) reported that conditions in the lairage need to be favourable to prevent diseases and avoid further or more stress after transportation.



However, Rey-Salgueiroa (2018) reported that animals transported for 15 minutes showed significant lower pH in muscle and a tendency to show most acid muscle compared with animals transported for three hours. Furthermore, a study by Perez *et al.* (2002) showed that pigs subjected to short journeys have a higher tendency to produce PSE (Pale soft exudative) meat than pigs transported longer. A study by Tekeet *et al.* (2013) showed that cattle that had shorter lairage duration were more stressed at slaughter, and their carcass had higher pH than those of long lairage duration. These findings agree with Listeet *et al.* (2011), who found that pre-slaughter stress, including lairage duration, had a significant effect on meat quality because the meat of those who were short-lairage had higher pH values. In contrast to these findings, Dokmanovik *et al.* (2014) and Liota *et al.* (2007) reported that animals undergoing long lairage duration had significantly higher pH values than short lairage duration.

The animals that rested for a longer period had meat with greater redness than those that rested for a short time (Gallo *et al.*, 2003; Rey-Salgueiret *et al.*, 2018). However, Ekizet *et al.* (2012) and Li *et al.* (2018) discovered that both the rate of pH decrease and the ultimate pH of post mortem muscle is vital for meat quality development, which affects meat tenderness, water holding capacity, and colour (Chulayo, 2016). Different times spent in lairage prior to slaughter have been introduced and presented by many authors, of which some agree on short lairage and some on long lairage. Nevertheless, Moss and Robb (1978), Liotta *et al.* (2007), and Tekeet *et al.* (2014) suggested that after transportation, longer lairage is needed to prevent the bad effects of transportation on meat quality because when buyers choose meat, they are willing to pay for the meat that is of good quality and highly tender. However, some literature reported short lairage duration as the best for both plasma stress indicators and meat quality (Ferguson, 2007). Therefore, it is very important to determine the exact hours suitable for cattle at lairage using plasma stress indicators (haematic, cortisol, glucose, and creatine kinase) and meat parameters. Investigation of factors that leads to the production of less tender meat by beef cattle is required.



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Table 2.4: Effect of pre-slaughter handling on carcass and meat quality of beef cattle

pre-slaughter handling	Carcass and meat quality effects	References
Overloading	Injury and damage	Tarrant (1990)
Held overnight in noisy yards	Bruise	Eldridge (1988)
Transportation	Spread of pathogens on the hides	Avery <i>et al.</i> (2002)
Transportation	Shedding of Salmonella spp.	Barham <i>et al.</i> (2002)
More than 24 hours of fasting	Carcass yield was reduced by 1.7%	Price (1981)
Cattle transported for 2hours	1.5 % loss in carcass yield	Smith <i>et al.</i> (1982)
Prolonged stress	Meat appears darker, and a heat ring is formed	Buycket <i>al.</i> (1985)
Poor handling	4.1 % of dark cutting beef	Brown and Bevis (1988)
Overloading	Animal injury and damage to the carcass	Tarrant (1990)
Longer journey	Associated with a significantly larger live weight loss	Gallo <i>et al.</i> (2003)
Longer lairage time	Decreased muscle luminosity and increased DFD	Gallo <i>et al.</i> (2003)
High stocking density	Increased bruising and reduce dressed carcass weight	Tarrant and Grandin (2000)
Long-distance road	Lost weight	Marahrenset <i>al.</i> (2002)

2.6.6 Extreme weather conditions

During periods of critical weather, optimum conditions for animal comfort and performance are compromised (Mader and Griffin, 2015). The combinations of humidity, precipitation, and heat radiation are the effective ambient temperatures that lead to increased stress levels. Hot weather can strongly affect animal bioenergetics (Hahn, 1999), with consequent adverse effects on beef cattle's performance and well-being (Piao *et al.*, 2015). These effects increase the levels of stress in animals resulting in reduced feed intake and growth production. Although Curtis *et al.* (2017) reported that environmental stressors may not immediately affect production variables, like feed intake. Environmental stressors lead to stress. When animals are stressed, there is a rapid release of chemicals (cortisol, creatine phosphokinase, and lactate). When animals release more chemical compounds, they lose more energy. Hence, alternative supplementation programs need to be considered for livestock challenges by environmental conditions, and in the case of heat, provision of shades on the farm is needed.

In a hot climate, high ambient temperatures are among the environmental stressing factors that may cause strain on livestock animals, including beef cattle. The well-being, performance, and survival of beef steers are strongly affected by climatic conditions (Mader, 2013). Livestock surviving in a natural environment experience different temperatures all day long. Under these conditions, animals may experience thermal stressors, including heat and cold stress. Although heat stress has been mostly studied in dairy cows, it has been found to affect the secretion of stress-related indicators or stress hormones in beef cattle (Grandin, 1980). Management systems and skills are needed that include information and strategies on how cattle respond to climatic conditions (Mader, 2003).

2.6.6.1 Heat stress

In most environments, cattle are raised in the pasture. According to Moonset *et al.* (2014), pasture-based farms are preferable for animals' welfare, even though animals reared on pasture

in farms are more exposed to climatic conditions, including heat and cold climate. Also, cattle feeding on pasture experience more heat stress than cattle that have access to graze under shades. Providing shade on farms will protect cattle against heat stress. Moons *et al.* (2014) and Grandin (2016) reported that cattle living and grazing under a shade and or shelter release lower corticosteroid concentrations due to lower stress than those exposed to a hot climate.

The effect of heat stress on those animals that have become more accustomed to handling is lower compared to those that are handled less (Young, 1993). However, there has been little information and discussion on literature regarding the relationship between heat and the secretion of stress-related hormones in beef cattle raised on natural pastures. According to Silanikove (2000), welfare is a characteristic of an animal, which differs from poor to good and can be distinguished by separate parameters such as hormone levels and body temperature changes.

Heat stress has resulted in major losses in animal production, including dairy cattle, beef cattle, swine, and poultry (Nejad *et al.*, 2016). Many studies found that behaviour, disease incidence, body temperature, and metabolic processes are badly influenced by heat stress (Romero and Butler, 2007; Jama *et al.*, 2016; Nejad *et al.*, 2016). In beef cattle, the effect of heat stress has not been typically measured. Still, heat stress has been reported by Mader (2013) to cause changes in concentrations of hormones and enzymes, including cortisol, creatine phosphokinase, and lactate. However, Jama *et al.* (2015) also reported a high secretion of stress-related indicators in pigs, which included increased cortisol levels and creatine kinase at high temperatures. Gonzalez *et al.* (2007) agreed that heat stress is a consequence and a stress factor that induce the secretion of cortisol more, especially during transportation with high stocking densities and poor ventilation.

2.7 Factors affecting haematological factors of farm animals

There are hereditary and non-genetic factors observed that affect the haematological parameters of farm animals (McGlorie, 1999; Chinekeet *al.*, 2006). These factors include physiological, environmental conditions, starvation, and drug administration (Adenkola and Ayo, 2010; Gupta *et al.*, 2014; Etimet *al.*, 2015). Also, Onasanyaet *al.* (2015) observed that other factors such as breed, sex, age, health status, and behaviour of an animal could also affect their blood constituents. Earley and O'Riordan (2006) agreed that the predominant factors that impact the haematological factors are sex, age, management, diseases and stress factors. Miceraet *al.* (2007) said that except for the physiological and environmental components that might affect the blood constituents, transport, exercise, breeding, and housing methods have also been recognized.



2.8 How to measure the well-being of animals in abattoir locations

In livestock, stress is now regarded as a response that inevitably occurs when livestock are introduced to harsh environmental situations, which could be the reason for many unfavorable results, ranging from anxiety to death (Alcalde *et al.*, 2017). At slaughter plants or houses, animals are handled and controlled in ways that can cause stress, which affects both the welfare of animals and the quality of meat. As a result, in some countries (including United Kingdom), pressure has been applied on slaughterhouses to significantly limit electric rods' use on farm animals during handling, including during lairageing (Wighamet *al.*, 2018). Therefore, establishing reliable and valid welfare evaluation procedures may perhaps permit the influence of welfare improvement methods to be quantified.

Furthermore, quantifying animals' well-being in abattoir locations can be a challenge since most of the sensitive physiological conditions for measuring welfare, such as respiratory and heart rate, are mentioned earlier (Grandin, 1980; Miranda, 2013) are more practically measured

in commercial slaughterhouse areas. There are significant animal-based welfare measures that should be assessed at slaughter, such as animal scoring systems, animal behaviour, weighted procedures and or animal-based standards, and biochemical and haematological measures (Grandin, 2010; Wigham *et al.*, 2018).

However, due to the four main principles, which are proper feeding, well-maintained housing, sanitation and appropriate behaviour, procedures have been planned to measure well-being in different livestock in a variety of environments, including abattoirs (Miranda-de la Lama *et al.*, 2012). Slaughter houses have experienced drastic changes to date because of the need to improve competence and add in modified technologies for the development of infrastructure, animal well-being, and the quality of the product. Grandin (2010) reported that using a scoring system for animals has resulted in good improvements in pre-slaughter stressors when it was for animals, resulting in good improvements in pre-slaughter stressors when it was for animals, resulting in good improvements in pre-slaughter stressors used to audit animal welfare at slaughterhouses. Five freedoms were established in 1965 by Animal Welfare Council (Brambell, 1965) and are considered one of the first animal scoring systems and the most widely recognized welfare model globally (Grandin 1997; Phillips, 2008; Wigham *et al.*, 2018). They have had an important influence on animal welfare (OIE, 2006). The five freedoms state the following (Grandin, 1997; Webster, 2001; Wigham *et al.*, 2018):

- Freedom from thirst, hunger, and malnutrition - by ready access to water and a diet to maintain health and vigour
- Freedom from discomfort – by providing an appropriate environment, including shelter and a contented resting area
- Freedom from pain, injury, and disease – by prevention or rapid diagnosis and treatment
- Freedom to express normal behaviour – by providing sufficient space, proper facilities, and the company of the animal's kind

- Freedom from fear and distress – by ensuring conditions and treatment, which prevent mental suffering

2.8.1 Some biochemical stress indicators

The way animals respond to pre-slaughter handling and distress disturb glycogen reduction in cattle and the quality of meat aspects that include color, pH, cooking loss, and juiciness (Muchenje *et al.*, 2009). Hence it must be taken into consideration that pre-slaughter stress may result in biological and bodily changes of an animal. Besides, these biological and physiological changes negatively impact animals, leading to distress (Chulayo *et al.*, 2016). Before slaughter and during slaughter procedures, animals may experience stress caused by many factors, including handling, restraint, weather conditions, fatigue, hunger and thirst (Grandin, 1990; Muchenje *et al.*, 2009). Moreover, the pre-slaughter stressors may result from new adaptations on the farm, due to feeding withdrawal when animals are being transported for many hours (Ferguson and Warner, 2008; Muchenje *et al.*, 2009), overcrowding of animals, mixing different breeds and gender of animals, long time standing during transportation (Chulayo *et al.*, 2016), no accessibility to grass, noise and off-loading (Grandin, 1990). During these critical situations, the nervous system influences the use of energy and protein, and imbalances can occur (Bristow and Holmes, 2007; Chulayo *et al.*, 2017; Romero *et al.*, 2017).

2.8.2 Animal stress-related compounds

Stress is a concept that has been discussed since the 1950s (Proudfoot *et al.*, 2015) but is often difficult to interpret. Many researchers describe stress as a response ascending from real or apparent environmental changes that can be assessed as frightening depending on an individual's adaptive coping assets (Kathryn and Gregory, 2015). According to Kathryn and Gregory (2015), stressors activate two main biological pathways; the sympatho adrenal medullary pathway and the hypothalamic-pituitary-adrenal(HPA) pathway. The most

commonly evaluated physiological reactions to stress are activation of the HPA axis (Jama *et al.*, 2014; Beery and Kaufer, 2015; Chulayo *et al.*, 2016). Activation of the HPA axis is the pathway that is most commonly measured for physiological stress response.

To assess the levels of distress experienced by cattle that are exposed to a variety of stressors arising from activities such as climate and common management procedures (handling) such as transport, castration, dehorning or branding (Tarrant *et al.*, 1992; Petreiet *et al.*, 1996; Gonzalez *et al.*, 2009), hormonal variables have been approved and are mostly used (Moya *et al.*, 2013). However, unlike with other animals, measures obtained from handled beef cattle are disturbed by the effects of animal handling, which itself can promote stress (Moberg and Mench, 2000; Moya *et al.*, 2013). The most known useful hormonal variables represent changes in the HPA axis activity and cortisol levels (Schwartzkopf-Genswein *et al.*, 2012).

Cortisol is commonly defined as a glucocorticoid hormone coming from the adrenal cortex that is produced routinely and has many constructive functions (Warrisset *et al.*, 1998; Perez *et al.*, 2004; Muchenje *et al.*, 2009; Bristow and Holmes, 2007; Choir *et al.*, 2012), and it also a time-dependent measure. However, when an animal experiences stress, rapid release of stress-related hormones occurs, such as cortisol, creatine phosphokinase, and lactate. Several authors reported that creatine kinase and lactate are muscle-specific and hormones, respectively which indicate levels of stress and can indicate leakage from the muscle as a result of suffering in critical conditions; especially during physical exercise (Boissy and Neindre, 1997; Grandin, 2000; Grigoret *et al.*, 2004; Jama *et al.*, 2014).

Corninet *et al.* (2013) agreed that the release of cortisol is often increased in response to stress. However, the production of stress directly activates the HPA axis (Stafford and Mellor, 2005), resulting in high cortisol concentrations (Lay *et al.*, 1996; Brown and Vosloo, 2017). Conversely, several factors lead to changes in cortisol concentration at the farm, including flies,

castration, and adaptation. Availability of flies, especially *Stomoxys calcitrans*, causes irritation, muscle flicking, muscle twitching tail switching, and leg stamping (Lehane *et al.*, 1997) with the intention of chasing flies away.

Additionally, it has been scientifically proven that *Stomoxys calcitrans* increase cortisol levels and discomfort in cattle (Vitela-Mandoza *et al.*, 2016) because in a stressful situation, corticotrophin releases stress hormone. The other significant factor that causes changes in the concentration of cortisol is castration. Canozzi *et al.* (2017) stated that castration is the most commonly used management technique by farmers increasing, increasing cortisol levels and changes, increasing cortisol levels, and changing animal behavior. Specific methods of castration and pain relief can be used to prevent and minimize the adversarial effects on beef cattle. Recently, it has been presented to be highly significant to be acquainted with the causes of cortisol changes during handling to find approaches to improve stress-related factors in animals and resolve these issues.

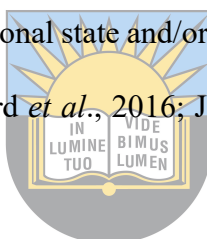


Moreover, poor operational techniques, unsociable settings and or sampling method used pre-slaughter often results in high secretion of creatine phosphokinase (Beerda *et al.*, 1997; Jama *et al.*, 2014). In agreement, Poletti *et al.* (2015) reported that Creatine kinase is an index of physical stresses which respond rather rapidly. Creatine kinase's effects are regenerating Adenosine Triphosphate (ATP) to maintain energy homeostasis (Warrise *et al.*, 1998). According to Jama *et al.* (2014), Adenosine Triphosphate is the primary energy source in living organisms for energy-demanding processes in cardiac and skeletal muscles, brain, retina and primitive-type spermatozoa (Grandin, 2013; Chulayo and Muchenje, 2013; Jama *et al.*, 2014).

More use of Adenosine triphosphate causes an increase of the enzyme creatine kinase (Chulayo and Muchenje, 2013). The production of glucocorticoid and catecholamine resulting from stress can cause rapid glycolysis and increased lactate production, leading to elevated blood

lactate (Probst *et al.*, 2012). According to Probst *et al.* (2012), lactate is frequently used in addition to cortisol to measure stress-related reactions as these indicators rapidly respond to stressors. Furthermore, its value has been used to indicate bodily stress and fatigue taking place in livestock (Broom, 2003; Petherick *et al.*, 2009).

Hoffman and Laubscher (2011) reported that the high secretion of cortisol, creatine phosphokinase, and or stress-related indicators result in decreasing meat quality. Similarly, Carreras *et al.* (2017) said that human handling influences the welfare of animals, as it increases corticosteroid rates (Aghwan *et al.*, 2016) and productivity and meat quality. Moreover, Brown and Volsoo (2017) found adverse effects affecting meat quality, including environmental stressors. It has been proven that stress from both internal and external factors by livestock results in severe changes in their emotional state and/or physiology (Vena *et al.*, 2010; Burdick *et al.*, 2011; Aghwan *et al.*, 2016; Baird *et al.*, 2016; Jama *et al.*, 2016; Carreras *et al.*, 2017; Brown and Vosloo, 2017).



2.9 Stress influence on meat quality

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When animals encounter a stressful situation, stress responses, including increased heart rate, high levels of body temperature, and high secretions of corticosteroids, appear (Warris, 1990), increasing pressure in the animal. Jung *et al.* (2004) reported that high levels of pressure negatively influence beef meat products, as it disturbs the enzymatic system and also negatively influences beef meat products, as it disturbs the enzymatic system and the texture and microbiological quality of the meat. Furthermore, King *et al.* (2006) discovered that stress reactions are most active in animals with a high temperament. Cattle with excitable temperament has been categorised as having higher dark cutting lean and increased Warner Bratler shear force (WBSF) values (Falkenberg *et al.*, 2005).

There are so many stress factors that influence beef meat quality, and among those, transportation is the major effect. Longer transportation time has a negative impact on meat

quality (Villarroel *et al.*, 2003), although there is less information known about its exact influence on the quality of meat attributes. Warner *et al.* (2007) reported that electric sticks during the unloading and loading of animals before slaughter have contributed to tough meat, poor juiciness, and flavor of loin steaks. There has been high interest in recent years for techniques to manage changes in environmental homeostasis due to their interactions with the quality of meat. However, animals are introduced to severe stressors when taken to slaughter plants as they get exposed to noise and new environment changes (Pena *et al.*, 2014), which usually occur when cattle are held at lairage. As a result, many stressful factors have a strong relationship with slaughter facilities and are therefore associated with meat quality problems related to stress, including higher pH, abnormal color, and less tender meat (Pen *et al.*, 2014). Nevertheless, differences in pre-slaughter management stages and between cattle and how humans interact with the animals have significant results on welfare and meat quality (Voisinet *et al.*, 1997).



In order to improve local livestock production and to ensure public health, cattle health and disease control must be prioritised in these emerging livestock systems. Therefore it is vital to understand the processes done during production stages and disease risks which become prevalent in more intensive and commercialised systems (Craighead *et al.*, 2021).

2.10 Conclusion

Lessening livestock stress during handling will create the benefits of increasing production and improving the quality of meat. As seen from studies to date, there are plenty of reasons and components that connect and affect meat quality and the consumer opinion of meat-eating quality. The influences range from how the animals are raised, transported from the farm to the abattoir, post-slaughter handling, and meat storage in butcheries, markets, and households. Therefore, at each period, different factors should be measured to improve the quality of meat.

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Chapter 3: Evaluating farmers' perceptions and knowledge on cattle breeds, management and marketing channels in selected villages of Alice, Eastern Cape

Abstract

A total of 101 structured questionnaires were administered to three selected villages in Alice, Eastern Cape Province, to evaluate farmers' perceptions and knowledge of cattle breeds, farming, and marketing. Records of interest included demographic information, breed selection and related performance, farming and welfare practices, and the marketing channels used. Various perceptions were recorded in each village, influenced by demographic differences ($P < 0.05$). The majority of cattle owners, which were also involved in herd management, were adult males (65%) compared to adult females (20 %) and youth (15 %). Age of the farmer, occupation and experience influenced ($P < 0.05$) the selection of breeds and knowledge of their importance, with the Boran (48.91%) and non-descript/crossbreds (23.12%) dominating. The Boran breed was associated with good mothering ability, longevity, superior meat quality, and efficient milk production. The most common farming practices reported were characterised by natural resources for grazing, drinking, and shade. Farmers reported using a combination of indigenous knowledge and commercial products for vaccination and treatment of diseases, dipping for external parasites, and applying practical experience (7-10 years) in their management practices. Overall, cattle were mostly kept for use during ceremonies, draft power and generating income. They mostly sold their cattle locally, at various ages and negotiable prices, in their live state during ceremonial seasons in their communities. They reported external factors that affected farming and marketing, such as drought, shortage of feeds, and disease outbreaks being the common causes of cattle mortality, especially in summer (48.91%). It can be concluded that the farmers are more reliant on indigenous and experiential knowledge and practices in their farming.

Keywords: Breed selection, Communal Farming practices, Marketing, Households



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3.1 Introduction

South Africa is one of the countries with diverse genetic resources of domestic animals, including indigenous beef cattle breeds, and has a diverse livestock production system (Freeman *et al.*, 2006). As a result, livestock production has the potential to contribute greatly to the national and local economy and enhance livelihoods. The impact of livestock on the total agricultural GDP was estimated at around 30 to 35% (Duguma *et al.*, 2010). Scholtz *et al.* (2018) revealed that 86% of livestock producers farm with cattle, making beef cattle farming the major livestock production initiative in the Eastern Cape. Furthermore, the Eastern Cape Province was reported to be the largest livestock producer in South Africa, estimated to have approximately 3.1 million beef cattle (Mapiye *et al.*, 2009). More than 65% of these were reported to be coming from the communal sector (National Department of Agriculture, 2008). Livestock farming in communal farming areas of South Africa is categorized by the Integrated Sustainable Rural Development Strategy (ISRDS) as the agricultural enterprise aiming to develop household food security and address ways of decreasing poverty (ISRDS, 2004; Coetzee *et al.*, 2005; FAO, 2016). Livestock has played an important role in people's life most especially in communal areas. Households benefit with income and financial security, animal source proteins (meat and milk) for consumption, drought power and other raw material (manure, skins/hides), status and insurance (Mapiye *et al.*, 2009; Moyo and Masika, 2009; Nowerset *et al.*, 2013; Mumba *et al.*, 2017).

In these communities, livestock farming is mostly practiced using traditional methods (management practices), resources (natural and communal feed and water), and knowledge (indigenous and practical knowledge). Thus, the farmers are sometimes challenged by various factors related to maintaining good animal welfare, controlled and consistent production. These hurdles often result from overgrazing, overstocking, and less productivity because most households keep large livestock numbers for various reasons (Bahta *et al.*, 2015; Gusha *et al.*,

2018), with limited/no management of the available resources. As a result, land degradation and lack of water were reported as the major issues (Ndoro *et al.*, 2014), particularly due to climate change (Orimoloye *et al.*, 2019).

Consequently, the rangelands have become poor in quality and quantity (species composition and standing biomass), thus increasing their inability to sustain livestock production (Scholtz *et al.*, 2008). This was also linked to the nature of communal resource use, where people have equal access to the land with no grazing management design for everyone to follow (Desta *et al.*, 2011; Coetzee *et al.*, 2012). Furthermore, this arrangement encourages uncontrolled mating amongst various herds. Petersen *et al.* (2007) added that, large livestock production leads to higher local release of contaminants such as odour from housing and can also increase the risk of disease spread among the livestock.

To increase production and maintain good herd quality, farmers have been advised to keep livestock that can withstand harsh environmental conditions such as drought, heat and disease challenges. Generally, the country has various cattle genotypes, spread throughout both the commercial and communal sectors. However, Scholtz *et al.* (2008) reported that over 35% of the bulls found in the emerging sector contain unidentified genes (unknown crosses). This is not a surprise, considering that most production is communal in this sector. Most production is communal in this sector; with no mating control. In the communal areas, breed and characteristic preferences of cattle keepers generally differ between communities and production systems (Leroy *et al.*, 2018). However, cattle breeds with maximum adaptive and productive are suitable for various environments, farming practices, and markets (Mwacharo *et al.*, 2005; Theunissen, 2011 ;Tada *et al.*, 2012).

There has been a great focus shift towards indigenous cattle breeds such as the Nguni and Boran over the years. According to Katiyatiya *et al.* (2014), the Nguni breed is considered as the best

breed to be kept and raised in communal and rural areas because of its ability to survive harsh environmental conditions such as hot temperature and low grazing (Jabbarnet *et al.*, 1998; Grobler *et al.*, 2018). On the same note, the Boran breed is known for good mothering abilities and can withstand a short water and feed shortage (Haile, 2011; Katiyatiya and Muchenje, 2017; Katiyatiya *et al.*, 2017). However, while breeds like the Nguni may have these superior environmental-related traits, it is usually discriminated for its small body frame, yielding lower profits than other cattle (Tada *et al.*, 2012; Nyamushamba *et al.*, 2017).

Marketing channels of livestock in South Africa consist of many channels, and these are widely divided into two groups: the commercial and traditional markets (Schmidt, 1999; Musemwaet *et al.*, 2007; Mapiyeet *et al.*, 2009); with the former market being more defined and organized, while the latter is more unstable and unpredictable. For various reasons, inclusive of undesirable livestock conditions, communal farmers often do not succeed in accessing the commercial markets. To avoid this, there is a need to properly investigate these challenges and further a need to properly investigate these challenges and provide communal farmers with suitable knowledge and skills to enhance their production output to suit market requirements. Furthermore, marketing should take an extremely important role in the practice of transforming small-scale farmers into commercial producers (Musemwaet *et al.*, 2010). Therefore, the study aimed to investigate rural farmers' perceptions and knowledge of cattle breeds, management, and marketing channels, with intentions to devise recommendations that can enhance farming practices in rural communities.

3.1 Materials and Methods

3.2 Ethical Considerations

Ethical Clearance and approval to conduct the study was sought from the SBS Ethical Clearance Committee, considering the Human Research Ethics Regulations. The study was conducted in an ethical manner, the researcher was responsible for and committing to warranty i) *Informed Consent* which encourages the researcher's transparency on the expectations of the respondents and what it means for them. A consent form was presented and signed by both the researcher and the participant; ii) *Voluntary* participation, where the respondents chose whether to participate or not; iii) The right to *withdraw* was permitted if at any point during the interviews they felt uncomfortable. Though, they were highly encouraged to participate; iv) *Confidentiality* to ensure that the identity and specific responses of the respondents were kept anonymous except between the researcher and the respondent.

3.2.1 Site description and socio-demographic information

The study was conducted in three selected villages located in Alice, Eastern Cape Province. These were Gaga, Ntselamanzi, and Ncerha locations, which all fall under Nkonkobe municipality. Gaga location is an inland area characterised by extensive cattle production systems. It is situated at an altitude of 430 to 500 m with an annual rainfall of 480 and 16.9°C annual temperature. The Gqumashe location has a cropping potential, but it is a small sequestered area surrounded by steep mountains. Gqumashe and Ncerha are situated at an altitude of 450 to 500 m with 17.1°C annual temperature. The vegetation is characterized by *Aristida Congesta*, *Cympopogon plurinodis*, *Cynodondactylon*, *Digitaria ariantha*, *Sporobolus africanus*, *Sporobolus fimbriatus*, *Themeda triandra* and *Eragrostis* grass species. *Acacia karroo*, *Scutiamyrtina*, and *Maytenus polyacantha* are the dominant tree species. These communities are characterized by high unemployment levels, estimated at over 87 % deprived residents (IDP, 2008). The residents livelihood is dependent mostly on government grants,

travelling and agricultural labor dominated by vegetable and livestock production. There are few small scale farmers who are funded directly by the Department of Agriculture.

Study Design

A structured questionnaire was used for gathering of information. The questionnaire and a schedule consisting of Section A which was the general introduction of the study as well as attaining consent to participate, which was signed by both the researcher and the respondent; Section B contained questions about the respondent's demographic information ; Section C contained questions specific to the research problems and /or objective of the current study.

Sample Size estimation

The research was conducted in Alice mainly in Gaga, Ntselamanzi and Ncerha villages. For the current study, a sample of 101 respondents were selected randomly from the household owning livestock.

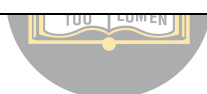


3.2.2 Data Collection

A sum of 101 cattle keeping households in three villages were randomly selected and interviewed. Data were collected over a seven day period per village. Structured open-question questionnaires were distributed, focusing on farmer perceptions and knowledge of cattle breeds, management and marketing channels. Households that kept livestock were interviewed. Questions relating to cattle farming and breed differences, husbandry practices, and their knowledge on the market chain conditions and animal welfare were asked in Gaga, Ntselamanzi and Ncerha villages, respectively. The data generated from open-ended questions were analyzed using proportional sampling.

Table 3.1: Summarized questions of the survey

Category	Description
Socio-demographic	Age: 18-28, 29-39, 40-50,51-61,>72 Gender: Male and Female Level of education Occupation Experience
General Knowledge on cattle farming and breed differences	Breed selection and performance Importance of Nguni and Boran breeds Farming practice and welfare
Marketing channels	Commercial methods Traditional methods- Informal markets



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3.2.3 Statistical Analysis

The PROC FREQ procedures of Statistical Analyses Systems (SAS, 2009) were used to determine the frequencies of gender, age, level of education, occupation and experience of the cattle farmers. To determine the associations between demographic information and reasons for keeping cattle and perceptions on-farm practices and market chain, the Chi-square test of SAS (2003) was used.



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3.3 Results and Discussion

3.3.1 Socio-demographic information

Table 3.2 shows the socio-demographics of the 101 farmers who participated in the study. The village with the highest number of cattle farmer household participants was Ncerha (36.6 %), while Gaga and Ntselamanzi had 32.7 % and 30.7%, respectively. From this study, most of the cattle owners interviewed were 50 years of age and older. The explanation for these findings were supported by the fact that youngsters or youth are focusing more on getting employed and working than owning a farm. Tada *et al.* (2012) stated that after matriculating, youth go to urban areas to continue their studies and search for better-earning jobs.

On the other hand, male cattle owners dominated (54.59 %) compared to women (45.41%). This agrees with many studies which reported that men are the ones with more experience and who own a large number of cattle, with the observations that in rural areas, there is a high number of men with cattle compared to women (Tada *et al.*, 2013; Katiyatiyaet *al.*, 2014; Sachs, 2018). Moreover, the older men are dominating in the livestock industry in rural areas as they are in ownership of more beef cattle compared to females (Nqenoet *al.*, 2011). This indicates that women were less involved in the agricultural industry, and it also shows that there might be other interests for women that are not related to cattle farming such as looking after the children and other house chores (Nyamushambaet *al.*, 2017, Molefiet *al.*, 2017). These results show that women still need to be empowered and encouraged to participate in the livestock industry, especially cattle farming.

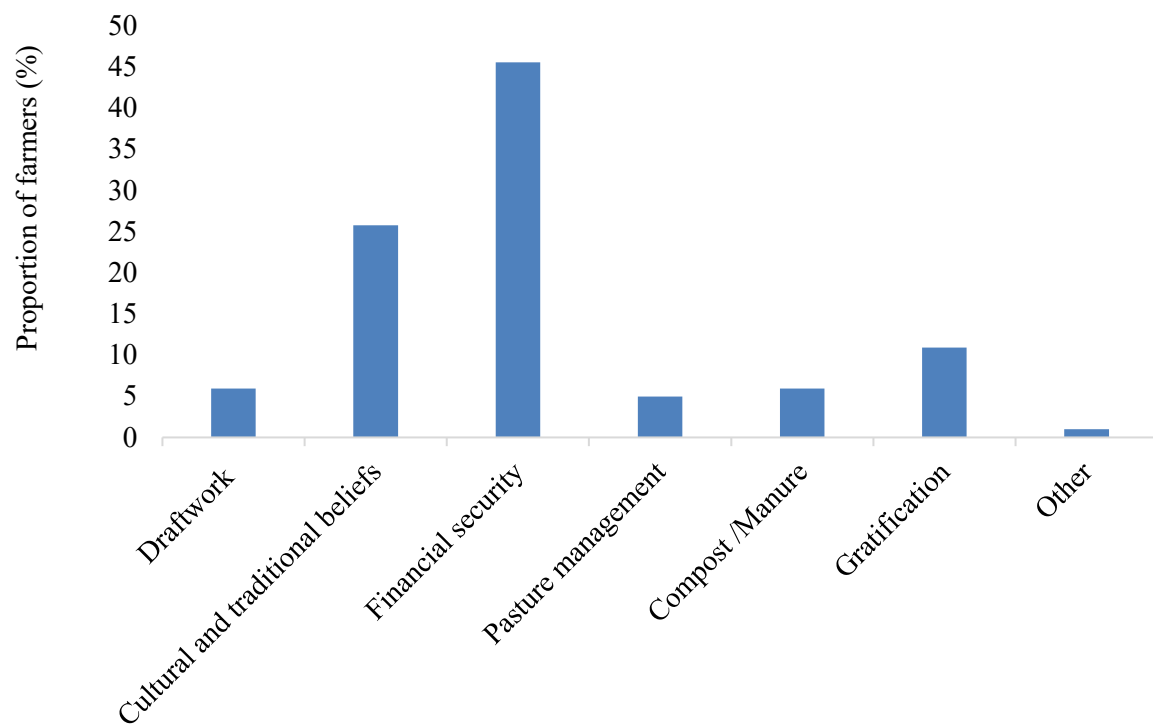
Table 3.2: Demography of cattle household in Alice communities in the Eastern Cape

	Gaga	Ntselamanzi	Ncerha
	Proportion (%)	Proportion (%)	Proportion (%)
Age			
18-28	3.03	3.23	5.41
29-39	18.18	9.68	24.32
40-50	33.33	32.25	27.03
51-61	24.24	35.48	32.43
>71	21.21	19.35	10.81
Gender			
Male	57.58	54.84	51.35
Female	42.42	45.16	48.65
Level of education			
Primary-Matric	54.55	58.06	62.16
College-Tertiary	45.45	41.94	37.84
Occupation			
Employed	48.89	38.71	48.65
Unemployed	18.18	29.03	27.03
Pensioner	33.33	32.26	24.32
Experience (years)			
1-10	69.69	45.16	59.46
11-15	15.15	35.48	32.43
16-30	15.15	19.36	8.11
Totals	100	100	100

It was also observed that women are most likely to partake in poultry farming (Nguyeni, 2018). Most of the farmers (43%) had gone through primary and secondary education (Grade 8 to 12) as their highest education level and depended on work and pension for income. The participants who had the most experience kept cattle from 1- 10 years, with the majority being male and older people, from all the villages (45.16 to 69.69 %). Also, Scholtz *et al.* (2018) stated that the labour movement results in young people, mostly men, leaving behind the older people, women and children in their rural birthplaces for job hunting. These findings contrast with Mapiyeet *al.* (2009), who reported that females and young people are involved in cattle farming practices.

3.3.2 Reasons for keeping cattle and choosing specific breeds

The proportion of farmers and the reasons for keeping cattle per village are represented in Figure 3.1. The participants pointed out that their reasons for cattle keeping include financial security (47.32%), traditional ceremonies (25.47%), gratification (10.76%), drought power (5.86%), compost (4.77%), and pasture management (4.72%), and other reasons (1.08%). The current results showed that the primary reason for keeping cattle was selling and meat (47.32 %). Regardless of a lack of well-built marketplaces in many rural areas of Alice, the informal marketing chain in beef cattle appears to succeed. These findings concur with Scholtz *et al.* (2008) and Mapiyeet *al.* (2009), who reported that people from rural areas mostly used cattle for business (cash) and traditional purposes, and these were the most highlighted significant reason for keeping cattle.



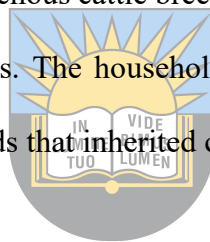
Reasons for keeping cattle



Figure 3.1: Reasons of the household's farmer for keeping cattle in the rural areas in the Alice Town

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Table 3.3 shows frequencies of breed choices as well as perceived reasons for selection. Some of the farmers kept more than one type of cattle breed. The nature of livestock production was usually extensive, with limited or no control on grazing and mating management due to a lack of resources. Hence, a mixture of genes among their herds was recognised. According to the obtained results, the most common breed types were Boran (34.76 %), Tuli (11.18 %), Drakensburger (9.86 %), Nguni (8.61 %), Bonsmara (7.60 %), and a total of 12.89 % were crossbreeds. The primary reasons for choosing specific breeds was according to their tick and disease tolerance (41.42%), temperament (16.23%), beef production (15.40%), and milk production and meat quality (10.08 %). The trend was the same in all the three villages, and this evidence shows a risk to the indigenous cattle breeds for which rural people have been the traditional keepers for many centuries. The households obtained cattle through buying and inheritance, and most of the households that inherited cattle were widows.



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Table 3.3: The awareness of breeds by cattle keepers and the reasons for selecting specific breeds

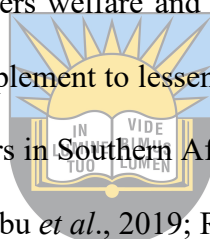
Breeds	Gaga		Ntselamanzi		Ncerha	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Bonsmara	2	6.06	1	3.23	5	13.51
Boran	12	36.37	11	35.48	12	32.43
Nguni	3	9.09	1	3.23	5	13.51
Tuli	2	6.06	6	19.35	3	8.12
Afrikaner	3	9.09	2	6.45	1	2.70
Drakensburg	3	9.09	3	9.68	4	10.81
Sanga						
Brahman	0	0	2	6.45	2	5.41
Local	2	6.06	2	6.45	1	2.70
crossbreeds	6	18.18	3	9.68	4	10.81
Totals	33	100	31	100	37	100

Reasons for selecting specific breeds

Disease	and					
tick tolerance	12	36.36	13	41.94	17	45.95
Fertility	3	9.09	1	6.45	0	0
Mothering ability	1	3.03	2	6.45	3	8.11
Beef breeders	1	3.03	5	16.13	10	27.03
Sufficient	beef 4	12.12	1	3.23	2	5.40
producers						
Temperament	7	21.21	6	19.36	3	8.11
Other	5	15.15	3	9.68	2	5.40
Totals	33	100	31	100	37	100

3.3.3 General views from the respondents about the importance of Nguni and Boran breeds

Table 3.4 presents findings on the knowledge of the Nguni and Boran breeds. The respondents shared similarities compared to the reasons for selecting specific breeds. The respondents ranked heat resistance as the major known importance of Nguni (27.32%) with tick tolerance (19.89 %) as the second, followed by fertility (13.20 %), mothering ability (12.78%), and meat quality (11.77%). There is information that indigenous Nguni cattle are well adapted to the resources available to resource-limited farmers who need disease resistant multiuse livestock with less-maintenance feed ratio but relatively high beef producers (Muchenje *et al.*, 2008; Mapiyeet *et al.*, 2009; Yakubu *et al.*, 2019). According to Roessler (2019), these good traits of the Nguni breeds develop cattle keepers welfare and maintain their marketing chain. Nguni cattle, therefore, can be used as an implement to lessen poverty and recover livelihoods of the resource-poor cattle communal farmers in Southern Africa (Muchenje *et al.*, 2008; Katiyatiya *et al.*, 2009; Mapiyeet *et al.*, 2009; Yakubu *et al.*, 2019; Roessler, 2019).



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Seemingly from the current study, the Boran breed was highly preferred by the cattle keepers from Alice villages of the Eastern Cape. However, the significant reasons for selecting Boran were stated, and also different views were obtained. More than 55% of households interviewed reported that Boran has a good mothering and fertility ability, followed by the fact that they are good beef breeders in terms of size and meat quality outputs. Boran was also recommended as a breed that is easy to handle and manage due to their behavior. Additionally, because of its good preferences, the breed in these communal areas is also used for meat and milk.

Table 3.4: Different views about the importance of Nguni and Boran breeds from three villages in the Alice town

Importance of Boran and Nguni	Gaga		Ntselamanzi		Ncerha	
	Frequency	Percentage (%)	Frequency	Percentage (%)	Frequency	Percentage (%)
Tick tolerance	6	18.18	7	22.58	7	18.92
Heat resistance	8	24.24	7	22.58	13	35.14
Easily Manageable	3	9.09	2	6.45	4	10.81
Mothering ability	5	15.15	3	9.68	5	13.51
Meat quality	4	12.12	3	9.68	5	13.51
Fertility	4	12.12	6	19.36	3	8.11
Most selling	3	9.09	3	9.68	0	0
Totals	33	100	31	100	37	100



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Similar findings were reported by Haile (2011), stating that although Boran is a beef breed, they have been recognized to be fertile, fast-growing, and high milk producers. Also, one of the facts stated by the respondents was that this breed has a long life span. Hence they are highly used in the communal areas, explaining briefly that they save money. The Boran breed's performance, such as reproduction, milk and meat production and growth, has been improved in South Africa and other countries like Kenya and Ethiopia (Karanja *et al.*, 2018, Zewduet *al.*, 2018).

3.3.4 Husbandry practices and animal welfare

Table 3.5 shows three feeding methods used by the farmers for feeding their cattle. It was observed that cattle farmers used mostly extensive farming (57.25%) followed by semi-intensive (35.99%), and lastly, few were using intensive feeding methods (6.73%). None of the demographic factors affected their perceptions of these practices, and the results were not statistically different. Thus, it was noted that there has not been much change in Alice's rural areas concerning modified feeding techniques. The farmers had common views about the use of these methods; hence no differences were obtained. This indicates that there are still less available resources in rural areas.

On the other side, there were positive relationships between the farmers' demographic information and their perceptions on practiced housing methods, including house types. Their observations on the use of different housing methods were statistically significant ($P < 0.05$) except for the occupation. Age, gender, education, and experience of the farmers influenced their perceptions of feeding methods. Age, education and experience had a large influence on farmers' views and choice of applying specific methods. However, many farmers (68%) were using traditional housing, which includes Kraals and open-sided wood shelter, for the accommodation of cattle, because traditional housing is more comfortable and suitable for large stock such as cattle. Moreover, 72.28 % were not using shelter or shade precautions since

considering traditional ways, and their reasons were supported by Coetzee *et al.* (2005) and Nguyen *et al.* (2016), who reported that in rural sectors of South Africa, cattle farming is a traditional practice.

The farmers aged between 28 to 45 mostly preferred commercial house types, while others aged from 46 to 72 were promoting and complementing traditional housing types. This may be due to changes in century times with also alternatives in the technology. Young people explained that buying and building commercial houses promotes a hygienic living environment and is safer for the cattle's security and welfare.

The major feeds used in the study locations are also shown in Table 3.5. In the current study, the perceptions of households were categorized from eight feeds, and were identified as probious feeds, block licks, lupin seeds, hay, lucerne, and maize. The respondents were most likely to use maize (raw maize) (40.33%), claiming that it is the most available and affordable feed they use. In addition, the households explained that this feed is also safe in terms of animal health. The use of feeds varied among the villages. Due to low rainfall and poor quality soils, the rangelands are mostly used for extensive grazing.

Table 3.5: Feeding methods and housing precautions practiced, and measures employed by cattle farmers in case of limited feeds in the villages in Alice

Husbandry Practices	Gaga		Ntselamanzi		Ncerha	
Feeding Methods	Frequency	Proportion (%)	Frequency	Proportion (%)	Frequency	Proportion (%)
Extensive	17	51.52	18	58.07	23	62.16
Semi-intensive	15	45.45	11	35.48	10	27.03
Intensive	1	3.03	2	6.45	4	10.81
Housing Precautions						
Shelter	6	18.18	3	9.68	7	18.92
Shade	4	12.12	5	16.13	3	8.11
Neither	23	69.70	23	74.19	27	72.97
Feeds						
Probiotic feed	2	6.06	4	12.90	6	16.22
Block licks	0	0	2	6.45	4	10.81
Lupin	6	18.18	4	12.90	8	21.62
Hay	6	18.18	3	9.70	4	10.81
Lucerne	2	6.06	4	12.90	6	16.22
Maize	17	51.52	14	45.16	9	24.32
Totals	33	100	31	100	37	100

3.3.5 The perceptions of the respondents on vaccination and dipping in their communal areas

The respondents reported that options for disease control include dipping, vaccination, and treatment during health practices. They stated that one of the best ways to control disease is to vaccinate and separate the diseased or infected animals from the herd to prevent disease spread and mortality rates. Different views from the households about the application of health practices are shown in Table 3.6. Vaccination was used to improve immunity in the exposed cattle herds in order to prevent diseases. The proportion of cattle households vaccinating was about 72.73 % in Gaga, 54.84 % in Ntselamazi, and 45.16 % in Ncerha, mostly using commercial methods. Few farmers were found not to vaccinate (36.76 %) or use traditional medicine.



This result indicates that vaccination in local communities is highly applied, either traditionally or commercially. This could be the reason for the low mortality rates of cattle, as noted by the respondents from their herds. Most households reported that their cattle died because of difficulties in pregnancy and due to harsh weather conditions more than disease causes. These results are comparable to Mayo and Masika (2009) findings who mentioned that residents for vaccinating their cattle against diseases use both commercial and traditional vaccination. The farmers explained that they were vaccinating cattle mainly against non-zoonotic diseases, which are highly occurring in their localities. The farmers in the current study also vaccinated cattle to avoid economic loss. FAO (2016) reported that cattle vaccination can protect against varied kinds of diseases that reduce animal production, fertility, and economic losses to cattle producers. Furthermore, most farmers (77%) reported using Terramycin La, with 12% making use of Clostridial for vaccination and 11% using acaricides and ethnoveterinary medicines for vaccination to treat and control and protect their herds (Table 3.6).

Though the interviewed had common perceptions about the time to vaccinate and dip their cattle depending on the different seasons and environmental conditions, more than 75% of the interviewees reported that for dipping to be effective, the cattle should be dipped fortnightly during the dry season, or twice a month for the elimination of ticks and control of other external parasites. Some respondents reported to do theirs only once a month. Similar findings were also reported by Katiyatiya *et al.* (2014) that for more dipping into cattle, dry season's cattle should be dipped fortnightly.

The households advised that in winter, livestock should be dipped once a month. Moreover, households complement dipping claiming that it has a much wider disease-preventing activity and further explained that tick control uses other measures, such as used oil from cars, bleach, and other house disinfectants by manually removing ticks brings out best results for external parasites control. These results agree with Mapiya *et al.* (1997) and Tschopp *et al.* (2010), who stated that adding some home remedies with the commercial dip gives effective results. As for vaccination application periods, about 60 % of the interviewed households reported that the effective periods for vaccinating are three weeks after birth, twice in summer seasons, and vaccination should be provided in sick and infected cattle.

Table 3.6: Households' perception and knowledge on health-related management practices (Vaccination and dipping of cattle) in the Alice villages

	Gaga	Ntselamanzi	Ncerha
Vaccination	Proportion (%)	Proportion (%)	Proportion (%)
Vaccinating	72.73	54.84	62.16
No Vaccination	27.27	45.16	37.84
Vaccination period			
Summer	36.36	45.16	45.95
Spring	27.27	12.90	13.51
Winter	36.36	41.94	40.54
Dipping			
Dip	96.97	93.55	89.19
No-Dip	3.03	6.45	10.81
Dipping period			
Summer	48.49	38.71	59.46
Spring	33.33	29.03	21.62
Winter	18.18	32.26	18.92
Totals	100	100	100



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The households reported diseases and poor animal condition reported diseases and poor animal conditions as chief constraints of cattle production in most communities. Figure 3.2 shows the proportion of farmer's perception of common diseases occurring in their village. The high rates of disease occurrence varied among each village. However, at Gaga, grass tetany was highly dominating (37.13), followed by blackleg in Ntselamanzi (32.36%) and anthrax in Ncerha (30.51%). Approximately 60% of the interviewees reported that these diseases were responsible for significant losses to their herd and market due to loss in weight, birth loss (miscarriage), and high mortality rate. This agrees with Sungirai *et al.* (2016), who stated that diseases are accountable for large economic losses in cattle production in many communal sectors where most cattle owners are the resource-poor local farmers. Bernues *et al.* (2016) also reported that in the market, diseases are the major cause of low reproductive performance in cattle, most especially those in local areas. However, organizations and governments have started programs where communal farmers are educated more about disease control from their cattle herds. Vaccination of young cattle against diseases is encouraged by preventing clinical disease and reducing viral spread to disposed of animals. To prevent viremia and the birth of continuously infected offspring in reproductive-age cattle, vaccination should be considered more essential since it is also more complicated to achieve than preventing clinical disease (Benjamin *et al.*, 2017).

Most diseases were described as seasonal infections. Most farmers (50%) reported summer as the season when tick infestation is highest in cattle. Hence, dipping is more advised in summer (FAO, 2014). Due to high rain rates in this season, there are high incidents and rapid spread of disease infections such as foot and mouth, and blackleg. The households from each village used different health management practices, as some used commercial methods while some used traditional methods.

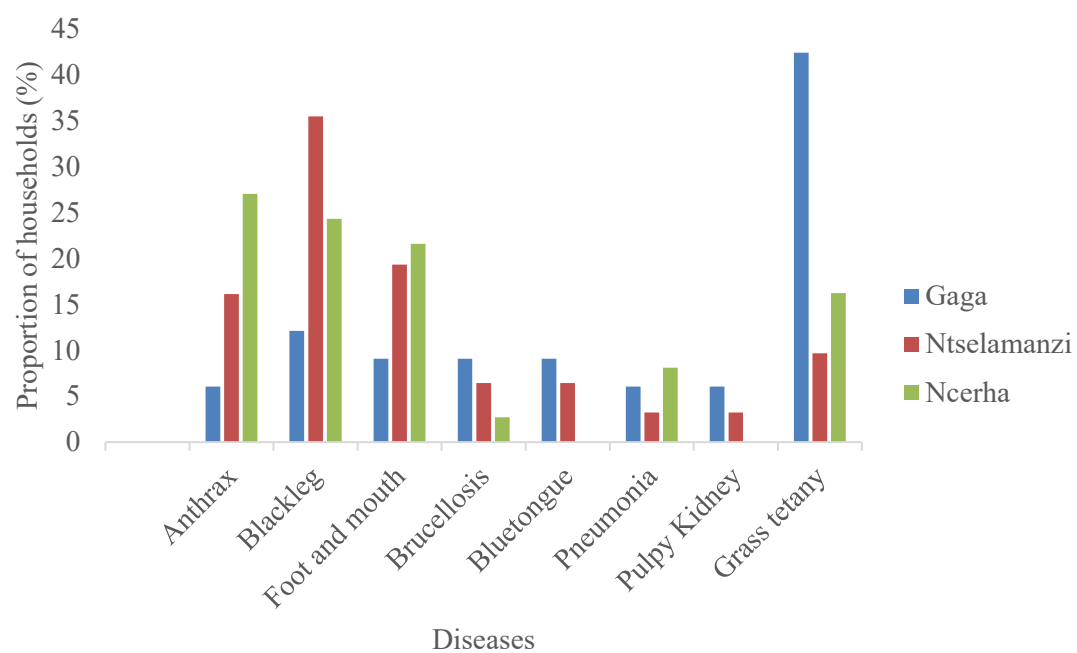


Figure 3.2: Household perceptions on common livestock diseases



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3.3.6 Knowledge of the market chain conditions and animal welfare

Table 3.7 represents marketing channels practiced in three villages of Alice town. In these villages, livestock were sold at formal and informal markets, mostly dominating informal marketing. The cattle were marketed in two ways of point sales, such as local and commercial forms, in different states of sale, i.e., either slaughtered or alive. Different transportation modes were used: 40.21% of the farmers were using a trailer, 35.83 % were considering van, and 23.95% were using trucks, respectively. The overall proportion of farmers in each village who were selling their livestock locally was 37.29% and for those selling to the commercials was 20.10 %.

Moreover, the proportion of farmers who were using both states of sale was 18.95%. Both men and women were involved in livestock marketing, but most of the respondents were predominantly male. Similar findings were reported by Musemwaet *et al.* (2010) and Groenewald and Jooste 2012), who reported that males mostly own agricultural sectors. It was observed that younger people (mean age= 50) used commercial slaughtering. The older farmers were slaughtering their cattle traditionally, following the trend that the older the farmer, the less they believed in or were interested in selling their livestock to abattoirs, at auctions or using commercial slaughter instruments. This was due to the expenses of hiring transport for delivery. Most of the old farmers were uneducated and lacked information on using slaughter tools in their marketing.

The major reason household farmers were using traditional methods was because household farmers were using traditional methods was that older people prefer to work with familiar or close people and relatives because household farmers were using traditional methods. Also, it was because of lack of access to information and costs. Nkosi *et al.* (1993) reported that cattle, particularly oxen and small stock, are traded through an informal market in rural sectors. This

trend was confirmed by Coetzee *et al.* (2012), who stated that informal markets are largely owned by older people, of whom very few sold their livestock to the abattoir or auctions.



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Table 3.7: Beef value chain in three different Alice villages

Marketing	Gaga	Ntselamanzi	Ncerha
Point of Sale	Proportion (%)	Proportion (%)	Proportion (%)
Local	51.52	14.39	45.95
Commercial	18.18	9.68	32.43
Both	30.30	4.94	21.62
State of Sale			
Dead	21.21	29.03	32.43
Alive	48.49	41.94	40.54
Both	30.30	29.03	27.03
Transportation Mode			
Trailer	42.42	32.26	45.95
Van	36.36	38.71	32.43
Truck	21.21	29.03	21.62
Totals	100	100	100

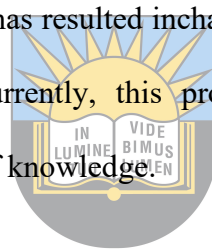


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These findings reveal that as time changes, cattle farming in the rural areas is depreciating due to unlimited resources and seasonal changes resulting in low rangelands and less palatable grass (Mapiyeet *al.*, 2009).

3.3.7 The relationship between socio-demographic factors and cattle breeds, farm practices, and marketing

As shown in Table 3.8, the association of the experience with the farmers' perceptions of vaccination and cattle dipping as health-related methods was statistically significant ($P < 0.05$). That might be because the more time farmers keep their cattle, the more they relate and understand how effective these methods work. Concerning that, some of the respondents criticised that the vaccines currently given by the government were no longer as effective as the ones used in the past years. This has resulted in challenges in improving farmer-managed, effective tick control measures. Currently, this procedure is constrained by poor-farm resources, farmer training, and lack of knowledge.



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Table 3.8: Association between demographic information and animal welfare and health-related practices

Demographic factors	Vaccination	Vaccination Period	Dipping	Dipping Period
Age	0.512 ^{NS}	0.571 ^{NS}	0.013 [*]	0.365 ^{NS}
Gender	0.081 ^{NS}	0.013 [*]	0.082 ^{NS}	0.412 ^{NS}
Education	0.033 [*]	0.310 ^{NS}	0.043 [*]	0.514 ^{NS}
Occupation	0.044 [*]	0.021 [*]	0.350 ^{NS}	0.301 ^{NS}
Experience	0.001 ^{**}	0.031 [*]	0.052 [*]	0.340 ^{NS}

Significant at * $P \leq 0.05$, ** $P \leq 0.01$, but NS not significant at $P \geq 0.05$.



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Table 3.9 shows the relationship between the socio-demographic factors, mortalities, and their seasonal occurrence. Some socio-demographic information did not affect the selected villages' treatments except for gender and experience ($P < 0.05$). The male respondents used more traditional treatment therapy than females who preferred commercial vaccines and antibiotics, and males had a longer experience. The farmers' perception and their demographic factors on mortality rates were statistically different ($P < 0.05$). The respondents reported that mortality was mainly caused by harsh weather conditions, including dry seasons, and occurred highly in summer, and also by disease and infections. The results are illustrated in Figure 3.2. Based on the findings, age, gender, education, occupation, and experience of the farmer highly affected ($P < 0.05$) their perceptions of cattle mortality on their farms. These results were because antibiotics as treatments were not commonly used.

Furthermore, the farmers elaborated that they were not getting any support from the government or suppliers regarding their farming, making it difficult for them to afford to buy vaccines and the required antibiotics. Therefore, it is not in concurrence with the Integrated Sustainable Rural Development Strategy (ISRDS, 2004), which identifies vaccination in livestock farming as the most essential agricultural practice to improve health status of cattle (Kubkomawaet *et al.*, 2015). Determination of cattle's health status is beneficial in quantifying the extent to which cattle are affected by disease or other environmental factors, mainly where seasonal variations in the quantity and quality of forages occur, as is common in dry tropical and subtropical parts (Ndlovu *et al.*, 2007).

Table 3.9: Demographic factors influencing perceptions of farmers regarding treatment, mortality and seasons in villages within Alice

Demographic factors	Treatment	Mortalities	Season of Mortality
Age	0.473 ^{NS}	0.001 ^{**}	0.092 ^{NS}
Gender	0.022 [*]	0.012 ^{**}	0.034 [*]
Education	0.091 ^{NS}	0.011 [*]	0.021 [*]
Occupation	0.511 ^{NS}	0.001 ^{**}	0.001 ^{**}
Experience	0.001 ^{**}	0.002 ^{**}	0.011 [*]

Significant at * $P \leq 0.05$, ** $P \leq 0.01$, but NS not significant at $P \geq 0.05$.



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Table 3.10 shows the relationship between demographics of the farmer and their views. According to the findings the age only influenced the choice of farmers on slaughtering methods ($P < 0.05$). Age had the same effect on the choice of marketing chains to farmers residing in Alice who were using local (private sales), commercial (abattoirs) and to those who using both local and commercial routes as points of sale, their views did not differ ($P > 0.05$). Both men and women were involved in livestock marketing, although most of the respondents were predominantly male. Gender did not affect the farmers' choice of marketing chains ($P > 0.05$). The education level of farmers had an influence ($P < 0.05$) on the choices made on the marketing chains, point of marketing sale and transport used except for the methods used for slaughter ($P > 0.05$). 58.26 % of the farmers were educated. Most of the farmers used trailer for transporting ($P < 0.05$), as illustrated in Table 3.7.

Farmers with higher levels of formal education preferred trailer transportation, explaining that trailers can be used even on private cars. They choose using a trailer due to the fact that it brings less costs when it comes to fuels and service, and is affordable compared to a van and truck. An observation occurs in some instances, with good reason, that the trucks are too expensive to be maintained by farmers owning a market in rural areas. The experience of farmers in raising cattle highly affected some of the marketing chains ($P < 0.05$). Experienced farmers used traditional slaughtering methods and preferred delivery, claiming that delivering brings more money by selling from home or on the street. On the other hand, farmers with minimal experience in keeping cattle were using commercial methods for slaughtering the cattle. Musemwaet *al.* (2012) reported that the experience of farmers influenced marketing channels, famers with longer experience in keeping cattle were using local sales and traditional ways to slaughter and sell their livestock, while those with less experience were choosing abattoirs and auctions and private buyers (Ndoroet *al.*, 2014).

Table 3.10: Association between demographic variables and the market chain of beef in Alice villages

Demographic	Marketing	Point of Sale	Mode of transport	Slaughter Methods
Age	0.291 ^{NS}	0.221 ^{NS}	0.410 ^{NS}	0.031 [*]
Gender	0.523 ^{NS}	0.904 ^{NS}	0.23 ^{NS}	0.484 ^{NS}
Education	0.021 [*]	0.013 [*]	0.051 [*]	0.624 ^{NS}
Occupation	0.053 [*]	0.042 [*]	0.013 [*]	0.093 ^{NS}
Experience	0.012 ^{**}	0.003 ^{**}	0.053 [*]	0.001 ^{**}

Significant at * $P \leq 0.05$, ** $P \leq 0.01$, but NS not significant at $P \geq 0.05$.



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The relationship between socio-demographic information and farmers' views differed statistically in terms of farmer perceptions in relation to farming practices, breed selection and market chains, as shown in Table 3.11. The responses of farmers in each village differed in how they handle and manage their livestock. Village topography, grazing pastures, and other environmental conditions, including climate, resulted in farmers' different strategies and technique. From each village over 75 % marketed their cattle. There was a statistical significance ($P<0.05$) between the demographic information and village on the choice of marketing preferred by farmers, breed preferences, and welfare management practices as shown in Table 3.11. This shows that the majority of farmers do keep cattle for security and as a source of income. Musemwaet *al.* (2010) agrees with the current study in that farmers had their individual reasons for using marketing channels. However, these results show that in each village cattle farming management, including health-related practices and marketing were practiced and according to the respondents' cattle were contributing about 85 % to their livelihood. However, there were significant differences ($P< 0.05$) between the farmer's perceptions in each village in relation to cattle herd management, health, housing and feeding management, and their markets.

Table 3.11: The effects of villages on farming practice, breed selection and, marketing

	Farming Practice	Breed Selection	Market Chain
Gaga	0.001**	0.04*	0.04*
Ntselamanzi	0.01*	0.51 ^{NS}	0.01*
Ncerha	0.002**	0.62 ^{NS}	0.02*

Significant at * $P \leq 0.05$, ** $P \leq 0.01$, but NS not significant at $P \geq 0.05$



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Conclusion

It is concluded that age, gender, experience, and education level play a vital role in farming practices and choices made in selecting certain breeds. It was perceived that the majority of cattle household owners have an average level of knowledge about cattle breeds, feeding, welfare and health management practices, and the use of marketing chains. Factors that contribute to lower livestock productivity are diseases, lack of knowledge, and poor resources. Therefore, there is a need to consider both socio-economic demography and farming management practices when developing future cattle management programmes.



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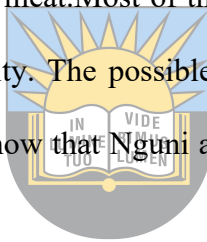
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Chapter 4: Investigating pre-slaughter blood-based stress indicators and their subsequent effects on beef quality of extensively reared Nguni and Boran steers

Abstract

The objective of the study was to investigate the differences in blood-based physiological stress indices of Boran and Nguni steers as influenced by the three pre-slaughter phases (on-farm, transportation, and lairage). Also, to determine the effect of stress responsiveness on some meat quality parameters such as pH, colour (Lightness (L^*), redness (a^*), yellowness (b^*), Chroma, Hue, Thawing and Cooking loss and Warner-Bratzler shear force (WBSF) of the two slaughtered groups. A total of twenty steers aged 18-month were transported to the abattoir for slaughter in two trips (morning and afternoon) with equal representation of each breed (10 steers in each group: 5 Nguni and 5 Boran) and kept in lairage units for a period of 16 and 24 hours, respectively. Blood samples were taken before and after transportation and at slaughter to measure the serum cortisol, glucose, creatine kinase (CK), and routine haematological stress-related parameters. From each steer, 2.5 kg of meat samples were obtained from the *longissimus thoracis et lumborum*. The CK and haematological parameters were not affected by the grouping and production stages. There were no differences among the groups ($P > 0.05$). However, cortisol and glucose levels were affected in both groups differently ($P < 0.05$). At the farm, group 1 had higher cortisol levels ($42.62\text{ng/mL} \pm 14.47$) compared to group 2 ($39.77\text{ng/mL} \pm 14.47$), while during transportation time, group 2 showed higher levels of cortisol ($148.80\text{ng/mL} \pm 14.47$) than group 1 ($116.0\text{ng/mL} \pm 14.47$). At slaughter after lairage, cortisol values for group 2 were higher ($104.88\text{ng/mL} \pm 14.47$) compared to group 1 ($101.49\text{ng/mL} \pm 14.47$). Similarly, with glucose, the groups differed significantly in pre-slaughter phases ($P < 0.05$), whereby group 1 had higher levels of glucose on the farm and during transportation ($4.15\text{nmol/L} \pm 0.46$ and $5.35\text{nmol/L} \pm 0.46$) compared to group 2 ($3.88\text{nmol/L} \pm 0.46$ and $5.27\text{nmol/L} \pm 0.46$), respectively. At slaughter, glucose levels were lower in group 1 ($4.71\text{nmol/L} \pm 0.46$) and increased in group 2 ($6.50\text{nmol/L} \pm 0.46$). For meat

quality, the L^* values for group 1 were low (32.38 ± 0.923) compared to group 2 (37.29 ± 0.923). The rest of the meat quality (pH, a^* , b^* , Chroma, hue, thawing and cooking loss, and tenderness) of the two groups did not differ ($P > 0.05$). As for the interactions between the groups and breeds, the effects were statistically significant ($P < 0.05$). The stress-related enzymes did not affect either of the breeds type ($P > 0.05$). The haematological parameters responded differently in each breed, with Boran showing higher Packed Cell Volume (PCV) values ($33.27\% \pm 0.54$) than the Nguni. Similarly with the Red Blood Cells (Boran = $7.66 \pm 0.19 \times 10^6 \mu\text{L}$, Nguni = $6.84 \pm 0.19 \times 10^6 \mu\text{L}$), and haemoglobin (Boran = $11.15 \pm 0.16 \text{ g/dl}$, Nguni = $10.43 \pm 0.16 \text{ g/dl}$). The cooking loss was significantly lower (16.91 ± 1.33 and 16.93 ± 1.33) in Nguni breeds compared to Boran (20.29 ± 1.33 and 24.08 ± 1.33). The Nguni meat was tenderer ($24.06 \pm$) than the Boran meat. Most of the stress-related enzymes did not affect physiological changes and meat quality. The possible reasons could be that the cattle were fairly handled. The obtained results show that Nguni and Boran are one of the preferred beef cattle in communal farmers.



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Keywords: Breed types, lairage duration, slaughter group, stress factors, meat quality

4.1 Introduction

Handling, transportation and the duration of the journey travelled by the steers to slaughter are critical stages in the production system (Brunel *et al.*, 2018). The different pre-slaughter phases can influence hormonal, biochemical, and haematological stress secretions and end up affecting their end product (Katiyatiya *et al.*, 2017). Loading at the farm, transportation, and offloading at the abattoir are essential stages in the production chain of beef cattle and, along the course of these procedures, the best conditions to decrease stress and promote good animal maintenance welfare must be recognised. Considering that production chains are the major physiological stressors that influence the animal's homeostasis; , the study's objective was to determine some physiological responses of Nguni and Boran breeds under various pre-slaughter conditions. To improve farm practices and decrease stress in cattle, it is necessary to investigate the effect of on-farm factors on cattle physiology during the rearing period. Beef cattle are categorised as one of the known animals sensitive to stress inductions (Mader, 2003). For instance, transferring cattle from the farm to the abattoir brings alterations to their behavior and physiological variables, displaying signs of shock (fear), nervousness, and dehydration (Miranda-De La Lama *et al.*, 2014). Stress-incited immune capacity changes have been recorded in steers, with changes to cell-intervened and humeral insusceptibility significantly affecting immune-competence which may render cattle progressively powerless to diseases (Mazzullo *et al.*, 2014). In addition, when animals encounter changes in the environment such as climate, temperature, and nutrition, they develop stress increasing the activity of enzymes, stress hormones, body temperature, and glycolysis (Mader, 2003; Jama *et al.*, 2016; Melesse *et al.*, 2011; Dokmanovic *et al.*, 2014). Therefore, the alternative of gentle relative to forceful management directly affects homeostasis, prompting versatile reactions intervened by physiological procedures aimed at avoiding the beginning of stressful processes (Collier *et al.*, 2006). However, according to Alcalde *et al.* (2017), there is still a gap in studies evaluating the

effects of on-farm management practices and transport duration on cattle's physiological factors and meat quality.

Haematological estimations have been used to distinguish limitations on productivity (Ahmad *et al.*, 2003) and come up with the diagnosis and treatment of diseases in beef cattle (Čobanović *et al.*, 2017). Instances of enzymatic discharges which are released into the serum through spillage ascending from changed membrane penetrability include alkaline phosphate (ALP), acid phosphate (ACP), aspartate aminotransferase (AST), and creatine kinase (CK) (Sattler and Fürll, 2004; Waters, 2017). In some cases, lactate, glucose, and plasma CK are produced when an animal's physiological system is formulating ways to cope with the environment that might lead to poor welfare (Terlouw, 2005).

The several stressful events are associated with transportation and handling of slaughter animal that compromise animal well-being (Perez *et al.*, 2002) and welfare. These also affect or reduce meat quality which may, therefore, cause economic losses (Adzitey *et al.*, 2011). According to King *et al.* (2006), disturbance of the animal's biological system, which leads to activation of the hypothalamic-pituitary-adrenal (HPA) axis in response to stressful stimuli releases certain physiological hormones in various amounts. Cruz *et al.* (2018) reported that the response of physical mechanisms highly affect the meat's physicochemical constraints. In livestock animals, including cattle, sheep, and goats, the influence of stress on meat quality is mostly recognised (Waters, 2017). However, there is still confusion between the preferable lairage duration for cattle. Transportation has been defined as the main element contributing the most to the pre-slaughter stressors in farm animals leading to poor meat quality and alterations in blood constituents (Warrisset *et al.*, 1998; Tadich *et al.*, 2005; Njisane and Muchenje, 2016). Hence resting period is required, allowing cattle to replenish muscle glycogen concentrations to supply ATP with the production of lactic acid. Thus helps in reducing meat pH (Li *et al.*, 2018), reduce dehydration of body tissues and carcass weight loss

(Gupta *et al.*, 2007) and to rest and recover from some of the effects of transport , as well as to improve meat quality. Under stressful circumstances, the rate and degree of *post mortem* muscle digestion might be fundamentally influenced by the physiological reaction, bringing about poorer meat quality (Lu *et al.*, 2018).Also, the stress response in cattle may be affected by the genetics of the animal (Stewart *et al.*, 2018). Therefore, understanding how hormonal and biochemical changes in blood constitute affect meat quality under different pre-slaughter handling is significant. Hence, the current study's objective is to investigate the physiological responsiveness of Boran and Nguni when subjected to pre-slaughter handling.



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4.2 Materials and Methods

4.2.1 Ethical consideration

Consent to carry out the study was approved and issued by the University of Fort Hare Ethical Clearance Committee (Reference Number: NJ1011SGUZ01).

4.2.2 Experimental site description

The steers were all handled, loaded, and transported from Fort Hare Honeydale farm in Alice town situated at an altitude of 524 m and mean annual rainfall of 480 mm. They were transported to the East London Abattoir (High-throughput), located in Cambridge in the Eastern Cape of South Africa and is approximately 120km from the farm. Its geographic coordinates are 32.58° S and 27.53° E. Average noontime temperatures in East London range between 20°C (July) to 26°C (February) with a yearly rainfall of about 593 mm mostly taking place during the summer months. The abattoir functions in typical commercial circumstances and is equipped with current technology to improve production. It functions according to standard laws and regulations governing abattoirs such as the Meat Safety Act (Act No. 40 of 2000) (SAMIC, 2006), and the Animal Protection Act (1962 and 1935) for animal welfare maintenance and to ensure public health safety.

4.2.3 Animal description and management

Twenty beef steers (10 Nguni and 10 Boran) aged-18 months with an initial weight ranging between 210-350 kg were used in the study and were all raised on the same farm (Honeydale Fort Hare farm). All steers were individually marked and identified alphabetically. They were all running together as a group throughout the experiment and grazing directly from the pastures and drinking water from on-farm dams. After the perceptions and analyses on the farm, the animals were all transported to the abattoir for the final stages of the experiment. At all pre-

slaughter stages (farm, transportation, and lairage/slaughter), the steers were described as 1 and 2 (1-for the first group and 2- for the second group).

4.2.4 Transportation details

Twenty steers were transported to the East London commercial abattoir in two loads that were moved by road in a morning and afternoon trip, respectively. Before loading, they were randomly divided into two groups of 10 steers for the morning trip (Group 1, 5 Boran and 5 Nguni) and another 10 steers for the afternoon trip (Group 2, 5 Boran and 5 Nguni). To avoid separation stress, the steers were moved and observed in their respective groups as opposed to individual animal evaluation. The first trip was loaded at the farm at 08:00 am and off-loaded at the East London abattoir at 10:00 am. The second trip left the farm at 13:00 and arrived at the abattoir at 14:45 pm. The driving distance from Alice to East London was 120.9 km for both trips, and the transportation time was in-between two hours in a 2 m high 2010 Mitsubishi (Model: Fuso FM 16-253) with two compartments of 4 m x 3 m size and approximately 0.15 m spacing within the side rails. An average speed of 80 km/h was used throughout the distance. During transportation, the stance and position of animals were observed before leaving the farm to ensure comfortability

4.2.5 Lairage duration

The lairage period was conditioned by the time of departure and of the arrival of the truck at the abattoir, taking into consideration that all the animals were slaughtered on the following day. On arrival at the abattoir for both trips, the steers were kept in the same groups of ten in nine roofed lairage pens. Group 1 was kept in lairage units for 24 hours, while group 2 was kept for 16 hours. The feed was not provided at the lairage pens to avoid carcass contamination during slaughter, but the animals were only provided *ad-libitum* access to water.

4.2.6 Slaughter procedure

The steers were moved from the lairage pens through a race into a weighing scale where they were individually weighed using a digital alleyway scale (Made in China, Mod. No; AN-1T). The live slaughter weight for the Nguni steers was approximately $\pm 356\text{kg}$, while Boran steers weighed on average $\pm 298\text{kg}$. They were then moved through another race to the slaughter floor, where they were enclosed for the process of stunning. The steers were held in line to allow normal identification procedures to be counted out before slaughter. Then for the exsanguination process, a captive bolt pistol was used on the steer's forehead to make it unconscious. Immediately after starting the bleeding process, two exsanguination blood samples were taken from each steer for cortisol, glucose, and creatine kinase analysis and haematological parameters.



4.2.7 Blood sampling and analysis

Two blood samples (10 ml each) from each steer were collected at the farm before transportation, after transportation at the abattoir, and after lairage at slaughter (during bleeding) for analysis. They were collected from the jugular vein into tubes; then, they were split into two aliquots: on the first one, haematological variables were determined, and on the second aliquot, biochemical and hormonal variables were determined. Samples were kept on ice until they were centrifuged and taken to the laboratory for routine biochemical and haematological measurements. All the samples were centrifuged at 3000 rpm and 10 °C for 15 min using Model 5403 Centrifuge (Gatenbay Eppendorf GmbH, Engelsdorp, Germany) before analysis for cortisol, glucose, creatine kinase (CK), and haematological parameters were carried out. The plasma samples were stored at -20 °C until the assay to avoid loss of bioactivity and contamination.

4.2.7.1 Cortisol analysis

Plasma cortisol concentrations were determined by enzymatic immunoassay (EIA) kit using an automatic analyser (DPC immulite and a Corti-cote kit). The enzyme activity which was bound into the solid phase was inversely proportional to the cortisol concentration in the standards and samples. Colorimetric readings were carried out using a spectrophotometer at 450 and 540 nm. The assay was performed in ng/ml, and the concentrations of cortisol were determined as described (ASPA, 1999).

4.2.7.2 Glucose

In the stored serum samples, creatine kinase levels were determined using a commercial colorimetric diagnostic kit (CK; IL Test kit, No. 181,605–90) on the Monarch 2000 Chemistry system (Monarch Chemistry System, Instrumentation Laboratories, Zaventem, Belgium). Concentrations of CK in serum were expressed in units per litre (U/L). Glucose was determined by taking 50 µl of blood serum and the samples were added to the measuring cells for dilution. Glucose concentrations in blood serum samples were determined by using the calibration curve in nmol/L. On individual plasma samples, Glucose and Creatine Kinase (CK) contents were determined by using an automatic biochemical analyser (BM HITACHI 911 - Roche).

4.2.7.3 Creatine kinase analysis

In the stored serum samples, creatine kinase levels were determined using a commercial colorimetric diagnostic kit (CK; IL Test kit, No. 181,605–90) on the Monarch 2000 Chemistry system (Monarch Chemistry System, Instrumentation Laboratories, Zaventem, Belgium). Concentrations of CK in serum were expressed in units per litre (U/L). Glucose was determined by taking 50 µl of blood serum, and the samples were added to the measuring cells for dilution. Glucose concentrations in blood serum samples were determined by using the calibration curve in nmol/L. On individual plasma sample, Glucose

and Creatine Kinase (CK) contents were determined by using an automatic biochemical analyser (BM HITACHI 911 - Roche).

4.2.7.4 Haematological parameters

Leukocyte count (WBC), Erythrocyte count (RBC), Haemoglobin (Hgb), Haematocrit (Hct), Mean Corpuscular Volume (MCV), Mean Cell Haemoglobin (MCH), Mean Cell Haemoglobin Concentration (MCHC), Red Cell Distribution (RDW) and Platelet Count (Plt), were analysed using an automated electronic particle analyser (GENIUS – VET; Celltac, MEK-6108K). Neutrophils, lymphocytes, eosinophil, basophils, monocyte and other cells the cells were counted and identified using an optic immersion microscope and were analysed using an electronic haematological analyser following the procedures described in Gupta *et al.* (2007) and Liotta *et al.* (2007). Neutrophil Lymphocyte ratio (N/L) was determined using blood smears stained with Wright stain.

4.2.8 Meat sampling and quality tests

After carcass dressing, 2.5 kg of meat samples were harvested from the Loin muscle (*Longissimus thoracic et. Lumborum* (LTL)) from each steer. Smaller sub-sections of the LTL muscle (approximately 100 mm thick) from the left side of each carcass were taken from the 10th rib in the direction of the rump for meat quality analysis. Samples were sealed in plastics before they were stored in a cooler box full of ice cubes for 3 hours during transportation. When the samples arrived at the University of Fort Hare Meat Science Lab, they were weighed and then frozen at -20°C until analysis of meat quality attributes including pH, meat colour (lightness; L*, redness; a*; and yellowness; b*) and thawing loss (TL%) were analysed. Before meat quality experiment analyses were performed, the samples were thawed at 4°C for 24 hours. After 7 days of refrigeration, measurements for cooking loss (CL %) and Warner Bratzler Shear Force (WBSF) were performed. For WBSF measurements, 100mm thick sub-sections were processed into the 20mm steak for CIE

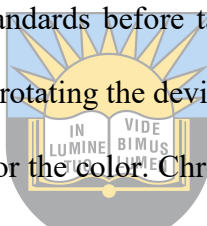
(Commission on Illumination lab color) measurements and 30mm steaks for WBSF measurements.

4.2.8.1 Determination of meat pH

A portable pH meter with a sharp metal sheath (A Testo 205 model) was used to determine the pH of the Loin muscles 24 hours after slaughter. The pH meter was calibrated before use.

4.2.8.2 Determination of meat color (L^* , a^* and b^*)

The color of meat coordinates L^* (lightness), a^* (redness) and b^* (yellowness) was determined using a Minolta color-guide 45/0 BYK-Gardener GmbH machine (illuminant: D65; Visual angle or standard observer: 10° ; diameter measurement: 20 mm). The machine was calibrated using the white standards before taking measurements. The results were taken after 3 readings achieved by rotating the device by 90° on the sample surface 3 times so as to obtain the average value for the color. Chroma (Cr) was calculated as $(a^{*2} + b^{*2})^{1/2}$ and the Hue angle (HA) was also calculated as $[\tan^{-1}(b/a)]$. The color values were then recorded accordingly.



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4.2.8.3 Thawing and cooking loss measurements

After determination of pH and colour, the samples were vacuum packed. The samples were weighed before freezing using a LBK weighing scale and then were kept at -20°C . The samples were subsequently weighed 7 days after refrigeration, then thawed for 24 hours at 4°C and weighed again. The recorded weight differences were expressed as the thawing loss percentage, which was calculated as follows:

$$\text{Thawing Loss (TL \%)} = \frac{\text{Weight before thawing} - \text{Weight after thawing}}{\text{Weight before thawing}} \times 100$$

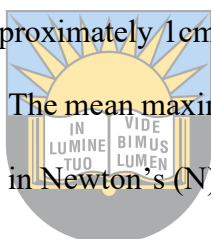
The same meat samples were then placed into thin-walled plastic bags and placed in a water bath until an internal temperature of 71°C (recorded by a portable thermometer) was

reached. The meat samples were cooked for 45 minutes at 71°C. After cooking, the samples were cooled to room temperature for 4 hours and weighed again so as to calculate the amount of water lost after thawing and during cooking. The results were expressed as the cooking loss percentage which was calculated as follows:

$$\text{Cooking loss \%} = \frac{\text{Weight before cooking} - \text{Weight after cooking}}{\text{Weight before cooking}} \times 100$$

4.2.8.4 Tenderness

Following the thawing and cooking loss estimations, for measuring the texture of the cooked meat, the samples were sheared opposite to the fibre direction using a Warner-Bratzler Shear Force (WBSF) device mounted on an Instron 3344 Universal Testing apparatus. Crosshead speed was at 20 mm/min, one shear in each center's focal point. From each sample, three subsamples of proximately 1cm core diameter were separated parallel to the long axis of the muscle fiber. The mean maximum load recorded for the three centres represents the peak force's average in Newton's (N) for each sample.



4.2.9 Statistical Analysis

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General linear model of SAS (2003) was used to determine the relationship between stress indicators and independent variables. The independent variables were breed type (Nguni and Boran) and production stages (farm handling, transportation, and slaughter). A PROC GLM test (SAS, 2003) was used to test the effect of production stages and breed type on serum cortisol, glucose, creatine kinase, and haematological parameters. The model used was: $Y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \gamma_k + \varepsilon_{ijk}$. Where Y_{ijk} is the response variable (cortisol, glucose, creatine kinase, and haematological parameters); μ is the mean; α_i is the breed effect; β_j is the group effect; $(\alpha\beta)_{ij}$ is the interaction between variables and ε_{ijk} is the standard error

Meat quality data were subjected to analysis of variance with the method of SAS using general linear model. PROC GLM test (SAS, 2003) was used to test the effect of breed type and stress

responsiveness induced by production stages on pH, color (L^* , a^* , b^*), Chroma, Hue, thawing and cooking losses and Warner Bratzler Shear Force (WBSF). The model used was: $Y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \epsilon_{ij}$ where, Y_{ijk} was the response variable (L^* , a^* , b^* , Chr, Hue, TL, CL and tenderness); μ was the mean; α_i was the breed effect; β_j was the effect of stress responsiveness; $(\alpha\beta)_{ij}$ was the interaction between breed and groups; and ϵ_{ij} was the standard error. Significant differences between the group mean were tested by least significant difference (LSD), and at $P < 0.05$ differences were considered significant.



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4.3 Results and Discussion

4.3.1 Response of physiological stress indicators at different production stages

On-farm loading (handling), transport and the duration of animal stay at lairage, signify critical stages in the production chain. Table 4.1 shows means and standard errors for serum cortisol, glucose, and creatine kinase affected by different production stages. The stages including loading the animals on the truck at the farm, transportation, off-loading the steers at the abattoir, and lairage duration were all observed as the main factors that triggered the steers' physiological stress except for the haematological parameters. When steers were taken from the farm to the abattoir in two groups at different times, the cortisol level significantly differed with each production stage. Group 2 had higher cortisol levels (148.80 ± 14.47 ng/ml) immediately after transportation at the abattoir compared to Group 1 (116.00 ± 14.47 ng/ml). This could be due to the reaction of the nervous system because when animals are experiencing a potential threat the hypothalamic-pituitary-adrenal axis becomes activated which later produces adrenal cortex that release glucocorticoid stress hormone (Casalet *al.*, 2017; Turpeinen *et al.*, 2013). However, it was proven that stressors due to fear and arousal increased cortisol during the transportation (Hagenmaier *et al.*, 2017).

Nevertheless, the concentrations of serum glucose also varied with each stage ($P < 0.05$). Group 1 had high glucose levels (5.35 ± 0.46 nmol/L) immediately after arrival at the abattoir, while Group 2 showed an increase (6.50 ± 0.46 nmol/L) during exsanguination. Conversely, Group 2 showed decreased glucose levels (5.27 ± 0.46 nmol/L) immediately after transportation at the abattoir, though Group 1 had low levels (4.71 ± 0.46 nmol/L) during exsanguination. According to the obtained results, group 1 was able to survive without feed because their glucose levels started to pick up during transportation but were found stabilized during exsanguination after the lairage duration.

The drastic changes for glucose concentrations appeared mostly on the second group, as it ranged from $(3.88 \pm 0.46 \text{ nmol/L})$ during farm handling to $(6.50 \pm 0.46 \text{ nmol/L})$ after lairage. This shows that feed withdrawal had a detrimental effect on the glucose concentrations. In agreement, Stewart *et al.* (2018) reported that feed deprivation in livestock results in changes in serum glucose concentrations. Tadich *et al.* (2013) also reported that lack of food can affect blood concentrations such as fatty acids and glucose. In contrast to the recent study, Todd *et al.* (2000) discovered that fasting times more than 15 h and transportation less than 15 h does not affect glucose concentrations in beef cattle. In addition, there were no differences in the levels of CK found for the three different production stages and also between the two breeds. The relevant reasons that may lead to no changes of CK levels on all the production stages and on the breeds might be the result of the small circulations of glycolysis caused by the catecholamine (Marencis *et al.*, 2012). Also, it may be the fact that the breeds were all subjected to the same situations and processes.



Furthermore, since higher levels of CK are associated with muscle damage, this may indicate less or no muscle damage during the pre-slaughter handling for all the production stages among the breeds. However, this can be a good indication of the degree of welfare during the whole handling procedures. Furthermore, it was discovered that only cortisol that was affected by the breed type, while glucose and CK did not vary between the breeds ($P > 0.05$). This could be due to the correspondences in the Boran and Nguni behavior during handling, and to the fact that both breeds had more similarities in terms of physiological state and how they respond to changes and adaptation.

Table 4.1: Mean and standard error for cortisol, creatine kinase, and glucose of Boran and Nguni steers at different production stages

Production stages		Cortisol (MSE)(ng/ml)	Glucose(nmol/L)	Creatine kinase (U/L)
Farm	1	42.62 ^b ±14.47	4.15 ^b ±0.46	370.40±76.21
	2	39.77 ^a ±14.47	3.88 ^a ±0.46	310.50±76.21
Transportation 1		116.0 ^a ±14.47	5.35 ^b ±0.46	366.50±76.21
2		148.80 ^b ±14.47	5.27 ^a ±0.46	378.90±76.21
Slaughter	1	101.49 ^a ±14.47	4.71 ^a ±0.46	373.20±76.21
	2	104.88 ^b ±14.47	6.50±0.46	340.20±76.21
Breed type	1	104.69±18.14	6.06±0.57	383.50±64.57
	2	159.68±18.14	5.71±0.57	335.60±64.57
P-value (groups)		0.0001 [*]	0.0025 [*]	0.9876 ^{NS}
P-value (breeds)		0.05 [*]	0.67 ^{ns}	0.61 ^{ns}

^{ab} Means in the same column with different superscripts and are significantly different at $P \leq 0.05$, but non-significant at $P > 0.05$.

4.3.2 Haematological Parameters

The effect of breed type on haematological parameter is presented in Table 3.2. In the results, production stages (farm loading, transportation, and at slaughter in the abattoir) did not have a significant effect ($P > 0.05$) on haematological parameters collected from the blood samples of both groups. Meanwhile, breeds had a significant effect ($P < 0.05$) on parameters such as RBC, PCV, and haemoglobin; with the Boran breeds having produced more of RBC ($33.27 \pm 0.54 \times 10^6 \mu\text{L}$), PCV ($7.66 \pm 0.19 \%$), and haemoglobin ($11.15 \pm 0.16 \text{ g/dl}$) values compared to Nguni steers that produced lower quantities of RBC, PCV, and haemoglobin. When the beef cattle were subjected to higher levels of stress, the Boran breeds showed higher levels of PCV levels. The recognized increase in PCV values in the Boran steers can be attributed to the lack of water during transport period, and also when the steers arrived at the abattoir they were not familiar with the novel environment therefore it was difficult to drink from the water troughs in the abattoir. This shows that Nguni breeds can hold or maintain water better than Boran steers. Also, too much stress induced in beef cattle during handling may activate sympathetic nerve system leading to a release of catecholamines that induce splenic contraction. In agreement to the current results, Polizopoulou (2010) and Habibuet *al.* (2018) reported that the increased values of PCV in handled and restrained livestock animals were due to splenic contractions. Therefore, this shows that Boran were more stressed by the situations compared to Nguni breeds which responded positively.

This demonstrates that the applied stressful handling could possibly disturb the animal's physiological condition. Brunel *et al.* (2018) reported that increased PCV values in the cattle submitted pre-slaughter handling could be the results of water imbalances due to dehydration during travelling times (transport time). Similar findings were reported by (Ruben *et al.*, 2016 and Habibuet *al.*, 2018), emphasizing that beef cattle had higher PCV values during handling processes such as loading and transportation. Correspondingly, RBC and haemoglobin count

showed a significant difference ($P < 0.05$) among the breeds. Haematological changes in cattle have been reported to be modulated mostly by the central nervous system through hypothalamic-pituitary-adrenal (HPA) axis during stressful situations (Habibuet *al.*, 2017). According to the current results central nervous system modulated erythrocyte parameters by affecting water intake and respiration, resulted from heat stress and sweating. Turpeinen *et al.*, (2013) observed that large amount of RBC may cause aberrations, such as increased values of PCV. In addition, Boran produced high RBC values (7.16 ± 0.19) because of the increased plasma fibrinogen levels (Tadich, 2005). Lastly, since Nguni had lower quantities of RB cells less haemoglobin was produced and, therefore less oxygen was transported throughout the body. These results are associated with reducing cellular oxygen necessities to decrease metabolic heat load (Habibuet *al.*, 2017). Therefore, the industry needs to consider using Nguni and should also create stopping stations on the way to abattoir plants allowing animals to rest and be provided clean water.



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Table 4.2: Effect of breed type on Packed Cell Volume, Red Blood Cells, and Haemoglobin during production stages (Mean± SE)

Breed type	Packed Cell Volume (%)	Red Blood Cells (10 ⁶ /μL)	Haemoglobin (g/dl)
Boran	33.27 ^b ±0.54	7.66 ^b ±0.19	11.15 ^b ±0.16
Nguni	30.21 ^a ±0.54	6.84 ^a ±0.19	10.43 ^a ±0.16
P-value	0.0002*	0.0037*	0.0021*

^{ab} Means in the same column with different superscripts are significantly different at $P<0.05$



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4.3.3 Meat quality attributes

Table 4.3 shows that the influence of breed and production phases on some instrumental meat quality traits were not significant ($P > 0.05$) except for lightness ($P=0.0320$), cooking loss ($P=0.0138$) and tenderness ($P=0.0226$). However, there were significant ($P < 0.05$) interactions between breed and group from farm handling, transport, and at slaughter on the meat colour (b^*) ($P= 0.0041$), and also on hue quality (0.0305), respectively. However, breed and group individually did not affect b^* and hue ($P > 0.05$). This proves that there was less of water provided as described that muscle colour is created on the reflectance of light of free water. In the current study the absence of significant effects of the stress responsiveness on meat quality parameters (pH, a^* , CHr, and thawing loss) is in agreement with work by Stewart *et al.* (2018) who reported no significance for meat pH between transported and lairaged beef cattle. In contrast to the current study, King *et al.* (2006) stated that the association between stress hormones and animals in particular beef cattle, has been found to affect meat quality by damaging muscle glycogen and increasing meat pH. Though Boran appear to have higher meat pH values than Nguni steers, statistically there was no difference ($P > 0.05$). Boran (22.19 ± 1.33) showed higher cooking loss values than the Nguni (16.92 ± 1.33). In addition, there was statistical significance ($P < 0.05$) among breeds and meat tenderness, Nguni breeds were tenderer (24.06 ± 1.39) compared to the Boran breeds (19.02 ± 1.39). There was less decrease of water loss in a slice of Nguni meat, hence it was tenderer compared to the Boran meat.

Extended stressors to beef cattle produce the chance of physiological reactions, which can be observed as a danger to their welfare and meat quality (Agbeniga and Webb, 2012). The effect of physiological reactions on the meat quality did not influence most of the measured meat parameters, the significant difference ($P < 0.05$) were only found on the colour attribute (L^*), group 1 had the lowest lightness (L^*) value (33.32 ± 0.88) compared to the other group (36.26 ± 0.88). This indicates that stress indicators did not react positively on muscle

characteristics. Diazeet *et al.* (2013) and Soji *et al.* (2015) reported that beef cattle lairaged for 24 hours tend to have lower meat lightness colour due to completion for available oxygen between mitochondrial enzymes and myoglobin resulting in less yellowness (b^*) and lighter (L^*) meat colour. In contrast to the recent results, Campo *et al.* (2010) reported that in their findings lairageing had no effect on L^* values in cattle. Also, Ekizet *et al.* (2012) studies show no significant effect of breed and pre-slaughter handling on meat L^* , b^* and a^* . The outcomes of studies on meat colour are not consistent. Gallo *et al.* (2003); Muchenje (2009); Zhong *et al.* (2011); Xin *et al.* (2018) found that there was a significant relationship between stress responsiveness hormonal concentrations and meat quality traits (L^* and b^*).

However, they also reported a significant effect of lairage and transportation on meat color b^* and a^* in beef cattle. Tenderness of meat from the two groups did not differ with regard to production stages ($P > 0.05$), but there were breed effects ($P < 0.05$) at slaughter on meat tenderness. It was statistically proven that meat from calm cattle tend to have a muscle pH of not less than 6.5 compared to the most excitable cattle (King *et al.*, 2006) which should have initiated *post-mortem* metabolism to occur at its high rate. In conclusion, to the results observed in the current study the levels of cortisol, glucose, creatine kinase and haematological parameters were mostly non-significant on meat quality traits, showing not much difference between the groups, breeds, and the production stages after slaughter. This could be due to how the steers reacted during handling and adaptation to the new changes, leading to less or less stress hormones production, thus reducing the meat quality.

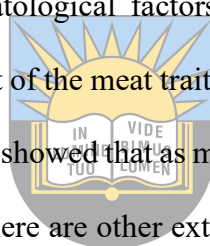
Table 4.3: Mean and standard error for meat quality parameters of Boran and Nguni steers as affected by stress responsiveness at slaughter

Breed	Group		P-value (breed)
	Group 1 (16 hrs)	Group 2 (24 hrs)	
Ultimate pH (pH ₂₄)			
Boran	5.63 ^{aB} ±0.025	5.60 ^{aB} ±0.025	NS
Nguni	5.59 ^{aB} ±0.025	5.62 ^{aB} ±0.025	
P-value (group)	NS		
Lightness (L*)			
Boran	32.38 ^{cA} ±0.923	37.29 ^{aA} ±0.923	NS
Nguni	34.26 ^{aA} ±0.923	35.23 ^{bA} ±0.923	
P-value (group)	0.0320		
Redness (a*)			
Boran	17.58 ^{aB} ±0.368	16.93 ^{aB} ±0.369	NS
Nguni	17.56 ^{aB} ±0.368	16.82 ^{aA} ±0.369	
P-value (group)	NS		
Yellowness (b*)			
Boran	10.43 ^{aB} ±0.605	13.03 ^{aB} ±0.605	NS
Nguni	12.42 ^{aB} ±0.605	11.65 ^{aB} ±0.605	
P-value (group)	NS		
P-value (interactions)	0.041		
Hue			
Boran	30.62 ^{aB} ±1.269	37.39 ^{bA} ±1.269	NS
Nguni	35.36 ^{Aa} ±1.269	34.62 ^{Bb} ±1.269	
P-value (group)	NS		
P-value (interactions)	0.0305*		
Chroma			
Boran	20.51 ^{aA} ±0.531	21.39 ^{aA} ±0.531	NS
Nguni	21.54 ^{aA} ±0.531	20.50 ^{aA} ±0.531	
P-value (group)	NS		
Thawing loss (TL)			
Boran	7.33 ^{aA} ±0.569	8.54 ^{Aa} ±0.569	NS
Nguni	8.01 ^{aA} ±0.569	7.79 ^{aA} ±0.569	
P-value (group)	NS		
Cooking loss (CL)			
Boran	20.29 ^{Ab} ±1.295	24.08 ^{aA} ±1.295	0.0138*
Nguni	16.93 ^{aA} ±1.295	16.91 ^{bA} ±1.295	
P-value (group)	NS		
Tenderness			
Boran	19.49 ^{aA} ±1.387	18.55 ^{bA} ±1.388	0.0226*
Nguni	22.07 ^{bA} ±1.387	26.05 ^{aA} ±1.388	
P-value	NS		

^{ABab}Means with different superscripts within the same row/column are significantly different ($P > 0.05$), * ($P < 0.05$), NS = Not significant

4.4 Conclusion

Management of animals during pre-slaughter handling is the main concern in the welfare of beef cattle. At the farm, during and after lairage some of the blood-based stress indicators such as cortisol and glucose showed different response. Also, exposing the steers to longer hours of transportation and new environment led to higher levels of cortisol and decreased glucose levels. Therefore, the study has also proven and agreed to previous studies that pre-slaughter handling activates the hypothalamic-pituitary adrenal axis of beef cattle. However, for the breed type there were no differences in terms of physiological changes, meaning both Nguni and Boran are the best preferable beef breeds to keep and for marketing due to their good characteristics. As regards to haematological parameters, RBC, PCV and haemoglobin values were affected by breed type. Haematological factors were not disturbed by either group. According to the obtained results, most of the meat traits were not affected by the stress-related enzymes. However, the current results showed that as much as welfare and meat quality relates, it is not always the case. Therefore, there are other external stimuli that still need to be further investigated that might affect meat parameters



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4.5 References

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Chapter 5: General Discussion, Conclusions, and Recommendations

5.1 General discussion

The aim of the study was to find both the most suitable breed that could be raised in rural areas and the most stress-inducing factors and subsequent effects on an animal's physiological response and meat quality. Livestock are a contributor to the environmental effects of human activity. Carreras *et al.* (2017) reported that exposure of animals to humans is one of the most frightening events to animals. Previous and current studies have revealed that animal-human interaction does not only intervene with animal welfare, but also meat quality. Various researchers across the world have suggested that animals should be subjected to human contact at an early stage in order to familiarize them with the human relationships (Losada-Espinosa *et al.*, 2018). Good farming practices for beef cattle care are principally practices of accountability that are epitomized, social, aggregate, and responsive (Barclay, 2016). Animal welfare is one of the new concerns of meat consumers together with detail on product quality and assurance of environmental wellbeing, which are consequently important to consider for characterizing farm animal production systems.



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Animal welfare alludes to the avoidance of affliction of conditions that are detrimental to the animals' wellbeing. It depends on the agreement between the individual animal and its condition, and identifies with the person's ability for consciousness and emotions. According to Fureix *et al.* (2015) the welfare of an animal is its state as respects its endeavours to adapt to its condition. Some livestock management methodology makes the environment more appropriate for the animals either by lessening the recurrence of potential aversive occasions or giving extra positive encounters to the animals, such as handling or dealing with.

In chapter 3, it was observed that, in Eastern Cape Province cattle are one of the significant livestock species in the traditional farming practices including mixed crop-animal production

by contributing mainly in their livelihood. The rural residents were living by the mixture of agriculture and livestock herding. They owned cattle, sheep, goats, pigs and chickens, and cultivated maize, cabbage, potatoes, pumpkins, and beans (Gushaet *al.*, 2018). In many cases maize and beans after harvesting were used as animal feeds, particularly in summer and during drought seasons. The respondents from all the villages participated in marketing for various reasons, including paying school fees, maintaining their family needs, ceremonies, and funerals. The cattle were mostly sold in an informal state due to age, beliefs, accustoms, and lack of resources and money. These findings reveal that as time changes cattle farming in the rural areas is depreciating due to limited resources and seasonal changes resulting in low rangelands and less palatable grass (Mapiyeet *al.*, 2009).

In most farming sectors, cattle are extensively and occasionally handled, and then later transferred to intensive system during their finishing stages (Njisane, 2016) such as abattoir. On farm situations and activities may bring some important benefits for animal welfare and health (Hernandez- Mendoet *al.*, 2007), in natural pastures there are less restrictions, animals get the chance to move and exercise, and the space given also decrease aggression and fights (Van laeret *al.*, 2013). On the other hand, there are negative outputs and consequences associated with occasionally handled beef producing farm cattle, as it leads to disease spread, economic costs as more labours will be needed to move the cattle (transport loading), and exposure to adverse weather conditions. The reaction of animals to the stressor is a pattern of endocrine, neural, immune, haematological, and metabolic changes for restoration of biological system (Chulayo and Muchenje, 2015; Carreras *et al.*, 2017). A great number of behavioural tests concentrated on measuring animals' emotions to assess biological responses and test the effect of different management on the end product. It has been reported that, animals which find handling difficult produces a negative response in terms of biological matrix (Mpamhanga and Wotton, 2015).

In chapter 4, the response of cortisol, creatine kinase, glucose, and haematic in two different slaughtered breeds at the farm (loading), after transportation and at slaughter (after lairage) were investigated. Hormonal and biochemical factors are very important in terms of detecting stress levels in animal's well-being. The results attained in chapter 4, showed that breed type had no effect on the biochemical (glucose and creatine kinase) and hormonal (cortisol) changes, it only had minimal effect on few haematological parameters such as RBC, PCV and haemoglobin. While, cortisol and glucose reactions were affected by the production stages (on-farm handling, transportation and at slaughter/after lairage) (Group 1 and 2: F, T, and S) as there were variable changes observed.

Earlier studies have revealed that physiological measurements taken after handling and transportation can be inconstant, changing from almost baseline to extremely high (Grandin and Shivley, 2015). However, when some cattle are restrained, transported and exposed to novelty, such situations disturb their welfare, leading them to react with unusual responses and higher cortisol, glucose, or CK, levels compared to others (Ndou *et al.*, 2011) since stress hormones are more stimulated and activated during such situations.

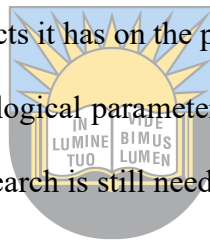
Moreover, in chapter 4, investigation of stress responsiveness on the meat quality traits was made. Moreover, it was observed that meat quality traits were least affected by some of the production stages. Also, there were few meat parameters which were affected by the breeds but better than the production stages. In response to pre-slaughter events, high secretion of stress related hormones can result in energy reduction, protein catabolism, dehydration and muscle depletion (Nikbinet *et al.*, 2016), which then affects meat quality parameters (Faucitano, 2017).

5.2 Conclusions

It was concluded that cattle owners from the rural areas are still struggling with taking care of their animals and improving their businesses, due to lack of information and resources. Pre-slaughter stress (which includes the circumstances and events at the farm, during transportation, and lairage period) affected the production of enzymes, cortisol and glucose, and also had an influence on some haematological parameters and the quality of beef harvested from the Nguni and Boran steers raised in communal areas of Alice, Eastern Cape.

5.3 Recommendations

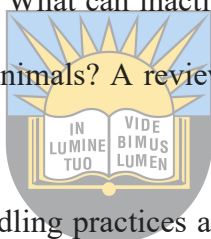
The study has produced the recommendations that, there is a need to demeanour this whole farm practices to abattoir phases. Transport logistics of beef cattle should be revised and improved to reduce the negative impacts it has on the physiology and meat of the steers. Little is known about the effect of haematological parameters on welfare and meat quality traits in beef cattle, then in this area, more research is still needed. Furthermore, between animal types, as much as there were slight differences but Boran responded positively to pre-slaughter stressors compared to Nguni breeds. Therefore, in improving meat quality, the selection of Boran should be targeted though more research is still required.



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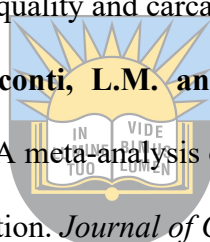
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Appendix 1



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