INVESTIGATION INTO THE PRECISION FEEDING OF NGUNI STEERS UNDER FEEDLOT CONDITIONS

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BLOEMFONTEIN
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DECLARATION OF INDEPENDENT WORK

DECLARATION WITH REGARD TO
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I, YOLANDA VENTER, identity number: and student number: , do hereby declare that this research project submitted to the Central University of Technology, Free State for the Degree MASTER OF AGRICULTURE, is my own independent work; and complies with the Code of Academic Integrity, as well as other relevant policies, procedures, rules and regulations of the Central University of Technology, Free State; and has not been submitted before to any institution by myself of any other person in fulfilment (or partial fulfilment) of the requirements for the attainment of any qualification.

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INVESTIGATION INTO THE PRECISION FEEDING OF NGUNI STEERS UNDER FEEDLOT CONDITIONS

SUMMARY

The purpose of the project was to assist the Nguni Cattle Breeders' Society to determine the most suitable ration for Nguni calves under feedlot conditions, and to investigate which animals will perform best under feedlot conditions. The rations that were evaluated were: Nguni Starter (High roughage), Nguni Grower (Medium roughage), Nguni Finisher (Low roughage) and Feedlot Grower Commercial (Low roughage). The trial was run at Sernick feedlot, near Edenville. Two hundred Nguni male calves, sourced from 24 different herds from five provinces, were divided into four groups of 50 each. They were backgrounded in the pre-conditioning phase for 32 days and received *ad lib* *Eragrostis* grass. They were randomly allocated to, and tested on four different rations, viz and slaughtered when they reached acceptable carcass subcutaneous fat classification, either after 105, 120 or 135 days on test. Animals with the highest initial weights were slaughtered first (105 days on feed and had the highest end- and carcass weights). None of the other slaughter groups were able to match these end and carcass weights, irrespective of the rations received. Calves on the commercial ration did significantly better than the calves on the other rations for ADG (1.34 kg/d vs 1.24-1.27 kg/d), total gain (159.1 kg vs 147-150 kg), end weight (7 to 11 kg heavier) and had a carcass weight of 204 kg vs. 196-198 kg for the other treatment groups.

Dressing percentage of animals on the commercial ration was 56.5%, which was not significantly better ($P > 0.05$) than the dressing percentage of the high (roughage) ration animals. Significant differences in starting weight and age were evident in calves originating from different provinces, but these differences were not significant at the end of the test with regards to carcass traits, as animals were not slaughtered on the same day. Arrival weight had a marked influence on test length and margin over feed costs, favouring the heavier calves. Carcase weights of calves with higher arrival weights were also heavier and closer to market requirements. It was concluded that Nguni cattle can be

fed profitable in feedlots. Results indicate that preconditioning calves to reach minimum weights close to 200 kg to be considered on arrival (or at the end of preconditioning or backgrounding phase) for profitable feeding of Nguni cattle in a feedlot. Although ration had a significant effect on ADG, it was negated by other factors contributing to differences in feedlot profitability. Although the low roughage and commercial rations were not the cheapest per ton, they were the most profitable to feed in this case. Nguni cattle did also perform profitably on the (normal) commercial diet. Significant differences in feedlot performance could be attributed to the source of animals. Individual herds were obviously restricted to region or province. Although not necessarily proven by this trial, these differences may be due to genetic merit, or environmental conditions prior to the trial. No excessive health fallouts occurred.

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TABLE OF CONTENT

	PAGE
DECLARATION OF INDEPENDENT WORK	ii
ACKNOWLEDGEMENTS	iii
SUMMARY	iv
LIST OF ABBREVIATIONS	ix
LIST OF FIGURES	x
LIST OF TABLES	xii
CHAPTER 1	
INTRODUCTION	1
1.1 Background	1
1.2 The feedlot industry in South Africa	5
1.3 Problem Statement	6
1.4 Objectives of the Study	7
1.5 Rationale	8
1.6 Precision feeding	10
1.7 Research hypothesis	11
CHAPTER 2	
LITERATURE OVERVIEW	13
2.1 Introduction	13
2.2 Background about the Nguni breed	13
2.3 Functionality of the breed	15
2.4 Nguni cattle in the feedlot	18
2.5 Location and design of a feedlot	19
2.6 Feedlot profitability	19
2.7 Factors that affect feedlot profitability	21
2.7.1 Costs	21
2.7.2 Management	22
2.7.3 Production efficiency	23

2.8 Efficiency measurements in the feedlot 23
2.8.1 Body weight (BW) 23
2.8.2 Feeding days 24
2.8.3 Average daily gain (ADG) 24
2.8.4 Feed conversion ratio (FCR) 25
2.8.5 Nutrition 26
2.8.6 Dressing percentage 26
2.8.7 Mortality and Morbidity 27
2.9 Development of body size and growth rate 27
2.10 Meat and carcass classification 28
2.11 Meat and carcass quality 29
2.12 Body composition traits 30
2.12.1 Background 30
2.12.2 Procedure for using ultrasound 31
2.13 Climate change 32

CHAPTER 3
MATERIALS AND METHODS 33
3.1 Study Site 33
3.2 Animals 33
3.3 Nutrition 36
3.4 Measurements 38
3.4.1 Weighing of the animals 38
3.4.2 Feeding of the animals 40
3.4.3 Real-time ultrasound measurements 40
3.4.4 Slaughtering of the animals 41
3.5 Investigation of the traits 42
3.5.1 Test length 42
3.5.2 Age and weight at start of test 42
3.5.3 Average daily gain weight 42
3.5.4 Total gain weight 42

3.5.5 Average daily gain and gain weight at 99 days 43
3.5.6 Age and weight at end of test 43
3.5.7 Carcass weight 43
3.5.8 Dressing percentage 43
3.6 Data analysis 43

CHAPTER 4
RESULTS AND DISCUSSION 44
4.1 Introduction 44
4.2 Feed intake of the different groups 44
4.2.1 The effect of feed conversion ratio 49
4.3 The effect of the different test lengths on the important traits 51
4.4 Influence of age on weaning calves 53
4.5 The effect of arrival weight 54
4.6 The effect of ration, test length and province of origin 56
4.7 Real time ultrasound scanning 59
4.8 Ration cost 62
4.9 Slaughtering of the animals 63

CHAPTER 5
CONCLUSION AND RECOMMENDATIONS 67
5.1 Conclusion 67
5.2 Recommendations 69

REFERENCES 71

ADDENDUM A: Scientific Article 82

LIST OF ABBREVIATIONS

DFI:	Daily feed intake
ADG:	Average daily weight gained
CP:	Crude protein
DMI:	Dry matter intake
DP:	Dressing percentage
EMA:	Eye Muscle Area
FCR:	Feed conversion ratio
F:G:	Feed to gain ration
ICAR:	International Committee for Animal Recording
LSM:	Least Squares Means
ME:	Metabolizable energy
MJ ME/kg DM:	Megajoules of metabolizable energy per kilogram dry matter
NCBS:	Nguni Cattle Breeders' Society
N:	Nitrogen
RFI:	Residual feed intake
RTU:	Real-time-ultrasound
SAMIC:	South African Meat Industry Company
SD:	Standard deviation

LIST OF FIGURES PAGE

Figure 1.1: The South African Beef Net Chain 3

Figure 3.1: Different feeding regimes in coloured bags 37

Figure 3.2: Image of bulls feeding at the feedlot 38

Figure 3.3: Weighing of the animals 40

Figure 3.4: Image of the scanning equipment 41

Figure 3.5: Image of the P8 (fat layer on the rump) taken with the PIE Medical Falco 100 scanner 41

Figure 4.1: Average total intake of the different rations 46

Figure 4.2: Average daily intake of the different rations over the trial period 47

Figure 4.3: Calves originating from different provinces showed differences in growth 58

Figure 4.4: Average cost of ration from August to December 2016 (R/ton) 62

Figure 4.5: Nett income per animal per treatment 63

Figure 4.6: Image of carcasses after the first slaughtering (105-days) in the feedlot 65

Figure 4.7: Image of carcasses after the second slaughtering (120-days) in the feedlot 65

LIST OF TABLES PAGE

Table 3.1: Feeding regimes of the different groups 36

Table 3.2: Chemical composition of rations on dry matter intake (DMI) basis 37

Table 3.3: Time schedule and measurements taken 39

Table 4.1: The number of total days in the feedlot for every month 45

Table 4.2: The total feed consumed per month (ton) 45

Table 4.3: Mean intake (kg) per animal per day from August to December 46

Table 4.4: LSM (Least Squares Means) for the different rations corrected for the effects of province of origin and test length for starting weight, ADG, final weight, total gain, cold carcass weight and dressing percentage 48

Table 4.5: The average daily feed intake (DFI), ADG (mean ± S.D.) and FCR per group 50

Table 4.6: Least square means (LSM) for Test Length corrected for the effects of Ration and Province for starting weight, ADG, end weight, total gain weight, cold carcass weight and dressing percentage 52

Table 4.7: Least square means (LSM) for test length corrected for the effects of ration and province of origin and the age of the animals **53**

Table 4.8: Effect of arrival weight on the test length, ADG, ADG (99 days) and carcass weight (Mean ± SD) **55**

Table 4.9: Least square means for the effect on the arrival weight of the animals on the different test lengths **56**

Table 4.10: Least square means for the effect of Province, corrected for test length and ration, on the test length, starting age, starting weight, ADG, weight gain and the age at the end of the test **57**

Table 4.11: Least square means for the effect of ration on the test length **59**

Table 4.12: Effect of ration on RTU measurements after 72 days of feeding (Mean ±SD) **60**

Table 4.13: Effect of the different test lengths on rump fat, rib fat marbling and EMA after 105, 120 and 135 days of feeding (Mean ± SD) **60**

Table 4.14: Phenotypic correlations between RTU traits, weight and age at 72 days on the test **61**

Table 4.15: The number of animals slaughtered in the different weight classes **64**

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

In South Africa livestock production contributes substantially to food security. Seventy per cent of agricultural land in South Africa can be utilised only by livestock and game. The gross value of livestock products increased by 185% from 1995/2000 to 2006/2010 (Meissner *et al*., 2013). According to the Red Meat Producers Organisation RPO (2018), there are currently ±1.2 billion people with a demand for red meat in Africa. This is approximately 15,5% of the world's population. Africa is the fastest growing population in the world, and it is estimated to double by 2050. By then, more than 25% of the earth's total population will live in Africa. The RPO estimate that the food market in East and South-East Africa will triple by 2040 (RPO, 2018).

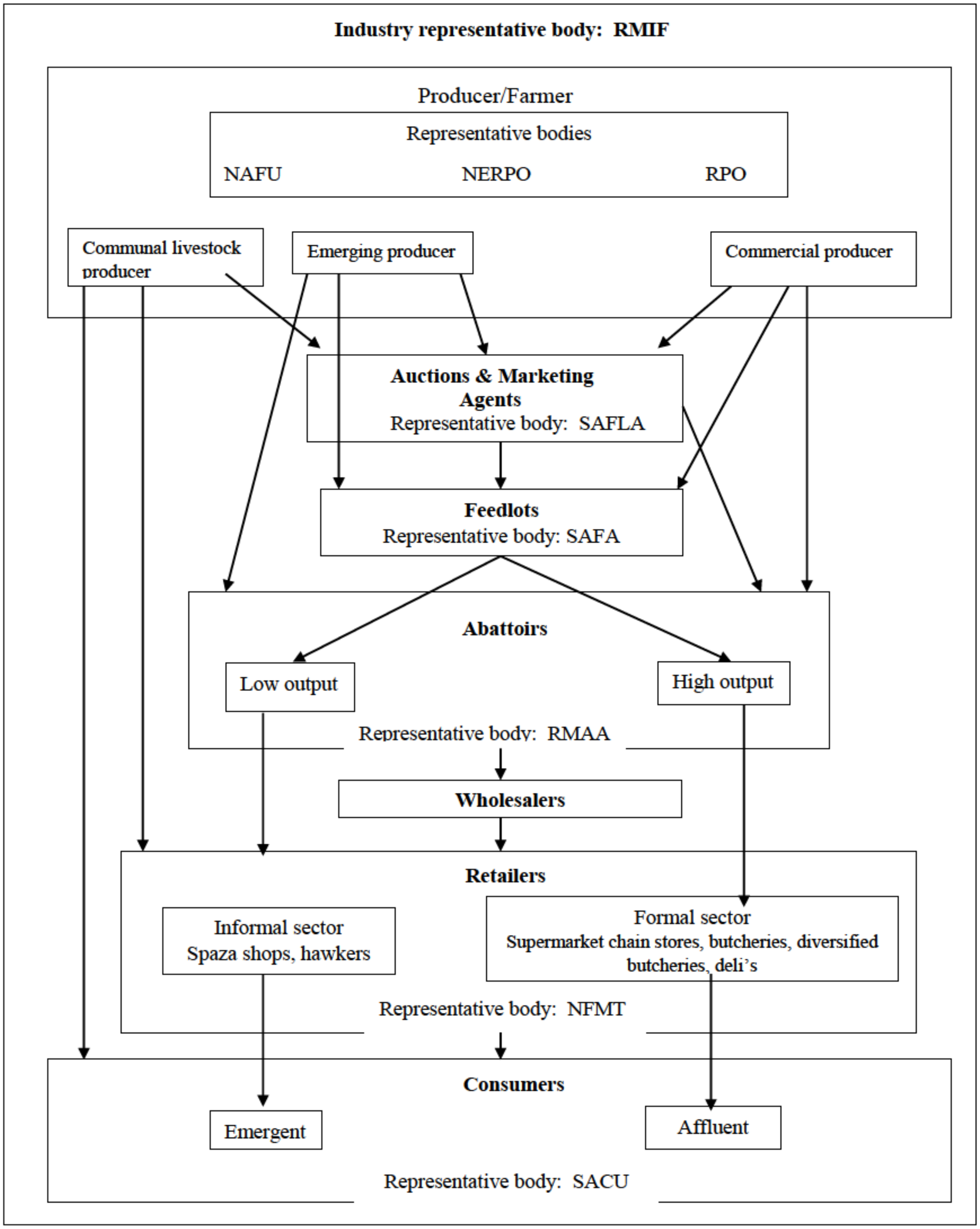
This rise in the value of animal products can be attributed to the value and demand for livestock foods, and in particular meat. The livestock sector is a major role player in the conservation of biodiversity through a variety of well-adapted indigenous and non-indigenous breeds, as well as rare game species. Numbers of animals, different breeds and species vary according to grazing, environment and different production systems (commercial, small-scale or communal) in South Africa. An estimated 2 million small-scale/communal farmers and approximately 38 500 commercial farms and intensive units (such as feedlots) are involved in livestock production (Meissner *et al*., 2013).

Beef cattle producers vary from highly sophisticated commercial to communal subsistence producers and can be classified into three groups of beef cattle, namely the commercial beef producer, emerging black beef cattle farmer who own or lease land, and the communal beef cattle farmer who farm on communal grazing land. Approximately

50 000 commercial farmers are currently farming with livestock, and they own around 11 million cattle. There are about 240 000 small-scale farmers and 3 million subsistence farmers that own around 5.69 million cattle (DAFF, 2015).

The South African beef industry is challenged by globalisation, increasing volumes and competition, shortage of skilled staff and pressures to meet changing customer needs. This demand was shifted from the supply side to the consumer (Labuschagne *et al.*, 2010). Over the past years, the beef supply chain has become vertically integrated. The feedlot industry plays a major role in this chain, because this is where the producer, feedlot, abattoir and wholesaler are linked together (DAFF, 2015).

Figure 1 illustrates the relationships among different role players in the red meat industry in South Africa under the guidance of the RMIF (Red Meat Industry Forum).



RMIF = Red Meat Industry Forum; NAFU = National African Farmers Union; NERPO = National Emergent Red Meat Producers Organisation; RPO = Red Meat Producers Organisation; SAFLA = South African Federation for Livestock Auctioneers / Agents; SAFA = South African Feedlot Association; RMAA = Red Meat Abattoir Association; NFMT = National Federation of Meat Traders; SACU = Southern African Customs Union

Figure 1: The South African Beef Net Chain (Source: Labuschagne *et al.*, 2010)

It is illustrated in Figure 1 that the South African beef market is a highly diverse network of linkages. There are different value and supply chains. The direct participants who play a role in delivering the product to the market are the producer (farmer), feedlot, abattoir, wholesaler, processor, distributor and retailer. There are also other participants and contributors in the beef value chain. They are the providers of hides and skin, meat processors, imports and exports, spices, packaging, etc. The supply chain is also determined by the characteristics of the beef product and is very competitive. The partners and role players in this chain are highly dependent on each other.

In South Africa, like in other countries, the beef industry contributes to food security and the nutritional well-being of the population. The slaughtering, processing and preserving of meat, add value to the activities in the meat industry. According to Labuschagne *et al.* (2010) there is an increase in beef consumption. The beef value chain has become increasingly vertically integrated and is mainly driven by feedlots who have their own abattoirs and wholesalers. Some of these feedlots sell their products directly to the consumer through their own retail outlets (Labuschagne, 2010). The South African Meat Consumption estimated a growth of 19% in the demand for beef from 2016-2026 (RPO, 2018).

Cattle producers in South Africa produce weaner calves that are ready to be marketed at the age of approximately 7 months. Breeds vary from indigenous to foreign breeds as well as crossbreeds. Management practices do play an important role in the success of the cattle industry. These practises include the management of the herd, pasture, nutrition, health, breeding and selection (Spies, 2011).

1.2 THE FEEDLOT INDUSTRY IN SOUTH AFRICA

The feedlot industry produces approximately 75% of all beef produced in South Africa. This is approximately 1.35 million head per annum (SAFA, 2018). Feedlot owners make use of market agents for product procurement, mainly weaner calves. The agents are provided with a base price on a weekly basis based on the current market conditions as well as other criteria specified by individual feedlots such as the breed, weight, sex, etc. for the procurement. It seems that very few contractual agreements take place between producers and feedlots for the procurement process. This is a challenge in the industry, since contractual relations should bring stability and lower volatility in the chain. Speculators in the South African red meat industry also plays a role in procuring animals at a low price and transforming these animals into market-ready animals (Spies, 2011).

Economic and management factors can affect the profitability of the feedlots, and this must be integrated to make decisions that will enhance the profit potential of a feedlot system. Some economic factors are beyond the control of feeders because purchase, sale and feed prices fluctuate. Producers are in control of management factors that may have an influence on the average daily gain weight (ADG), feed conversion and efficiency. This depends on the type of animals in terms of genetics, weight, nutritional background of the animal, nutritional management and health (AMT, 2016).

According to Spies (2011), approximately 70% – 80% of all cattle in South Africa are marketed through the feedlot sector. During February 2015 the highest number of animals in feedlots was 668 082, compared to 531 662 animals on feed in December 2015 (SAFA, 2015). The production parameters of SA feedlot cattle entering the feedlot are an average entry weight of 230 kg with a feeding period of about 120 days. The exit weight is about 460 kg, with a carcass weight of ±268 kg. The production parameters are an average daily gain weight of 1.65 kg, with feed consumed of 12.5 kg/day. The average water intake per day in summer is 55-60 litres and in winter 40 – 45 litres. SA Feedlots prefer male weaner calves at an age between 8 – 10 months of purebred as well as crossbred weaners that have the potential to produce economically to a live weight of

450 – 470 kg in the A-class after a feeding period of at least 120-days (SAFA, 2016). Cattle feedlot owners have to meet certain code of conducts to ensure standards and the use of good animal husbandry practices in all types of feedlots. The five rights of animals as summarised in the livestock code for feedlots ensure the establishment of humane environments for the handling and production of cattle in intensive feeding systems (Spies, 2011). According to the South African Feedlot Association (SAFA, 2016) the five rights of animals in the feedlot are the right of freedom of movement, the right to free access to fresh feed and water at all times, the right to appropriate health care, the right to freedom from injury and suffering, and the right to freedom from harassment. This is to establish a humane environment for the handling and production of beef in intensive feeding systems.

1.3 PROBLEM STATEMENT

According to Oosthuizen (2016), the main variable cost of a feedlot is the purchase price of weaners (64.4%), the price of feed (23.3%), overhead costs (6.7%), transport (2.43%), and interest (2.27%). The purchase and feed price contribute 87% of the variable cost. Although mortality can influence the profitability of the feedlot, it can be reduced by proper health management. The purchase price of weaners will depend on the supply and demand of the market.

The common practice for beef production in South Africa consists of a production chain where cattle are grown out and finished off in feedlots at a relatively early age after weaning. According to Esterhuizen *et al*. (2008), cattle raised in a feedlot grew faster and produced larger carcasses than cattle raised on pastures. Feedlot cattle are also more profitable than feeding cattle on pastures, mainly due to faster and more efficient growth (Esterhuizen *et al*., 2008). Furthermore, feedlot cattle have significantly higher final weights, warm and cold carcass weights, warm and cold dressing percentage, average daily gain (ADG), intramuscular fat content and back fat thickness measurements than organic and conventional pasture cattle. Esterhuizen *et al.* (2008) also noted that the extension of the growth phase of lighter Bonsmara animals is successful in producing uniform carcass weights and conditions, as no significant differences (P >0.05) were observed in live weight or carcass weight and other production traits between groups fed for 85 and 120 days. However, when determining price and feed margins, the authors did not determine the difference in profit between different test lengths (Esterhuizen *et al*., 2008).

Although price cycles vary, the feedlot industry is usually under pressure due to high grain prices and the pressure to source the right cattle types that are heavier at the same or younger ages than in the past. The average carcass weight of cattle produced from SA Feedlots increased by 10%, namely from 226 kg to 250 kg, while the weaner and carcass prices doubled over the years from 2001 to 2008 (Strydom, 2008). Feedlots ideally prefer weaner calves weighing around 220 kg that grow at a rate of 2 kg per day, with a good feed efficiency and temperament. It is also required from them to have positive feed margins, which can only be obtained with high growth rate and low feed costs per kilogram gain (Sernick Group, 2016).

Lower final weights and perceived bad feed conversion ratio (FCR) may be some of the reasons why feedlots discriminate against Nguni cattle and pay less per kilogram live weight for Nguni weaners purchased than for other breeds (Botha, 2014). This is a dilemma for beef producers relying on the Nguni breed as the basis for their production. This also influences the viability of the Nguni stud breeders, as it negatively affects the marketability of Nguni seed stock animals.

1.4 OBJECTIVES OF THE STUDY

The aim of the investigation is to determine the reasons for the discrimination against Nguni cattle by feedlots, and to determine whether these reasons are fair to the breed. This study also aims to investigate the optimal finishing of Nguni steers, and to determine the types of feeding regimes that could alleviate the discriminatory practices applied by feedlots against the Nguni.

Specific objectives:

- To determine the optimal feeding period, linked to live and carcass weight(s).

- To determine the effect of age and maturity on feedlot performance.
- To determine the optimal feeding regime and ration, suitable for Nguni steers.
- To record composition changes linked to carcass suitability for different market segments by using regular weight and ultrasound recordings.
- Using the information for alternative feedlotting of Nguni cattle.

1.5 RATIONALE

In South Africa, the Nguni cattle breed is best known for its low production input costs and the ability to market a good grade carcass off natural grazing. The success of feedlots depends on the economical deposition of lean meat over an extended feeding period, relatively high final carcass weight, relatively low and even fat coverage, and good carcass conformation at slaughter. Some cattle breeds are more suited for the feedlot process, while other breeds are more suited to marketing directly off the veld (Venter, 2013). In recent years, feedlots have started to discriminate against the Nguni for various reasons.

A characteristic of Nguni cattle is the economic benefits of the breed's ability to maintain body condition on poorer dry pastures (Van de Pypekamp, 2013). According to Bester *et al*. (2001) the Nguni has a superior ability to maintain its condition in winter. Blood samples of Nguni cattle showed that they had significantly higher blood plasma-urea-nitrogen levels compared to the Bonsmara and Brahman (Bester *et al*. 2001). This indicates that the Nguni has an adapted re-circulation system in the body for recycling and making urea available to the animal, whereby the kidneys and the rumen probably also play a role (Van de Pypekamp, 2013).

According to Pretorius (2011), blood and rumen samples of Hereford, Bonsmara and Nguni cattle showed that there were significant differences between the breeds in respect of urea and ammonia contents, where the Nguni has significantly higher urea and nitrogen levels in the blood plasma. Schoeman (1989) recorded that reasons for these differences in the concentration of blood urea and rumen ammonia between the three breeds are possibly due to grazing habits and/or differences in the rate of urea excretion by the kidneys. It was also indicated that Nguni cattle had higher levels of blood urea, and these animals were more capable of maintain body condition during winter periods. From these results Nguni cattle needs significantly less additional protein or urea lick in the dry periods compared to other breeds, which is an economic benefit (Pretorius, 2011).

As a calf grows, the order of tissue growth and development is firstly bone, followed by muscle and lastly fat. When an animal reaches sexual maturity, bone development is generally complete and muscle development almost complete. To increase growth after puberty, the increase in weight is caused by the addition of muscle and mostly fat. In normal slaughter ranges, as weight increases, fat percentage increases, while muscle and bone percentage decreases. The stage of development at slaughter thus has an influence on carcass composition. An animal is usually slaughtered once an acceptable level of carcass fat is reached (DARD, 2018). An early maturing type of animal will be mature at a younger chronological age, and therefore have more fat and a heavier weight at an earlier age than later maturing types, which makes it more difficult to feed early maturing types profitably in a feedlot. The Nguni breed is an early maturing, small framed indigenous Sanga breed (Strydom *et al*., 2001; 2008). As feedlots prefer medium- to late maturing breeds, major feedlots are either not accepting Nguni weaners or pay significantly less for them (NCBS, 2014c).

The body weight and growth rate of the Nguni cattle tends to be similar to that of *Indicus* breeds, which is usually lower than the *Bos Taurus* breeds. Despite its low body weight, the feed conversion ratio of the Nguni is generally more favourable than most *Indicus* breeds (Ferreira, 2001).

It is well known that when a calf is born, there is very little fat in the carcass, relative to the other tissues. As the animal gains weight and matures, a stage is reached when fat deposition accelerates. Depending on the market demand, animals that reach the acceptable level of carcass fat, after some level of finishing, can be slaughtered. The price that is paid for feedlot cattle influences the profitability of a feedlot enterprise, especially where there is a small feed margin (live gain weight x (sale price / kg - cost / kg gained). Therefore, feedlots are looking for positive feed margins and that can be done with high weight gain and a lower feed cost. The feedlot ration must be matched to the type of animal and should be the most cost-effective ration available. If an animal is early maturing, it will deposit fat at an earlier (chronological) age and will be market ready at a lower live weight versus late maturing types (Venter, 2013).

Bone, muscle and fat are measured on live animals by using real-time-ultrasound (RTU) technology and are used to indicate carcass traits on possible breeding bulls. Measurements with RTU technology includes Eye Muscle Area (EMA), two measurements of subcutaneous fat (easily mobilised), as well as marbling (intramuscular fat, not easily mobilised). Correlations between these traits and various other production traits may also be of importance (Pabiou, 2012).

Despite all these popular characteristics the breed is severely challenged when the calves are to be marketed, as most feedlots do not regard the Nguni as a breed suitable for the feedlot. This study will shed light on the possible precision feeding of Nguni calves, which may provide a solution for the marketing dilemma the breeders are confronted with.

1.6 PRECISION FEEDING

For a feedlot to increase the productivity of its largest variable input (feed), each type of beef breed must be fed according to its own genetic growth potential (Oosthuizen, 2016). As the level of nutrition also affects growth and therefore carcass composition (Berg e*t al.*, 1968; Esterhuizen *et al.*, 2008) an optimum and cost-effective nutritional level specifically for early maturing cattle like the Nguni cattle must be determined.

Precision feeding is very important for modern livestock production, according to Laura Star (AAF, 2018). The largest cost for a farmer is feed, and therefore it is important to feed animals close to requirements to reduce feed costs. It is important to provide the correct nutrients for animals in feedlots, as imbalanced rations can affect the health of the animals negatively. This might also increase the use of antibiotics. The management of feedlots can be improved by monitoring the feed intake, growth, animal health and other factors influencing efficiency of production. Precision feeding will help producers to optimise efficiency and profitability, and this will have a positive effect on animal health, animal welfare and the environment. Laura Star (AAF, 2018) is of the opinion that precision feeding is the practise of meeting the nutrient requirement of animals as accurately as possible in the interest of a safe, high quality and efficient production, while ensuring the lowest possible load on the environment under the given conditions. Specific production objectives must be taken into account. Economic factors play a major role in the different objectives and can also be affected by legislation, the environment, welfare, consumer demands, animal health and availability of labour (AAF, 2018).

Nutrient utilisation, the reducing of feeding cost and nutrient excretion can be improved by precision feeding. The use of feeding techniques allows the right amount of feed with the right composition to be provided at the right time to the "right" animals (Pomar *et al*., 2011).

According to Oosthuizen (2016) the genetic differences between cattle breed types will have an effect on the most suitable management factors. It is therefore important to gain knowledge in order to determine feeding periods and enhance precision farming techniques in the feedlot.

1.7 RESEARCH HYPOTHESES

- Nguni cattle can be fed profitable in feedlots if precision feeding is applied;
- Nguni cattle can be fed profitable in feedlots with a low roughage ration.
- If heavier Nguni calves are entered into feedlots, the feeding period may be shorter, and carcasses may be produced closer to market requirements.

- Carcass weights of calves with higher arrival (intake) weights might also be heavier and closer to market requirements.

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CHAPTER 2

LITERATURE OVERVIEW

2.1 Introduction

Maree & Casey (1993) describe feedlotting in practice as an intensification to keep more animals per unit of land in a well-managed manner. This allows the producer to have better control in preparing animals for the market. A marketing policy can be implemented, and the growth can be controlled more effectively.

Economic and management factors play an important role in the profitability of the feedlot industry. A common characteristic of the feedlot industry is negative buying price margins and positive feeding margins. When considering the profitability of the feedlot industry, one of the most important rations is the relationship (price ratio) between the weaner and the A2/A3 carcass price. The input (weaner and feed) prices and the output (A2/A3 carcass) prices have a direct influence on the profitability of the industry. These are mostly uncontrollable economic factors (AMT, 2016). The type of animal considered in the feedlot and its performance is, however, controllable. It is therefore appropriate to access the Nguni in terms of its suitability.

2.2 Background about the Nguni breed

The Nguni breed is classified under Sanga cattle. The difference between Sanga cattle and the Zebu type is that the hump of Sanga cattle is muscular, more rounded and carried between the head and shoulders. For over 1 200 years these cattle adapted to the environmental extremes of Southern, Central and Eastern Africa. The breed migrated through areas where endemic diseases occurred and have survived seasonal and periodic droughts. This period of adaptation made the Nguni one of the hardiest breeds and worthy of a place in modern beef production systems (Ferreira, 2001). The Nguni is a product of selection under natural conditions over many years, and it is expected that natural selection would have favoured the fittest (more fertile and better surviving) animals under these conditions. They have the ability to efficiently produce meat with low input costs in a variety of environments (Bosman, 2011).

Bulls are of medium size and weigh between 500 – 800kg, while females are smaller and weigh between 300 – 400 kg (Armstrong & Meyer, 1986). Nguni cattle have been described as a respiratory type. This means that the forequarter is deeper, and the ribs are relatively flatter and lie at a backward angle. The respiratory type generates relatively less heat during metabolism, while the skin area is wider on the back, which makes the body's heat regulation more effective, especially in warmer climates (Armstrong & Meyer, 1986, & Bosman, 2011). Sexual dimorphism is marked in Nguni cattle, which means that the males are relatively larger and heavier than the females when compared to other cattle breeds (Ferreira, 2001).

Several Nguni ecotypes exist, and adult body weight shows considerable variation among such ecotypes. However, within the different ecotypes, the typical characteristics of the Nguni remain relatively unchanged (Ferreira, 2001). Through centuries of natural selection, the Nguni breed has low maintenance requirements, good walking ability, high reproductive performance and resilience to tick-borne diseases. These cattle are adapted to harsh environments (Muchenje *et al*., 2008c).

All the indigenous breeds of Africa are naturally fairly small in size, and there is a misconception that these breeds are poor performers due to overstocking and poor management. The Nguni seems to be the ideal dam line in terminal crossbreeding, because of its high fertility, rare incidence of calving difficulties and the good performance of the crosses. The effect of tick infestation on the productivity of Nguni cows is not significant, as a very limited number of ticks feed to maturity on this breed due to its natural resistance. As a result of this type of natural selection, the Nguni has become adapted to the prevailing conditions, and have a most important role to play in animal production. According to Scholtz & Lombard (1992), the Nguni is one of the most productive breeds in South Africa, despite its relatively small size and low growth rate (ADG).

The Nguni breed is the most resistant to ticks of all breeds in South Africa, and its production is least effected by ecto-parasites. Scholtz *et.al.* (2011) showed that tick infestation in Nguni cattle resulted in a weaning weight loss off 4.4 kg weight, versus 29.5 kg in the case of the exotic breed under situations of severe tick infestation.

2.3 Functionality of the breed

Although the Nguni is small-framed, they are highly profitable under extensive range conditions due to their lower maintenance requirements (Maree & Casey, 1993). Ferreira (2001) reported that the Nguni animals have inherent capabilities such as exceptional fertility, especially under harsh conditions. They mature sexually early, particularly heifers, and are the ideal dam line for terminal cross breeding. Their temperament is placid. With their adaptability to harsh conditions, they also have a low mortality rate. Some of their most important characteristics are their ease of calving, and their mothering abilities. Nguni cattle have a long-life expectancy and have a good foraging ability linked with growth potential when grazing on natural veld. They are very resistant to ticks and tick-borne diseases and can adapt to harsh environments. This is mainly due to its high-performance reproductive performance, good walking and foraging ability, and low maintenance requirements acquired through centuries of natural selection. Muchenje *et al.* (2008b) echoes the qualities of the Nguni as a breed that is adaptable to tough conditions such as feed scarcity, ticks and tick-borne diseases, and this provides the breed an opportunity for natural beef production.

The Nguni Cattle Breeders' Society (NCBS, 2014a) claims that the breed requires little supplementary feeding and graze veld efficiency, utilising grass, trees and bush, and covering long distances to forage. They mature early and finish off quickly on free-range conditions, are highly efficient at converting even poor-quality veld into prime beef, and they produce more beef per hectare than most other breeds. This can provide free-range beef to health-conscious consumers. Heifers breed at an early age, and with their longevity and good calving performance they ensure a long-term utilisation at a low replacement cost (NCBS, 2014a).

The Nguni Cattle Breeders' Society further claims that Nguni cows have the ability to limit the birth weight of their calves, even if they are crossed with large-frame breeds. Nguni cows therefore have the ability to limit the size of the foetus before birth, and therefore calving difficulties seldomly occur (NCBS, 2014b). Although the Nguni is known for small calves, the easy calving is mainly due to the conformation of the cow and the calf. A unique feature of the Nguni dam is her ability to limit the size of the unborn fetus (Van de Pypekamp, 2013).

Nguni calves are known to be small at birth, averaging a birth weight of 27 kg. The breed average for age at first calving is 32 months, and the average inter-calving period is 426 days (SAS, 2016).

According to Muchenje *et al*. (2008c), Nguni steers had poorer conformation, higher ADG, lower carcass weight and dressing percentage, and besides being a smaller and multipurpose breed, the Nguni can compete favourably with established breeds in terms of productive performance and meat quality.

There is an increased preference for naturally or organically produced meat, and since the Nguni can survive on natural pasture, they have an important role to play in this regard. Organic meat production is the minimal use of chemicals in cattle management activities such as parasite control.

According to Muchenje *et al*. (2008b), studies revealed that the Nguni can be successfully finished off on natural pasture without supplementation. During dry seasons when there was no dietary supplementation, when compared to other breeds that were studied at the same time, the Nguni had the best growth performance. Although Nguni's received no supplementation during the dry season, they maintained relatively high liveweight and body conditions scores. Amongst several breeds that were studied, the Nguni had the lowest tick loads. Non-dipping of the Nguni, despite causing high tick loads, did not reduce its growth rates, liveweight and carcass characteristics. The carcass characteristics of dipped and non-dipped Nguni animals were investigated for slaughter- and warm carcass weight, dressing percentage and the eye muscle area (mm^2). As Muchenje *et al*. (2008b) stated, the Nguni also had the lowest nematode faecal egg counts compared to other breeds. Relatively high levels of nutritionally-related blood metabolites, such as urea, glucose, phosphorus and calcium help the Nguni to adapt to limited grazing conditions. It was also found that the beef quality of Nguni finished on natural pasture is comparable to beef quality of European breeds. By being less vulnerable to pre-slaughter stress, and hence having the optimum ultimate meat pH levels, the quality of Nguni beef is high. Nguni cattle are generally docile with their calm behaviour, they have low levels of stress hormones at slaughter. Their meat had low cholesterol levels when they were finishing off on natural pastures before slaughter. Their meat also had beneficial (in terms of health) fatty acid ratio levels that are within recommended international standards.

According to these studies, it can be concluded that Nguni cattle play a significant role in the production of high value organic beef under harsh environmental conditions prevalent in most parts of South Africa (Muchenje *et al*., 2008b).

As the Nguni has a lower body weight, they have an advantage over the breeds with higher body weight when there is a food shortage. In larger framed animals more feed must be provided to ensure optimal reproduction and lactation, which is almost impossible in most parts of Africa (Ferreira, 2001). The Nguni is an exceptional veld-adapted breed; hardy and fertile; and can be sustainably utilised in most livestock farming systems as a dam line (Scholtz *et al*., 2011). Their low maintenance requirements allow them to be highly suitable for areas where rainfall is lower and seasonal. They are selective grazers and browsers and are capable of obtaining nutritional value from available vegetation, which may not necessarily be the case with the *Bos Taurus* breeds (Bester *et al*., 2001).

2.4 Nguni cattle in the feedlot

Weaners are purchased by the feedlots and are then categorised into early-, medium- or late maturing breeds. Feedlots generally give preference to the intermediate and late maturing animals, while early maturing animals are discriminated against, as they are perceived to not meet the requirements mentioned. Ngunis fall into the early maturing category, which is more suited to marketing directly off the veld, rather than being finished in feedlots. Veld finishing is not always possible, because not all farmers have enough veld and infrastructure, or even due to the variability in feed resources in natural grazing. It is generally recommended that breeders refrain from changing the Nguni into a bigger framed feedlot type of animal, because some of the desirable characteristics of the Nguni will be sacrificed. The breed is the ideal dam line for economical meat production and cross-breeding under natural conditions due to its smaller frame and lighter mature weight. More animals can be kept per area. Lighter frame calves tend to gain fat quickly, and it is therefore difficult to feed in feedlot conditions. A smaller carcass is also deemed to be less profitable for feedlots. Smaller framed carcasses tend to have lower dressing percentages, and lighter weaned calves have to be fed longer. Therefore, the costs of feeding will be higher, resulting in less profitability (De Brouwer, 2014).

To address the lower prices paid for Nguni weaners by feedlot buyers, a feedlot at Douglas, with assistance from GWK (an agricultural co-op), embarked on a service where Ngunis were fed on a lower energy, but higher protein diet. The expected growth rate was in the order of 1300 gram per day. Preferable intake weight was between 200kg to 220kg (with an absolute minimum of 160kg allowed), and days on feed of between 90 to 120 days resulting in slaughter weights of between 360kg to 400kg (Dugmore, 2014). Although this option was offered to Nguni producers, it is subsequently no longer available.

For feedlots to be cost effective, they need to improve the feed-intake, resulting in a better feed conversion ratio (FCR) and higher average daily gain weight (ADG). In the most intensive production systems, feed is the greatest expense. To ensure success, intensive feeding and fattening of livestock are highly specialised practises. This requires high levels of management (Maasz, 2006; Bosman, 1996).

2.5 Location and design of a feedlot

There are a few factors which effect feedlots' economic performance. Maree & Casey (1993) stated that factors to consider on the location of a feedlot include climate, topography, water, layout and the design possibilities (due to topography) of the feedlot.

High temperatures might lead to reduced feed intake and weight gains. Muddy conditions can occur if the feedlot is in a high rainfall area and when drainage is poor. Drainage furthermore has a huge impact on feedlot sanitation, mud prevention and pollution (Maree & Casey, 1993).

As cattle require approximately four litres of water for every kilogram of dry feed consumed, water is a very important source in a feedlot. Water must be fresh and clean to assure good consumption and animal performance (Maree & Casey, 1993).

Feedlots must have well-designed facilities, and therefore the layout must also be planned to facilitate the free flow of traffic, feed, animals and people. Cattle require 20-30cm feeding space per head, which means that construction must facilitate the filling, cleaning and reduction of wastage to an absolute minimum (Maree & Casey, 1993).

2.6 Feedlot profitability

Feedlot profitability is also affected by economic or management factors. Macro-economic factors cannot be controlled by feedlots. These include purchase, sale and feed prices. Management factors have an effect on ADG and efficiency, which is largely dependent on the type of animal and weight entered into the feedlot. This is influenced by genetic differences, nutritional background of the animal, nutritional management and the overall health condition of the animal. To make decisions that will enhance the profit potential of a feedlot, it is important to integrate economic and management factors (AMT, 2016).

As feed costs in feedlots are one of the major sources of expenses, one way to reduce feed costs is through genetic selection of more efficient animals. Robinson & Oddy (2004) highlighted the potential difficulties associated with the relationship between feed conversion ratio (FCR) and growth. It is suggested that it may be more desirable to select for a trait such as residual feed intake (RFI). RFI is defined as the amount of feed eaten by an animal less what would be expected based on its growth rate and body weight.

Maree & Casey (1993) state that small animals have a higher fasting metabolism than larger animals. Fasting metabolism is the basis for estimating maintenance. It also depends largely on the type of animal fed in the feedlot, dictated by genetic differences (the breed), weight, nutritional background and the overall health condition (Spies, 2011). Spies (2011) further stipulated that animals with better genetic merit have improved herd performance and productivity, while better pre- and post-slaughter activities have improved the quality of the end product.

The aim of any cattle operation is optimal weaner production, and to then finish off these weaners to be market ready. Under South African conditions, finishing occurs in a feedlot, as approximately 70% of all calves weaned find their way to feedlots to be prepared for slaughter. This emphasises the importance of the feedlot industry as a link in the production chain of beef. Some factors are of crucial importance to the feedlot operator to control and reduce risks. These factors are growth, feed conversion ratio (FCR) and dressing percentage. Health and mortalities can also have a significant influence on profitability. Profits in feedlots can be unstable if one or more of these factors are not favourable, especially weaner, feed and carcass prices. Every cattle breed is unique in their production potential in a feedlot. Therefore, it is important to treat each individual breed according to its own individual production potential to generate maximum production and profit (Brahman Breeders' Society, 2017). Oosthuizen (2016) also stated that the carcass price, weaner price and feed price have a significant influence on profitability. These factors should be considered when profit margins and risks are calculated.

For feedlots to be successful, they need a foundation of sound planning, a good understanding of animals and their requirements, and veterinary care and economic expertise. It is imperative that the right kind of animal be selected for a particular feedlot. It is necessary to place the factors that affect profitability of feedlots in proper perspective to determine the specific types of cattle that are most likely to be profitable under particular market conditions (Maree & Casey, 1993).

2.7 Factors that affect feedlot profitability

Important requirements for successful feedlotting of cattle are the formulation of fattening and growth rations that will produce the most profitable gains. Therefore, suitable feeds and the correct formulation to provide all the nutrients in the required balanced quantities are essential. Suitable sources are energy, protein, roughage, minerals and vitamins. As already indicated, the costliest item in a feedlot is feed, and the success of a feedlot depends on the correct formulation, feeding practice and feed bunk management (Maree & Casey, 1993).

2.7.1 Costs

The purchase price of weaners paid by the feedlot is determined by supply and demand of weaners in the market. This is confirmed by Oosthuizen (2016). This can be influenced by processing costs such as vaccination, hormones, vitamin supplements, deworming and other processing needed. Most of the feedlots in the South Africa feedlot industry mainly use grain by-products like maize, hominy chop and bran in the feeding rations as an energy source. To ensure good feedlot performance, feeds with a high proportion of energy is required, such as maize, hominy chop or one of the other grains. The cost of the feeding ration in relation to the beef price has a significant impact on the profitability of the feedlot (AMT, 2016).

Langemeier *et al*. (1992) found that the price of sales, feed and maize had the biggest impact on the profit variability over time. Environmental factors such as droughts and the high cost of feed can have a dramatic decrease in cattle prices, because beef operations usually reduce herd sizes, resulting in larger numbers of cattle sold, and as a result, the market is flooded. The prices of feedlot animals can fluctuate considerably in almost every season of the year. Cattle that have a better conformation are usually assigned a higher grade and sell for a higher price per kilogram. The difference in purchase price and sales price of feedlot cattle is often higher for healthy, but thinner lower grade weaning calves. The reason for this is because these calves are more likely to increase in quality in the time between when they are purchased and when they are sold (sometimes referred to as a positive price margin). Lower grading thinner calves can incur additional costs such as higher medical treatment costs, lower sale prices and higher death-loss rates. However, even with these disadvantages, the lower grading weaner calves can still be profitable if the entire market for finishing cattle is taken into account. Market prices are better for bigger frame animals that is uniformly finished off than for less uniform smaller framed type breeds. When weaners are offered to feedlots, they are usually sorted by breed, sex, weight, colour and condition. The objectives for purchasing feedlot animals are to buy cattle that have the genetic ability to grow well and increase in weight fast to efficiently convert feed to weight gain, as such animals will have a high potential to stay healthy during the feeding period, and to be marketed as high-quality carcasses after feeding (Comerford *et al*., 2017).

2.7.2 Management

Management factors as well as animal performance such as ADG, feed efficiency, dressing percentage, response on growth hormones, mortality, morbidity and the feeding periods of the cattle in feedlot may have an influence on the profitability of feedlots (Oosthuizen, 2016). To save more costs in feedlots the length of stay of the animals can also be decreased (Maree & Casey, 1993), and is it therefore important to determine the correct feeding period to ensure a suitable profit margin in order to produce sustainably (Oosthuizen, 2016).

As the management of feedlots has a major influence on their profitability, it is very important that the right type of animal is bought at the right price and at the right time. It is also important that the feedlot ration must be balanced in respect of nutrient content, and must match the type of animal to be fed. This must be the most cost-effective ration available at the time of feeding. The price paid for feedlot cattle (cost/kg) is a critical factor affecting the feedlot profitability, especially when a small or negative feed margin exists. Therefore, a positive feed margin must be realised with a high weight gain and a relatively low cost of feed (DARD, 2018). Oosthuizen (2016) stated that profit will be maximised if the value of the marginal product (value of the weight gain) equals the value of the marginal factor cost, which is the feed fed to the weaners. A positive feed margin can be influenced by the feed price and the efficiency of growth (gain/kg consumed). A positive price margin is when the price per kg body weight realised at selling is higher than the price/kg (body weight) of weaners bought (DARD, 2018).

2.7.3 Production efficiency

The efficiency of feed conversion is very important in profit realisation. The reason for this is because feed costs account for 70-80% of variable costs in a feedlot. According to Maree & Casey (1993), the net returns per animal are determined by the gross margin minus feed and non-feed variable costs. The gross margin is the selling price minus the buying price. Non-feed variable cost includes veterinary cost, interest, labour, fuel, transport and marketing costs. The length of time an animal spends in the feedlot will also have an impact on the non-feed costs. A shorter stay in the feedlot will result in a better turnover, which will improve the profits. The length of time in the feedlot is the effect on interest paid on the percentage price of the weaner. Langemeier *et al*. (1992) found that for lighter weight cattle, the profit variability was strongly influenced by the average price of feed.

2.8 Efficiency measurements in the feedlot

2.8.1 Body weight (BW)

Body weight change evaluate growth (Otto *et al*., 1992). One of the most important traits in beef production is weaning weight. The reason is because weaning calves are usually the first marketable product in the beef herd. The weight of the calf is also an indication of cow efficiency (Maree & Casey, 1993).

Efficiency for a cow may be defined by the relationship between the weight of the calf produced and the feed inputs required to sustain the cow and allow her to provide for her calf. One way this can be quantified is by the ratio of calf weight at weaning to the cow weight (MacNeil *et al*., 2017).

According to the BCRC (2016) the feed to gain ratio (F:G) is a measure of an animal's efficiency in converting feed nutrients into increased body weight. This ratio is an important variable in the cost to finish an animal.

2.8.2 Feeding days

Feeding days refer to the number of days the animal remains on feed to achieve the desired slaughter weight and carcass characteristics (Spies, 2011). According to Oosthuizen (2016), frame size has a big influence on the feeding period. Larger-frame cattle benefit from an early feedlot entry, while the smaller frame cattle benefit from being grown on pastures before entering the feedlot, which is beneficial to feedlot profitability. The fat content on the carcass also plays a role, as excessive fat decreases the value of the carcass (Oosthuizen, 2016).

2.8.3 Average daily gain (ADG)

Average daily gain weight refers to the average daily live weight gained during the feeding period. The ADG can be influenced by the quality of the feed ration and the quality of the animal on feed (Spies, 2011). Different breeds have different growth rates and can be classified as late-, medium-, or early maturing cattle that have to be managed according to their genetic potential. Breeds have different growth potentials and have to be managed according to their genetic potential (Oosthuizen, 2016).

The ADG can be used as an appropriate guideline, because it affects the costs directly through the days fed in the feedlot and the relationship with carcass gain. Gain differences also reflect on the time needed to recover the original cost (investment) of purchasing weaners. It also affects costs indirectly because of the high correlation with feed conversion efficiency (Meissner *et al*., 1995).

Oosthuizen (2016) states that the benchmark ADG in South African feedlots is between 1.3 kg/day and 2 .00 kg/day.

2.8.4 Feed conversion ratio (FCR)

Feed conversion ratio or rate is the measuring of the efficiency with which livestock convert animal feed into body weight. It is possible to lower the costs of production if there is an improvement in the FCR (Maasz, 2006). FCR is defined as the amount of feed needed to add a kilogram of live weight. This may vary depending on the quality of the animal as well as between breeds, weather conditions (ADG declines in colder, wet weather) and stress levels in the feedlot (Spies, 2011).

The ingredience and quality of feed fed to specific animals will have an influence on the FCR. The feed intake and feed conversion also differ between breed types. If poor quality feed is fed, the FCR will be poorer, because the animals will need more feed to gain weight (Oosthuizen, 2016). The FCR benchmark range for beef cattle in South Africa is between 5.5:1 and 7:1 kilogram feed per kilogram of live weight gained (Oosthuizen 2016).

When the feed intake of groups of animals is known as in the case in feedlots, it can be used in relation to measured growth to determine the feed conversion ratio of such groups. This is necessary to evaluate the profitability, compare different rations with each other, and to determine purchase and selling prices (Naudé, 2016).

As feed efficiency is important to improve profitability, the feed efficiency in young animals may differ from the efficiency of older, fatter cattle on a high-energy feedlot diet. Feed efficiency is heritable and genetic improvement is possible (Robinson & Oddy, 2004). In the study conducted by Sobrinho *et al.* (2011), it was found that feed efficiency improvement is a major concern in animal production. It was also established that technological advances have been generated to quantify feed intake in an easy and low-cost manner. The study concluded that residual feed intake can be used as a tool to identify the most efficient animals.

2.8.5 Nutrition

It is important for animals to receive a certain amount of nutrients to maintain essential body functions. Animals require a balanced ration that complies with the net energy, protein, carbohydrate, fat, mineral and vitamin needs for maintenance and production (growth efficiency). Feeding a ration is expressed in multiples of the quantity of feed required for maintenance. Nutrients are contained in the dry matter of feed and the components are a potential energy source for metabolism. Energy is the primary nutritional need of all animals, therefore the main cost item in feedlot feeding is energy. The intake is expressed in terms of megajoules of metabolisable energy per unit dry material (MJ ME/kg DM). The costs per unit energy in feed (MJ ME/kg DM) will determine how effective the feed composition is, and thus the total feed cost per kilogram increase of the animals (Maree & Casey, 1993).

2.8.6 Dressing percentage

Dressing percentage (DP) describes carcass yield and expresses a ratio of carcass weight to live weight, and many other factors that impact on these characteristics (Maree & Casey, 1993). Spies (2011) describes dressing percentage as the ratio between the weight of the carcass and the weight of the live animal slaughtered. The following factors can influence the DP namely the size, weight and age of the animal, the genetic merit of the animal (varies between breeds), the percentage fat and bone in a carcass (direct related to breed and feeding rations and methods), the feed quality, stimulants and/or growth rations (Spies, 2011). According to the Beef Carcass Classification system the cold- and warm carcass weights are also recorded in the carcass classification system. The carcass weight (cold dressing weight) is the cold weight of the carcass after refrigeration. The cold carcass weight is 2 to 3% less than the warm carcass weight, which is determined immediately after slaughter (DARD, 2018).

2.8.7 Mortality and morbidity

Percentage mortality refers to the percentage of animal deaths, while percentage morbidity refers to the percentage of sick animals in the feedlot (Spies, 2011). Health problems can have a major influence on feedlot profitability and economic losses such as death, whilst diseases can result in lower weight gain and a reduction in carcass value. Direct costs include treatment costs, while indirect costs refer to the loss due to lower performance of sick animals. Weaned calves may have stress when commingled with cattle from other sources. The environmental conditions can also expose the calves to infectious pathogens and contribute to diseases. Temperature changes, dust, transportation and crowding are all factors which can lead to illnesses and deaths (Fulton *et al*., 2002).

According to the Feedlot analysis and outlook of the AMT (2018), a critical issue that relates to the success and viability of feedlots is to strive for a mortality rate of lower than 1%, but preferably lower than 0,8%.

2.9 Development of body size and growth rate

As an animal grows, it increases in weight until its mature size is reached. Growth does not only entail a change in weight, but also changes in body conformation, shape and various body functions. This is known as development. Live weight increases at a faster rate during the postnatal stage of growth. According to Bosman (1997), the skeleton, at birth, is relatively better developed than muscle. The flesh makes up the greatest proportion of the weight in the full-grown animal. Early growth traits such as birth and weaning weights are positively correlated with mature weight (Bosman, 1997).

The stage of development of animals are determined by the proportions of muscle, fat and bone on the carcasses. The sex of the animal and the level of nutrition during growth will also determine the level of maturity. Muscles need to become stronger in order to fulfil their functions for movement. Under a normal, natural feeding regime the feed conversion is highly efficient during the muscle development phase of growth. The carcasses are then lean with minimum fat content. When animals are fed a regime containing more nutrients than necessary for normal body functions, growth and development, the excess energy consumed changes into fat. When these animals reach maturity, less energy is needed for their growth. This is when the animal deposits the excess fat as the growth rate of fat increases, while the muscle growth decreases. This, in turn, leads to a decrease in the efficiency of converting feed to meat. Maree & Casey, 1993. Berg & Butterfield (1968) stated that the patterns of tissue growth are influenced by several environmental and genetic factors. There are about two parts of muscle to one part of bone in the carcass of a calf at birth. During the post-natal period, muscle grows relatively faster than bone, resulting in an increase in the ratio of muscle to bone. At birth, fat makes up a small percentage of the carcass. It increases slowly until the calf receives adequate nutrition, after which the fattening phase takes place (Berg & Butterfield, 1968).

The optimal size of animals is determined by the interaction between growth genes and the environment. The feed conversion efficiency differs little between large and small-framed cattle types, if measured at the same stages of maturity. There is a negative interaction between frame size and reproduction efficiency when the environment limits maturity size. The productive value of large-, medium- and small-framed cattle types is different between cow and calf herds if compared in feedlots or on pasture conditions (Maree & Casey, 1993). Large frame animals in particularly in harsh environments are usually less adapted, because they have more biological tissue to maintain. Animals must therefore be well adapted to the environment of each farm, and their type must be described by objective measurements (Bosman, 1997).

It has already been indicated that early maturing cattle have a lower mature size, and they enter the fattening phase at lighter weights (Berg & Butterfield, 1968). This will then have an obvious influence on carcass composition and must be accordingly be controlled within acceptable limits to ensure feedlot profitability (Berg & Butterfield, 1968).

2.10 Meat and carcass classification

Meat classification can be defined as a mark of quality that indicates the value differences (money value) between different qualities of meat. The South African Meat

Industry Company (SAMIC) has been appointed by the Government to monitor uniform standards and to ensure that the different meat qualities are handled according to legislation. The age of the animal and fatness of the carcass are the most important characteristics of meat classification, although conformation of the carcass, damage to the carcass and sex are also important during purchasing. Different colour roller marks are used on the carcasses to indicate their classification. The aim of the meat classification roller marks on the carcasses is to reassure the trader and consumer regarding specific preferences and to some degree, meat quality (SAMIC, 2006).

Carcass classification is where carcasses are allocated a class code according to the carcass characteristics within that class. During the first to two years, cattle cut their first permanent incisors which means that the carcasses are classified in the A category. When the first permanent incisor breaks the skin, the tooth is deemed to have erupted and the carcasses of these animals are classed as the B age group, *i.e.* they are no longer classed as zero tooth (A category). Carcass fat content and the fat distribution are taken into account when a trained official makes a visual assessment, and the carcasses are assigned to one of seven fat classes (0 to 6). A2 carcasses depict a lean fat carcass with a subcutaneous fat percentage of 4.1%, and fat thickness of 1 to 3 mm. For A3 carcasses the fat percentage must be medium, with the subcutaneous fat percentage of 5.2% and fat thickness of >3 and ≤5mm (DARD, 2018).

2.11 Meat and carcass quality

Carcasses of similar features and grading are grouped together. This is an important marketing tool (Maree & Casey, 1993). Meat tenderness is generally regarded as the single most important component of meat quality for the consumer. Environmental factors proved to have major influences on meat quality, especially tenderness. The genetic basis of the end-product is very important, as this influences the potential meat quality (Strydom *et al*., 2000). Meat quality analyses indicate small or no differences between indigenous and exotic European/British breeds, but with potentially superior quality compared to *Bos indicus* breeds (Strydom, 2008).

Animals that are grown out and finished in feedlots or on pastures are mostly slaughtered at the young age of about 12 to 16 months before the eruption of permanent incisors. This is classified as A-age class according to the SA Beef Carcass Classification System. In a study conducted by Frylinck *et al.* (2013), the results show that the feeding nutritional status of animals can be influenced by different production systems. Diet and slaughter conditions influence meat tenderness more than the age of the animals (Frylinck *et al.*, 2013).

The maturity type of animals can also influence the meat yield and composition. Since Nguni cattle are early maturers and are smaller, they are more compact with lighter mature weights. According to Maree & Casey (1993), early maturers yield fatter carcasses at the same live weight than late maturers. Nguni cattle are well adapted and fertile, but also possess good carcass characteristics and yield meat of excellent eating quality (Maree & Casey, 1993).

The study from Strydom *et al*. (2000) showed that the loin cut section of two Sanga (indigenous) breeds (Afrikaner and Nguni), one indigenous composite breed (Bonsmara) and two continental breeds (Brown Swiss and Pinzgauer), were more tender than that of a foreign composite breed (Santa Gertrudis).

2.12 Body composition traits

2.12.1 Background

Real-time ultrasound (RTU) can be used as a method whereby accurate measurement of several body compositions traits (carcass traits) can be predicted on live beef animals. The traits that can be scanned for is ribeye area (EMA), intramuscular fat percentage (marbling), subcutaneous rump fat thickness (fat covering – P8) and rib fat thickness (between the 12th-13th rib).

The purpose of scanning animals is a non-invasive technique that attempts to measure carcass characteristics on live animals in an acceptable and accurate manner. Therefore, the goal is to take these measurements of animals before they are slaughtered. The results are generally used for breeding goal purposes.

The suggested age for scanning must coincide more or less with the age and weight of the animal at slaughter. This is usually between 12 and 18 months of age as an average of the contemporary group. Scanning is usually done on bull calves. The person who qualifies to do RTU scanning must be accredited according to the minimum accuracy guidelines as proposed by the International Committee for Animal Recording (ICAR) (Vermeulen, 20 July 2017, pers. comm.). According to the ICAR guidelines, the accurate interpretation of real-time ultrasound images for fat thickness, eye muscle area and intramuscular fat % (IMF %) requires a high degree of skill (ICAR, 2018).

These traits are moderately heritable and are significant in determining carcass properties and lean yield in beef cattle. Breeding values or selection indexes can be calculated and used as a selection tool to identify genetically superior breeding animals at a relatively young age (Botes, 2017).

2.12.2 Procedure for using ultrasound

The procedure for using ultrasound involves the application of a mineral oil to the area of the body to be measured, and the placement of the sensor on the chosen area. The ultrasound equipment transfers electrical pulses to high-frequency sound waves, named ultrasound. These sound waves travel into the body where it is reflected between different densities of tissue. The ultrasound waves transmit the image to the transducer onto a screen of the ultrasound unit. The appropriate measurements are then done (Houghton & Turlington, 1992).

During the feeding period ultrasound is used to predict carcass traits. Houghton & Turlington (1992) emphasise that scanning cattle near the end of the feedlot phase should result in more accurate carcass trait predictions, although there are disadvantages associated with scanning at this time such as stress, expenses and labour (Houghton & Turlington, 1992).

2.13 Climate change

Climate change is expected to have a more extreme effect on the southern hemisphere continents and that the anticipated global warming is expected to have a negative effect on the beef production environment. The Nguni breed, as an indigenous breed, has the potential to adapt better to these changes. For centuries they have been exposed to high temperature conditions, and it appears that through adaptation, they have developed mechanisms to cope with heat stress and possibly also the higher heat increments associated with higher lignin content grasses (Scholtz *et al*., 2011).

Factors that have a direct effect on animals are temperatures, solar radiation, humidity and wind, while factors such as feed intake, quality, quantity of grazing, pests, diseases, and digestibility of the feed are influenced by climate change, and have an indirect effect on animals. Scholtz (2011) indicates that it is predicted that climate change will have a more extreme effect on the African continent than on any other continent. In some areas the grazing capacity is expected to decline, and the anticipated global warming will change the southern hemisphere environments and vegetation of Africa. It is important that livestock must be adapted to these higher temperatures, because the higher temperatures can reduce feed intake in order to reduce digestive heat production and reduce grazing time (Scholtz, 2011).

Climate change can have an influence on effective management, and major challenges are associated with climate change and the environmental impact on the livestock industry. The projections of climate change are that southern Africa in general will become drier and warmer. Temperatures are predicted to be higher, and this may result in heat stress in livestock, which, in turn, can lead to lower productivity. Heat stress can also have an impact on the effect on farming systems, species and the choice of breeds (Meissner *et al.*, 2013).

CHAPTER 3

MATERIALS AND METHODS

3.1 STUDY SITE

This study was conducted at the Sernick Feedlot, near Edenville, in the Northern Free-State. The Sernick Group is a family business founded by Mr Nick Serfontein in 1983. The company includes a Bonsmara stud, Phase C bull testing station, a feed factory, feedlot and an abattoir. The feedlot is located on the farm, Liebenbergstroom. The farmland of the Sernick Group is 5000 ha and consists of cultivated pastures and natural grazing. The GPS co-ordinates are: -27.609704, 27.724085.

Edenville falls within the summer rainfall area, with an average annual rainfall of 550mm occurring mostly during November and December. During the winter months the average minimum and maximum temperatures vary between -1°C and 18°C, and during the summer the average temperatures vary between 12°C and 37 °C. During November and December, it is very hot, with maximum temperatures between 32 – 37°C. According to Coetzee (pers. comm. 16 January 2017) the wind blows strongly from July until September, while spring usually starts in October.

The standard feedlot practice was followed, where a humane environment was established for the handling and production of beef in intensive feeding systems. Animals are allowed to move freely in the kraals (SAFA, 2016). Coetzee (pers. comm. 16 January 2017) confirmed that the kraals are level and 26 x 40m in size, while the feeding throughs are 13m in length. The animals are fed in the mornings and afternoons, and have free access to fresh water at all times.

3.2 ANIMALS

Two hundred Nguni male calves were sourced from different registered herds in South Africa. Seven of the male calves were oxen. These herds were from five provinces and originated from 24 herds, which vary between three and 26 animals per herd. Almost 50% of the animals originated from the Eastern Cape, 16 % from the Free State, 16 % from the Northern Cape, 13 % from the North West Province and 7 % from the Western Cape. Most of the animals were stud animals, although some were appendix A or B animals, while grade animals were also included in the trial. Stud animals are animals registered in the Appendix and Stud Book Proper sections of the Herd Book. The status recordings of the animals in the different sections of the herd book were 68% stud book proper, 8% appendix B, 18% appendix A with multi-sires, 4% appendix A from first recording parents, and 2% were grade animals.

The animals were randomly allocated into four groups and tested on four different rations. Each group consisted of 50 animals, and each herd was equally represented under each ration.

The mean ages of calves were 10 months, whilst their age ranged between six and fourteen months in age. They weighed between 94 and 242 kg on arrive. The mean weight of all the calves on arrival was 165 ± 30kg.

All the animals received a microchip tag that was connected to the Meat matrix computer programme. Every animal was also tagged with an All flex F4 tag and number. Each group's animals had different colour tags.

Upon arrival the animals received the first processing of medication:

- 2 ml Botuthrax against botulism and anthrax;
- 4 ml Coglavax against infection in ruminants;
- 4 ml Ivermax against parasites;
- 1 ml Bovitect PI against Pasteurella;
- 1 ml Multisomni for histofillus somni virus (lunges);
- 5 ml Multimin as a supplement for minerals (zinc, manganese, selenium);
- 7 ml Micotil as an antibiotic for the treatment of bovine respiratory disease;
- 1 pellet Revalor XS as an implant to improve the rate of gain and feed

efficiency; and

- 25 ml Ectoshield as a pour-on to controls ticks and flies.

The animals arrived at the feedlot between 8 and 15 July 2016 and went to the natural grazing on 15 July 2016. During this pre-conditioning phase, the animals were backgrounded for 32 days and received *ad lib Eragrostis* grass with the starter ration. The feedlot phase commenced on 16 August 2016, after which they were randomly divided into the four different treatment groups. Each group received a different ration.

With the commencement of the feedlot phase the animals received the second processing:

- 2 ml Pyramid 4 plus Presponse was vaccinated in prevention of Bovine virus diarrhea;
- 2 ml Covexin 10 as an active immunization against infections caused by clostridial species;
- 15 ml Ultraject as a treatment and control of respiratory and common systemic and urinary infections;
- 1 ml Multisomni for Histofillus somni virus (Lunges);
- 25 ml Amipor as a combination pour-on for comprehensive ectoparasite control; and
- 5 ml Ivermax as an injectable parasiticide.

After 72 days in the feedlot the animals received the third processing which was one pellet Revalor H per animal. This implant improves weight gain and feed conversion and was given approximately 72 days after the first implant.

No animals received Zilmax.

3.3 NUTRITION

During the feedlot phase the animals were fed twice a day (in the morning at 08:30 and in the afternoon at 16:30). The feeding rations (formulated by a Nutritionist of Sernick feedlots) met the standards and protect both human and animal health.

The Nguni weaner calves were tested for growth and general performance under four different rations containing different roughage contents. These treatment groups were named White, Orange, Yellow and Green, as indicated below. There were, on average, 50 animals per treatment group, where the Green group acted as control, as these animals received the commercial (Sernick) feedlot ration. For easier interpretation of results, the colours will be replaced with High for White (1), Medium for Orange (2), Low for Yellow (3) and Commercial for Green (4).

The four main feeding regimes were as follows:

1. White group – Starter (High roughage ration)
2. Orange Group – Grower (Medium roughage ration)
3. Yellow Group – Finisher (Low roughage ration)
4. Green group – Commercial feedlot grower (Low roughage ration)

Table 3.1 Feeding regimes of the different groups

Parameter	Ration	Number of animals
1. White	Nguni Starter High roughage	51
2. Orange	Nguni Grower Medium roughage	49
3. Yellow	Nguni Finisher Low roughage	50
4. Green	Feedlot Grower Commercial low roughage, Normal	50

Figure 3.1 Different feeding regimes in coloured bags

Table 3.2 Chemical composition of rations on dry matter intake (DMI) basis

Parameter	CLR	LR	MR	HR
Dry material (%)	87	86	86	86
Metabolizable energy (MJ/kg)	11.6	11.5	10.9	10.4
Crude protein (CP)	14.3	14.2	14.7	14.4
Neutral resistant fiber (%)	22.5	23.3	28.5	33.6
Fat (%)	4.7	4.4	4.1	4.0
Calcium (%)	0.75	0.71	0.72	0.74
Phosphorus (%)	0.37	0.37	0.36	0.35

Commercial low roughage diet – Control (CLR), Low roughage diet (LR), Medium roughage (MR), High roughage diet (HR)

Metabolizable Energy (ME) characterises the nutritional value of animal feeds. It is an estimate of the energy available to an animal from digested feed material and is expressed in units of megajoules metobolisable energy per kilogram of feed (MJ/kg DM). During the digestion process, the total energy value of the feed consumed is partitioned into waste and metabolizable energy. During the metabolisable process it partitioned into energy for maintenance, growth and production (Hill Laboratories, 2018).

Figure 3.2 Image of bulls feeding at the feedlot

3.4 MEASUREMENTS

3.4.1 Weighing of the animals

Animals were measured and weighed for several traits on various occasions during the trial. The animals were weighed in the mornings on an empty stomach, on an electronic scale.

Table 3.3 Time schedule and measurements taken

Parameter (days on test)	Date	Days (since previous)	Measurements
-32 (Backgrounding)	15/07/2016		Weight
0 (Start of test)	16/08/2016	32	Weight
9	25/08/2016	9	Weight
44	29/09/2016	35	Weight & RTU (Fat & Marb*)
72	27/10/2016	28	Weight RTU (Fat, Marb, EMA)
91	15/11/2016	19	RTU (Fat & EMA)
99	23/11/2016	8	Weight
105(Slaughter)	29/11/2016	6	Weight Carcass & Health
120 (Slaughter)	13/12/2016	14	Weight RTU (fat) Carcass & Health
135 (Slaughter)	29/12/2016	16	Weight Carcass Traits

*Not on all animals

Figure 3.3 Weighing of the animals

3.4.2 Feeding of the animals

During the feedlot phase the animals were fed twice a day (in the morning at 08:30 and in the afternoon at 16:30).

3.4.3 Real-time ultrasound measurements (RTU)

During the trial period ultrasound measurements were taken to measure specific traits. Rib fat thickness (between the 12^{th}-13^{th} rib) and rump fat thickness (fat covering – P8) were taken on all four RTU scanning occasions. Ribeye area (EMA) and intramuscular fat percentage (marbling) were also measured on two occasions. The scannings in this project were conducted by an ICAR (International Committee for Animal Recording) accredited technician. This is standard practice for the data to be accepted by SA Studbook, who is the registering authority of the Nguni Cattle Breeders' Society.

Figure 3.4 Image of the scanning equipment

Figure 3.5 Image of the P8 (fat layer on the rump) taken with the PIE Medical Falco 100 scanner. (The space between the 2 markers at the top of the image indicates the fat layer on the rump)

3.4.4 Slaughtering of the animals

Animals were slaughtered according to normal abattoir protocol, and the age classification was done according to the SA System Subcutaneous fat classification.

Carcass weight was recorded after the refrigeration of the carcass, which was 2 to 3 % less than carcass weight determined immediately after slaughtering (DARD, 2018).

Animals were slaughtered when they reached a marketable carcass weight and uniform condition (A2 carcass classification). They were slaughtered at three dates, which was after 105, 120 or 135 days on test. The animals that were deemed to be ready to be slaughtered, were selected for slaughtering on the first and second occasions – after 105 days and 120 days on test. All remaining animals were slaughtered after 135 days on test. Animals were identified according to their weight, body condition and visual appearance for slaughtering.

3.5 INVESTIGATION OF THE TRAITS

3.5.1 Test Length

Time needed to reach market weight might have a significant influence on profitability for the feedlot, depending on the feed margin. Excessively long-standing time will result in lower profitability.

3.5.2 Age and weight at start of test

The age and weight that calves should enter the feedlot were investigated.

3.5.3 Average daily gain weight (ADG)

Average daily gain is an indicator of growth of the animal, and also affects profitability. The more effective an animal puts on weight, the more profitable it will be. Higher weight gain in a shorter time is more desirable. This was calculated for the duration of the animal on the test.

ADG = (Weight at end of test – Weight at start of test) / Test length (days)

3.5.4 Total gain weight

The total weight gained during the test, irrespective of time needed to attain the gain, indicates the increase in muscle weight, and therefore edible meat, during the test.

3.5.5 Average daily gain and gain weight at 99 days

Comparisons between the groups were also done should the tests have ended on 99 days. Test length = 99 days for all animals.

3.5.6 Age and weight at end of test

The test was ended at the same market ready conditions for all animals, which was when an A2 carcass classification (market ready) was reached.

3.5.7 Carcass weight

Warm carcass weight is the weight of the unchilled carcass after the head, hide and internal organs have been removed and is measured. Cold carcass weight however, was calculated as 2% less than hot carcass weight. This is a direct measure of profitability for the feedlot.

3.5.8 Dressing percentage

This is the cold carcass weight divided by the slaughter weight, and it and should be as high as possible.

3.6 DATA ANALYSIS

For this data set, the 'Least Squares Means' was calculated for the traits, using the PROC General Linear Model procedure of SAS (2013). A model was fitted for each trait, which tests all known effects in the data for significance.

As most of the calves were registered stud animals, the data was linked to the Logix data base, and additional information could be obtained, notably date of birth, which made it possible to calculate the exact ages at measurement.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 INTRODUCTION

The Nguni breed is an early maturing, small framed indigenous Sanga breed (Strydom *et al*., 2001; 2008). According to NCBS (2014c), feedlots generally prefer medium to late maturing breeds, and thus major feedlots either do not accept Nguni weaners, or they pay significantly less for them (NCBS, 2014c).

The main focus of this investigation is to determine the reasons for discrimination against the Nguni in the feedlot, and to investigate the optimal finishing of Nguni steers. It is also important to determine the kind of feeding regimes will be suitable for Nguni calves. Two hundred Nguni male calves were sourced from different herds and were randomly allocated and tested on four different rations. They were slaughtered when they reached acceptable carcass subcutaneous fat classification, either after 105, 120 or 135 days in the test.

4.2 FEED INTAKE OF THE DIFFERENT GROUPS

All animals that started the trial, completed the test, and no animals were lost during the trial, although two were lost during adaptation. Calves were slaughtered on 29 November, 14 December and 29 December 2016 respectively. The intakes recorded in December therefore only reflected the remaining animals, as some were already slaughtered. This is reflected in Tables 4.1 and 4.2.

Table 4.1 The number of total days in the feedlot for every month

Treatment group	Aug.	Sept.	Oct.	Nov.	Dec.
High roughage	867	1530	1581	1494	714
Medium roughage	833	1470	1519	1446	736
Low roughage	850	1500	1550	1466	639
Commercial low roughage	850	1500	1550	1474	781

Total days = Number of animals x days in month

The high roughage group animals were fed the longest during the feedlot period (6 186 days), while the medium roughage group were fed the shortest period (6 004 days). The low roughage and commercial low roughage groups were fed 6 005 and 6 155 days respectively, during this period.

Table 4.2 The total feed consumed per month (ton)

Treatment Group	Aug.	Sept.	Oct.	Nov.	Dec.
High roughage	5.74	12.88	14.64	17.75	7.4
Medium roughage	5.42	12.16	14.4	17.2	7.4
Low roughage	5.86	12.68	13.44	15.9	5.85
Commercial low roughage	6.18	11.72	13.2	16.5	8.35

The total intake on the different rations was 58.41 ton for the high roughage ration, 56.58 ton for the medium roughage ration, 53.73 ton for the low roughage ration and 55.95 ton for the commercial low roughage ration.

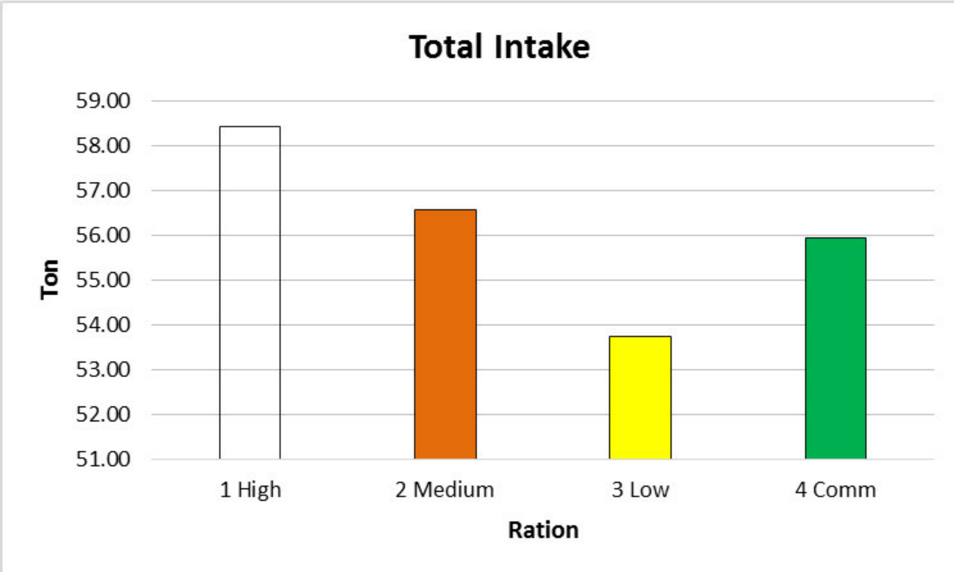

Figure 4.1 Average total intake of the different rations

From Figure 4.1 it is evident that the low and commercial roughage group had the lowest average total intake, while the high and medium roughage group had the highest average total intake during the trial period. The difference in intake is due to the changes in the number of animals on feed which was due to sequential slaughter. This is more evident in Table 4.3.

Table 4.3 Mean intake (kg) per animal per day from August to December

Treatment Group	Aug.	Sept.	Oct.	Nov.	Dec.
High roughage	6.62	8.42	9.26	11.88	10.36
Medium roughage	6.51	8.27	9.48	11.89	10.05
Low roughage	6.89	8.45	8.67	10.85	9.15
Commercial low roughage	7.27	7.81	8.52	11.19	10.69

Intake / animal / day = Ton feed/ (No. animals x days in month) x 1000

During the months October to December, the feed intake of the low and commercial roughage groups was less per animal per day than for the high and medium roughage. During the beginning of the trial in August and September, the intake was more or less the same for all four treatment groups. During November the intake for all four treatment groups was the highest (Table 4.3). This period could have been the peak growth period, and as a result of the fact that the animals were well adapted to the rations after 105 days.

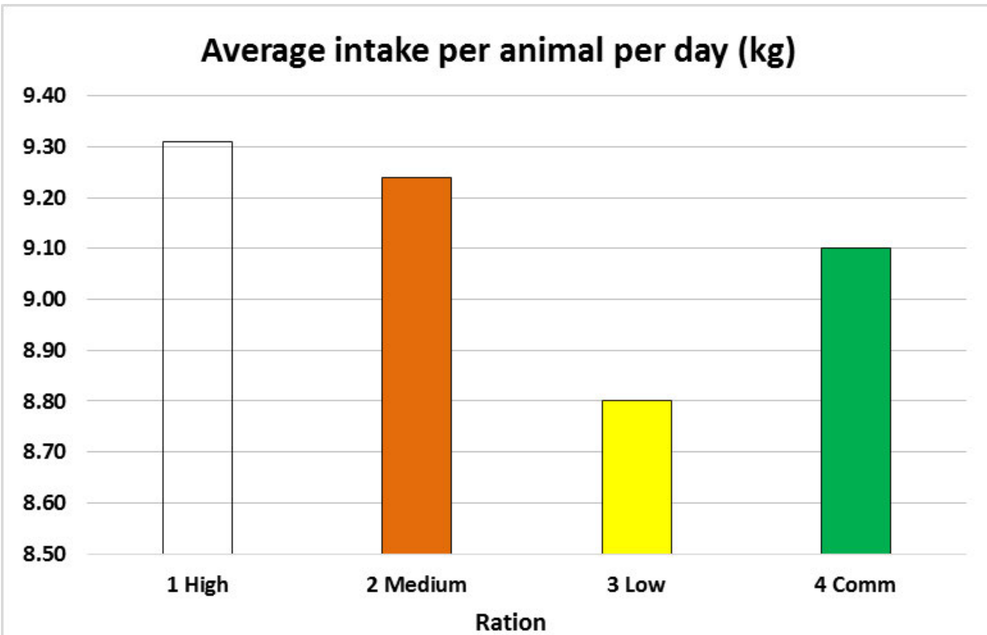

Figure 4.2 Average daily intake of the different rations over the trial period

From Figure 4.2 it is evident that the mean intake per animal per day was 9.31 kg for the high roughage ration, 9.24 kg for the medium roughage ration, 8.80 kg for the low roughage ration and 9.10 kg for the commercial low roughage ration. The low and commercial roughage group had the lowest average intake per animal per day, while the high and medium groups had the highest average intake per day.

Table 4.3 and Figure 4.2 show differences in average performance and subsequent days on feed due to sequential culling of animals allocated to different rations.

Table 4.4 LSM (Least Squares Means) for the different rations corrected for the effects of province of origin and test length for starting weight, ADG, final weight, total gain, cold carcass weight and dressing percentage

Parameter	High	Medium	Low	Commercial (Low)
Start Weight (kg)	191 ± 3.55^{a}	198 ± 3.77^{ab}	192 ± 3.68^{a}	201 ± 3.68^{b}
ADG (kg)	1.24 ± 0.02^{b}	1.27 ± 0.03^{b}	1.27 ± 0.03^{b}	1.34 ± 0.03^{a}
End Weight (kg)	342 ± 2.44^{b}	343 ± 2.51^{b}	339 ± 2.44^{b}	350 ± 2.49^{a}
Total Gain (kg)	147 ± 3.05^{b}	150 ± 3.24^{b}	150 ± 3.16^{b}	159 ± 3.16^{a}
Cold Carcass Weight (kg)	196 ± 1.74^{b}	199 ± 1.77^{b}	198 ± 1.74^{b}	204 ± 1.76^{a}
Dressing %	56.2 ± 0.16^{ab}	55.8 ± 0.17^{b}	55.9 ± 0.17^{b}	56.5 ± 0.18^{a}

Means with different superscripts within the same row differ significantly at the 5% level.

At the start of the test, the calves that were heavier and older were the ones that were ready to be marketed at 105 days. It seems that the effect of weight of the animal were more important than the effect of the ration.

The calves on the commercial ration did significantly ($P < 0.05$) better than the calves on the other rations for ADG to slaughter (1.34 vs 1.24-1.27), total gain to slaughter (159.1 vs 147-150), end weight (7 to 11 kg heavier) and carcass weight of 204kg vs. 196-198 kg for the other rations. According to Oosthuizen (2016), the benchmark ADG in South African feedlots is between 1.3 kg/day and 2 .00 kg/day. The results of the commercial ration showed that the ADG generated for this group was within the benchmark range.

Dressing percentage was 56.5%, which was not significantly better than the dressing percentage of the high ration animals. However, the commercial ration animals started out slower (about 9-10 kg), although they were significantly heavier at 201 kg than the high and low ration groups and needed on average 3 to 5 days longer to reach marketability than the calves on the other rations. The calves on the commercial ration performed the best, due to the higher ADG, total gain and carcass weights. Bosman (2002) indicates that the average benchmark for dressing percentage is between 52% and 62%. The dressing percentage for the four different rations are therefore in accordance with the benchmark range.

Research conducted by Muchenje *et al*. (2008b) indicated that, although on natural pasture, the Nguni had the highest (P <0.05) average daily gain from weaning to slaughter, compared to the Bonsmara and Angus. There were significant breed effects in the live weight between these breeds. The Nguni was lighter (P < 0.05) but had a higher (P < 0.05) daily gain from weaning to slaughter. It also had a lower (P < 0.05) daily loss when veld conditions were poor. This demonstrated the Nguni's ability to perform better than bigger breeds on natural pasture, particularly if the quality of grazing is low during dry seasons in rural areas. The dressing percentage was similar (P < 0.05) between the Nguni and Angus, but lower (P < 0.05) in the Bonsmara, which had a dressing percentage of 56.9 (±0.78). Although the Nguni steers had poorer conformation, higher ADG, lower carcass weight and dressing percentage than the other two breeds, the Nguni can compete favourably with established breeds in terms of productive performance and meat quality (Muchenje *et al*., 2008a).

4.2.1 The effect of feed conversion ratio (FCR)

Feed conversion ratio (FCR) gives an indication of the efficiency of the animal to convert feed into live weight gain. Oosthuizen (2016) states that the FCR benchmark range for beef cattle in South Africa is between 5.5:1 and 7:1kilogram feed per kilogram of live weight gained.

Table 4.5 The average daily feed intake (DFI), ADG (mean ± S.D.) and FCR per group

Parameter	High	Medium	Low	Commercial (Low)
DFI (kg)	9.31	9.24	8.8	9.10
ADG (kg)	1.26±0.2	1.26±0.22	1.29±0.2	1.32±0.22
FCR (kg)	7.5	7.3	6.3	6.8

FCR per group = (Average feed intake/animal/day) / (average ADG)

Oosthuizen (2016) indicates that there is variation between breeds when averages of each breed are compared. The ADG of *Bos Taurus* cattle is higher than that of *Bos indicus* cattle. Between the breeds, the FCR varies with a maximum of 7.31:1 and minimum of 6.09:1. Some of the breeds did utilise up to 1.22 kg more feed to gain 1 kg of muscle than other breeds. The Nguni was identified as *Bos Taurus africanus* and in this study, the ADG and FCR was 1.12kg and 6.7 respectively. According to Oosthuizen (2016), the proven differences in genetic production potential of breeds can be used as motivation to apply precision agricultural principles in a feedlot (Oosthuizen, 2016).

Two of the four ration groups showed FCR values within the acceptable benchmark range. The low- and commercial ration group had the most efficient FCR, while the high and medium ration groups generated the least efficient FCR. The difference between the highest and lowest FCR in this study for the different groups were 1.2kg. It is evident from the results that the ADG, feed intake and FCR differed between the different ration groups. The individual FI was not measured, and therefore the FCR was calculated per ration group. It should be noted that the ADG averages and standard deviation (SD) in Table 4.5 reflect raw values not corrected, as is reflected in Table 4.4, where it was indicated that the ADG of the commercial ration differed significantly from that of the others.

The average FCR in Oosthuizen's (2016) study was 5.47:1 for Brahman, Afrikaner, Bonsmara, Simbra, Angus, Simmentaler and Limousin. Feed conversion rations are largely based on the quality of the feed that the animals received. It is thus better to compare animals in the same study that received the same type of feed than to compare animals from different studies (Oosthuizen, 2016).

Bosman (1995) stated that there is a highly negative (favourable) correlation between ADG and FCR (-0.60). The better the growth of the animal, the more efficient (lower) the FCR will be. When the feed intake of the animal increases, the rate of growth of the animal will also be enhanced, causing the correlated response in ADG.

In the study of Arthur *et al*. (2001), it was indicated that genetic improvement in feed efficiency can be achieved through selection and that in general, correlated responses in growth and other postweaning traits will be minimal.

4.3 THE EFFECT OF THE DIFFERENT TEST LENGTHS ON THE IMPORTANT TRAITS

Table 4.6 reflects the different parameters, based on ultimate days of test length, corrected for differences caused by different rations and province of origin.

Table 4.6 Least square means (LSM) for Test Length corrected for the effects of Ration and Province or Origin for starting weight, ADG, end weight, total gain weight, cold carcass weight and dressing percentage

Parameter	105 days (n = 60)	120 days (n = 67)	135 days (n = 69)
Start Weight (kg)[#]	229 ± 3.50^{a}	195 ± 3.36^{b}	162 ± 3.49^{c}
ADG (kg)	1.51 ± 0.02^{a}	1.23 ± 0.02^{b}	1.10 ± 0.02^{c}
End Weight (kg)	352 ± 3.43^{a}	344 ± 2.10^{a}	334 ± 2.84^{b}
Total Gain (kg)	159 ± 3.01^{a}	147 ± 2.89^{b}	149 ± 3.00^{b}
Cold Carcass Weight (kg)	212 ± 2.01^{a}	197 ± 1.47^{b}	189 ± 1.78^{c}
Dressing %	56.51 ± 0.23^{a}	55.86 ± 0.14^{b}	55.89 ± 0.20^{b}

Means with different superscripts in the same row differ at 5% level.
[#] Corrected weight

The effect of ration on the growth of the calves is not as clear cut as the effect of test length. From Table 4.6 it can be depicted that the calves that reached slaughter condition after 105 days performed better (P <0.05) than the calves from the 120- and 135-days' slaughter groups for all the traits. The heaviest calves at the start of the test also had the shortest test lengths.

The traits are starting weight, ADG, total gain, end weight, carcass weight and dressing percentage. Although the age of the animals did not differ (P >0.05), they were significantly heavier at the start of the test at a corrected mean weight of 229kg, meeting the requirement of the feedlots of a weaner weighing around 220+ kg. A total average weight gain of 159 kg, and ADG of 1.51kg were recorded. The mean weight at the end of the test for the 105-day slaughter group was 352 kg, with a cold carcass weight of 212 kg and a dressing percentage of 56.5%. The calves that were slaughtered after 120 days had an average corrected starting weight of 195 kg, while the starting weight of the 135-day group were only 162 kg. Both these groups did not reach average carcass weights of 200 kg, despite having been on test for a longer period than the 105-day group. The 120-day group nearly reached 200kg carcass weight, whilst the 135-day group had the same total gain up to slaughter and dressing percentage than the 120-day group. The best performers were the 105-day group with a starting weight of 229 kg, ADG more than 1.5kg/day and a total gain of 159kg in 105 days. Carcass weight was also above 200 kg (212kg), with a dressing percentage of 56.5 %.

The 120- and 135-day groups never reached the weights of the first slaughter groups despite being in the feedlot for two to four weeks longer. Carcass weight and dressing percentage were also significantly better *(P* <0.05) for the 105-day group than for the 120- and 135-day groups respectively.

In the study done by Casey *et al.* (1990), analyses of the growth performance and carcass characteristics of the Afrikaner, Nguni and Pedi bulls indicated that growth rates did not differ, although the Nguni yielded the heavier carcass (*P* <0.05), the greater dressing percentage (*P* <0.05) and the more compact carcass and hind quarter (*P* <0.01). There were no overall differences that could be established between young Afrikaner, Nguni and Pedi bulls (Casey *et al.*, 1990).

4.4 INFLUENCE OF AGE ON WEANING CALVES

Table 4.7 reflects the age differences of animals slaughtered at different test lengths, corrected for the effects caused by province of origin and ration.

Table 4.7 Least square means (LSM) for test length corrected for the effects of ration and province of origin and the age of the animals

Parameter	105 days (*n* = 60)	120 days (*n* = 67)	135 days (*n* = 69)
Begin test age (days)	316^{a}	302^{a}	311^{a}
End test age (days)	423^{a}	422^{a}	444^{b}

Means with different superscripts in the same row differ at 5% level.

Statistical results of the effect of the test lengths during the starting and end age were non-significant. There were no significant differences in the ages at the start of the test between the different test lengths. The test length and ration had no significant effect on starting age trait, which is an indication that calves on the different test lengths and rations were not significantly older or younger than calves on other test lengths or rations. The calves that were on average older at the start of the growth test, tended to have the shortest test lengths.

4.5 THE EFFECT OF ARRIVAL WEIGHT

Arrival weight is the weight before the backgrounding started. It was important to calculate the effect of arrival weight in the test length, ADG and carcass weight to see whether accepting calves within certain weight ranges could predict a better outcome for the feedlot.

Table 4.8 Effect of arrival weight on the test length, ADG, ADG (99 days) and carcass weight (Mean±SD)

Parameter	Arrival weight groups (kg)			
	<160 (*n* = 97)	161 – 180 (*n* = 43)	181 – 200 (*n* = 34)	>200 (*n* = 26)
Arrival weight	139 ± 14[a]	172 ± 6[b]	191 ± 6[c]	214 ± 11[d]
Min. – Max. (kg)	94 -160	162 – 180	182 – 200	220 – 242
Test length	129 ± 9[a]	118 ± 9[b]	110 ± 7[c]	107 ± 7[c]
Min. – Max. (kg)	105 -135	105 – 135	105 – 120	105 – 135
ADG	1.21 ± 0.16[a]	1.28 ± 0.19[b]	1.35 ± 0.21[bc]	1.46 ± 0.26[c]
Min. – Max. (kg)	0.84 -1.66	0.92 – 1.66	0.88 – 1.85	0.49 – 1.79
ADG 99 days	1.35 ± 0.17[a]	1.39 ± 0.16[ab]	1.44 ± 0.19[bc]	1.51 ± 0.23[c]
Min. – Max. (kg)	0.75 -1.68	1.03 – 1.76	1.05 – 1.84	0.75 – 1.96
Carcass weight	185 ± 15[a]	200 ± 11[b]	211 ± 14[c]	231 ± 18[d]
Min. – Max. (kg)	133 - 215	178 – 222	181.6 – 241	176.2 – 259

Means with different superscripts in the same row differ at 5% level.

From Table 4.8 it is clear that the heavier the animal is on arrive, the shorter the time in the feedlot, as these animals recorded better ADGs and heavier carcass weights. From these results it is recommended that animals should weigh more than 200kg on arrival for the best results. Nearly half of the calves in this study weighed less than 160kg on arrival. All the animals were also weighed in all the groups at 99 days. This is within the norm of a 90- to 120-day feedlot feeding period (DARD, 2018).

Table 4.9 Least square means for the effect on the arrival weight of the animals on the different test lengths

Parameter	105 days (n = 60)	120 days (n = 67)	135 days (n = 69)
Arrival weight (kg)	196^a	164^b	138^c

Means with different superscripts differ at 5% level.

Although the 105-day group was significantly heavier (P <0.05), they were not significantly older than the other groups at the start of the test. The animals that were heaviest on arrival were slaughtered first. They were the 105-day group.

4.6 THE EFFECT OF RATION, TEST LENGTH AND PROVINCE OF ORIGIN

A statistical model was fitted for each trait which tests all known effects in the data for significance. The test length and ration had no significant effect (P <0.05) on the trait starting age, which can be interpreted as that the age of the calves on the different test lengths and rations did not differ (P >0.05). However, province of origin did test significant (P <0.05) for starting age, which can be interpreted as calves from the Free State and Northern Cape being significantly younger (308-day) than calves from the Eastern Cape (331-day).

Table 4.10 Least square means for the effect of province, corrected for test length and ration, on the test length, starting age, starting weight, ADG, weight gain and age at the end of the test

Parameter	Test Length	Start Age	Start Weight	ADG Slaughter	Gain Slaughter	End Age
North West	122^{a}	347^{a}	175^{c}	1.39^{a}	165^{a}	454^{a}
Eastern Cape	122^{a}	331^{a}	193^{b}	1.33^{b}	158^{a}	439^{a}
Free State	119^{b}	308^{b}	206^{a}	1.22^{c}	144^{b}	412^{b}
Northern Cape	118^{b}	294^{b}	205^{a}	1.20^{c}	142^{b}	400^{b}
Western Cape	118^{b}	348^{a}	198^{ab}	1.26^{c}	149^{b}	450^{a}

Averages with different superscripts within the same column differ significantly at the 5% level.

Calves from the Free State, Northern Cape and Western Cape had the shortest test length (118 - 119 days). They, however, had the heaviest starting weights (205kg, 206kg and 198kg on average). The calves from the Free State and Northern Cape were the youngest at the start and the end of the test as well. These calves gained 142 to 144 kg in total, with an ADG of 1.20 - 1.22 kg per day. The Western Cape calves were slightly older (348 days) at start and end of the test, but gained 149kg in 118 days, with an ADG of 1.26 kg per day. Province of origin did not have a significant effect (P >0.05) on either end weight, carcass weight or dressing percentage. The North West and Eastern Cape calves started out older and lighter and had a longer test length of 122 days than calves of the other provinces. They gained between 158kg and 165kg and grew faster than the calves of the other regions at 1.33kg to 1.39kg per day. Although being longer on test, they had better ADG and total weight gain than calves from other provinces. Most of the calves from the Eastern Cape were slaughtered at the last slaughter date.

An advantage of this method of analysis is that the effect of a trait can be determined irrespective of other confounding aspects. Starting weight, as a trait, has significant effects on the test length, ration and provinces of calves. Therefore, it could determine the average starting weight of calves tested for 105 days, irrespective of the ration they were on, or the province they came from. The average starting weights for test lengths are corrected for the effects of ration and province, giving a much clearer picture of the effect of the starting weight trait on a trait such as test length. The traits that were significant were the test length, ration and herd/province of origin. Test length had a significantly larger effect on important traits than ration.

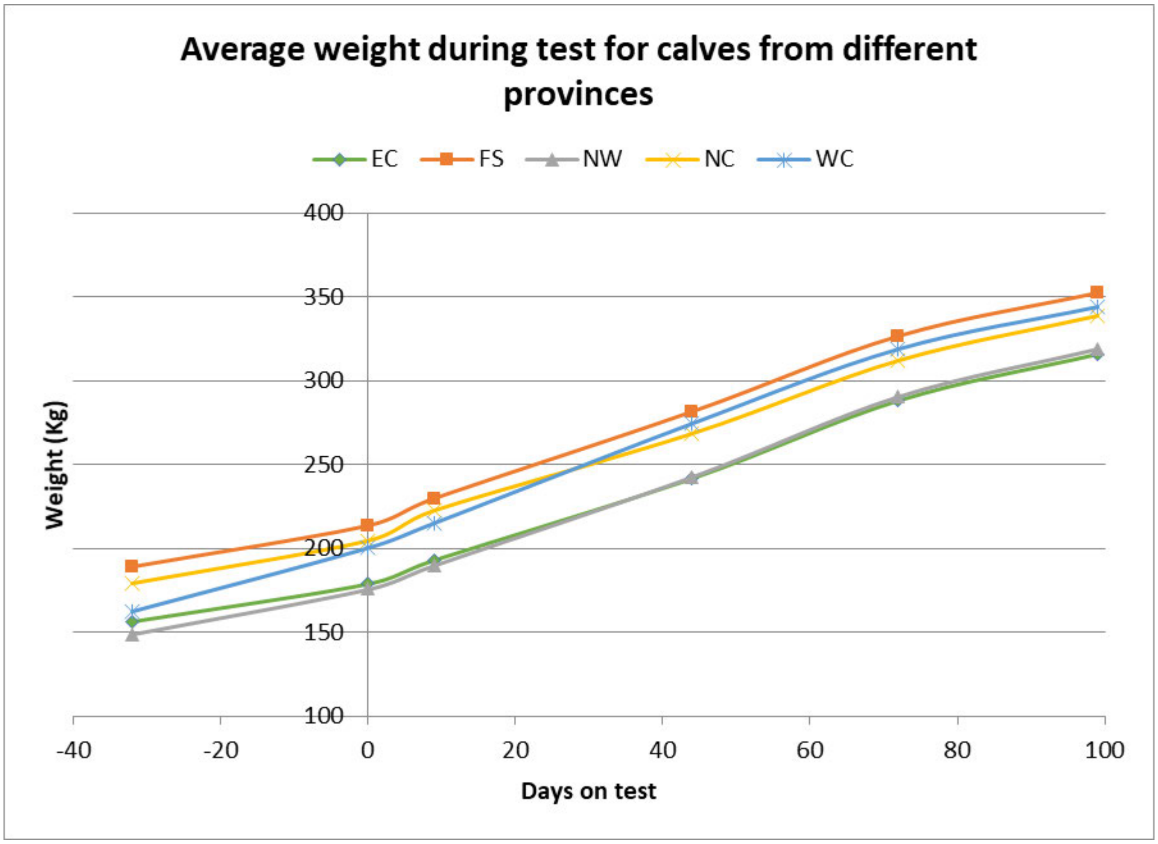

Figure 4.3 Calves originating from different provinces showed differences in growth

The Eastern Cape animals had a lighter average weight which may be ascribed to environmental conditions. Scholtz & Linington (2006) stated that the quality of natural pasture also rapidly decreases through summer, which results in lower energy and nitrogen (N) availability. They also stated that nitrogen (N) deficient diet reduces feed intake by limiting microbial growth rate and organic matter digestion in the rumen, which in turn reduces the amount of amino acids available for digestion and absorption from the small intestines. Animals can develop different nutrient requirements due to selection (Scholtz & Linington, 2006). Nguni cattle were more capable of maintaining their body weight during winter, and hence animal productivity can be improved by choosing the best genotype for each environment (Scholtz & Linington, 2006). It is evident from Figure 4.3 that the animals of the 24 different herds and from five different provinces, had differences in growth.

Table 4.11 Least square means for the effect of ration on the test length

Parameter	Test Length
High roughage ration	117^{c}
Medium roughage ration	120^{b}
Low roughage ration	119^{c}
Commercial roughage ration	123^{a}

Means with different superscripts differ significantly at the 5% level.

The slaughter groups were weighed at 105 days and 135 days, while all the remaining animals were weighed at 120 days. There were calves on all four rations slaughtered at all three test lengths.

4.7 REAL TIME ULTRASOUND SCANNING (RTU)

The RTU traits were not measured at all the occasions, but on day 72 of the trial all the traits were measured, and the animals were weighed as well. The data was therefore statistically analysed on day 72. The measurements that were taken was EMA (ribeye area), rump fat thickness (fat covering – P8), rib fat thickness between the 12th – 13th rib, and marbling (intramuscular fat percentage).

Table 4.12 Effect of ration on RTU measurements after 72 days of feeding (Mean ±SD)

Parameter	High roughage (n = 51)	Medium roughage (n = 49)	Low roughage (n = 50)	Commercial roughage (n = 50)
Rump fat	5.01 ± 1.38^{a}	5.11 ± 1.07^{a}	5.37 ± 1.35^{a}	4.68 ± 1.13^{a}
Rib fat	2.89 ± 0.91^{a}	3.32 ± 0.65^{a}	3.35 ± 0.8^{a}	3.06 ± 0.8^{a}
Marbling	2.77 ± 0.55^{a}	2.71 ± 0.43^{a}	2.68 ± 0.45^{a}	2.57 ± 0.46^{a}
EMA	47.71 ± 5.88^{a}	49.51 ± 5.4^{a}	49.98 ± 7.29^{a}	49.72 ± 6.35^{a}

Means with different superscripts differ significantly at the 5% level.

It is evident from Table 4.12 that the different rations did not have a significant effect on rump fat, rib fat, marbling and EMA.

Table 4.13 Effect of the different test lengths on rump fat, rib fat marbling and EMA after 105, 120 and 135 days of feeding (Mean ± SD)

Parameter	105 days (n = 60)	120 days (n = 70)	135 days (n = 70)
Rump fat	5.87 ± 1.17^{a}	4.98 ± 1.19^{b}	4.36 ± 0.97^{c}
Rib fat	3.79 ± 0.68^{a}	3.12 ± 0.68^{b}	2.64 ± 0.65^{c}
Marbling	2.73 ± 0.53^{a}	2.7 ± 0.47^{a}	2.62 ± 0.45^{a}
EMA	55.2 ± 4.98^{a}	49.14 ± 3.97^{b}	44.17 ± 4.5^{c}

Means with different superscripts differ significantly at the 5% level

In Table 4.13 it is clear that there was a significant effect on rump and rib fat for the animals that were tested on 105 days, compared to the animals that were tested on 120 and 135 days. The 105-days feeding group had the highest rump and rib fat content. There was no significant effect between the three test length groups for marbling. There was also a significant effect on EMA between the 105, 120 and 135 days of feeding groups. EMA for the 105 days feeding period were the highest, and EMA for the 135 days were the lowest.

Drake (2004) explained that ultrasound may be used to obtain carcass data on finished cattle in a feedlot as a substitute for actually measuring carcasses. It was stated that for finished cattle, the correlation of ultrasound fat thickness and ribeye area measurements to actual carcass data is greater than 0.80. The ultrasound measurements of marbling are reported as a percentage intramuscular fat in the ribeye muscle. For this reason, the quality grade of a carcass is mostly determined by the amount of marbling on the cut surface of the ribeye between the 12th and 13th ribs. Cattle were entered at various ages (6, 12 and 18 months), at different initial weights, and with various numbers of days on feed. The marbling scores increase with more days on feed (Drake, 2004).

Table 4.14 Phenotypic correlations between RTU traits, weight and age at 72 days on the test

Parameter	Rib fat	Marbling	EMA	Weight	Age	ADG
Rump fat	0.59*	-0.02	0.41*	0.29*	0.02	0.21*
Rib fat		0.07	0.52*	0.60 *	0.21*	0.39*
Marbling			0.02	0.02	0.18*	0.07
EMA				**0.78***	0.12	0.49*
Weight					0.25*	0.62*
Age						0.14*

* denotes significant (*P<0.05*) Pearson correlation coefficients

In Table 4.14 it is evident that the correlation between weight and rib fat was highly significant. The eye muscle area (EMA) and weight was also highly significant. The weight was not significantly correlated (0.02) to marbling (intra-muscular fat). Age was low correlated (0.18) with marbling. This can be an indication that older animals had more marbling. Although the correlation is low (0.18), it can also be an indication that the animals have not yet started to lay down intra-muscular fat (72 days on test). Rib fat is significantly correlated to rump fat (0.59), while weight was low correlated (0.29) to rump fat at 72 days on the test.

Drake (2004) stated that heavier carcasses produce larger rib-eyes, and that larger carcasses are more efficient in processing time and labour. There is a range of acceptable carcass weights, and therefore many markets have minimum and maximum sizes for specific cuts. It was also found that the rib-eye area and fat thickness (rib fat) increases with more days on feed, and that there was a low genetic correlation between marbling and fat thickness (Drake, 2004).

4.8 RATION COST

Although the low roughage and commercial rations were more expensive per ton, the animals fed on them were the most profitable.

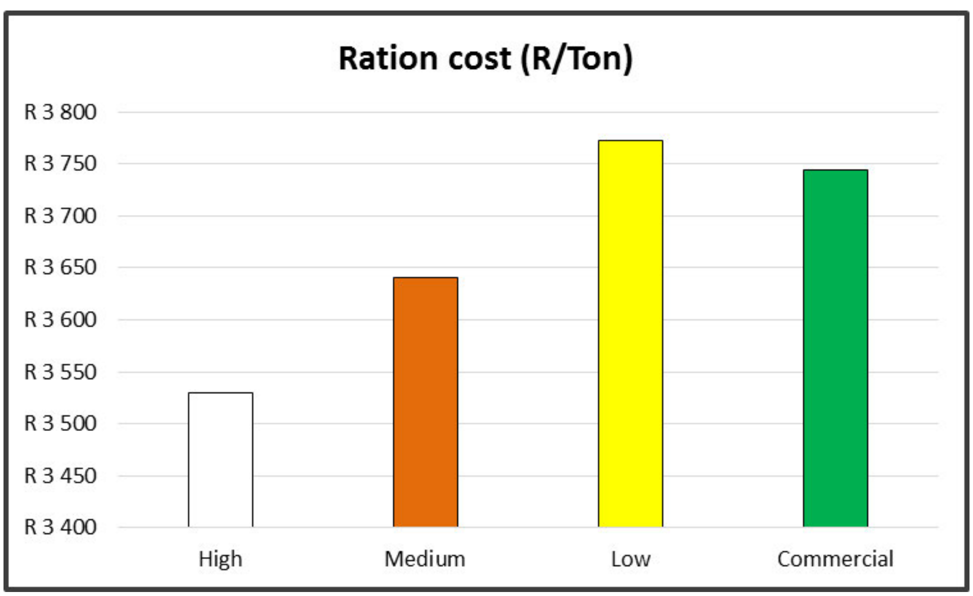

Figure 4.4 Average cost of ration from August to December 2016 (R/ton)

The low and commercial roughage ration average costs were the highest with R3 773 and R3 745 (R/ton) respectively, while the high- and medium roughage ration costs were R3 530 and R3 641 (R/ton) respectively.

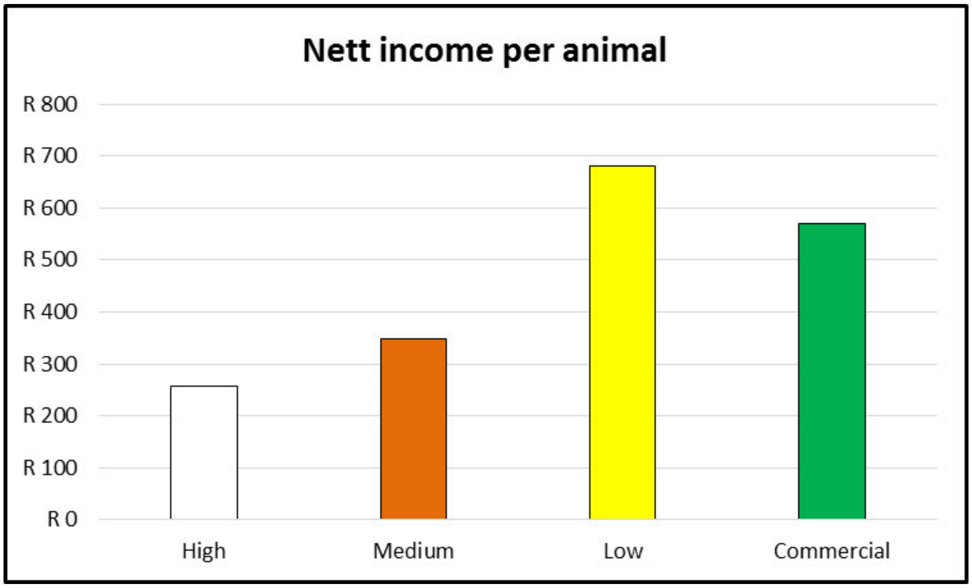

Figure 4.5 Nett income per animal per treatment

The nett income per animal for the different rations was R256.18 (high roughage ration), R347.80 (medium roughage ration), R680.24 (low roughage ration) and R569.50 (commercial low roughage ration). The Nguni calves performed the best on the low and commercial rations in terms of their nett income per animal and made the biggest profit due to the shorter feeding time and their faster growth (Figure 4.4).

4.9 SLAUGHTERING OF THE ANIMALS

Animals were slaughtered at the Sernick abattoir in Kroonstad according to normal abattoir protocol.

Table 4.15 The number of animals slaughtered in the different weight classes

Slaughter weight (Price/kg)	High (n = 51)	Medium (n = 49)	Low (n = 50)	Commercial (n = 50)
120-130 (R35/kg)			1	
140-150 (R36/kg)	1			
150-160 (R36/kg)	3		1	1
160-170 (R37/kg)	3	5	2	2
170-180 (37/kg)	10	6	5	7
180-190 (R38/kg)	16	11	12	4
190-200 (R38/kg)	3	13	9	9
200+ (R38/kg)	15	14	20	27

n = number of animals

Animals were identified according to their body weight, body condition and visual appearance for slaughtering. They were slaughtered according to the carcass classification of A2 (no permanent teeth and relatively lean), although three animals in the 105-day group already reached A3 (no teeth, medium fatness) and one animal in the 135-day group only reached an A1 carcass classification (no teeth and very lean) (SAMIC, 2006).

According to SAFA (2016), the practice is to select the heaviest animals first for slaughtering. The rations were subdivided into test lengths, with the heaviest animals under each ration being 105 days on test, the more or less average animals in the trial being 120 days on test, and the animals needing the most time to grow, being 135 days on test. The calves tested were very diverse, from calves ready to be slaughtered at 105 days to calves only ready 30 days later.

Figure 4.6 Image of carcasses after the first slaughtering (105 days) in the feedlot

Figure 4.7 Image of carcasses after the second slaughtering (120 days) in the feedlot

From the images in figure 4.4 and 4.5 it is evident that there are visual differences in the carcasses between the groups that were slaughtered at 105 days and 120 days in the feedlot.

According to Mapiye *et al.* (2007), the Nguni breed is a multipurpose disease-resistant animal with low-maintenance feed requirements and relatively high output. These cattle perform well under harsh pedo-climatic and socio-economic conditions. It is important to add value to the final product for each stage in the production, delivery and marketing process and the ability to meet specific needs through unique traits. As the Nguni breed is perceived to have little or no value as a source of beef due to its small size, it is important to capitalise on any traits that makes the Nguni breed an economically viable alternative to exotic breeds and crossbreds. Nguni cattle have the inherent capacity to produce beef of comparably high yield under both feedlot and natural pasture conditions (Mapiye *et al*., 2007).

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

The results of this study were acceptable and concluded satisfactory answers to the objectives of this study. The profitability of feeding Nguni cattle has not been compared to other breeds; however, the research findings of this study confirm that Nguni cattle can be fed profitable in the feedlots with low roughage and commercial rations. The study found that the low roughage group had the lowest average intake per animal per day, while the high and medium roughage groups had the highest average intake per day. Calves on the commercial ration did significantly (P <0.05) better than the calves on the other rations for ADG at slaughter (1.34 kg/d vs 1.24-1.27 kg/d), total gain to slaughter (159 kg vs. 147-150 kg), end weight (7 to 11 kg heavier) and carcass weight of 204 kg vs. 196 – 198 kg for the other rations. Although the low roughage and commercial rations were more expensive per ton, the animals fed on them were the most profitable. As the Nguni calves performed the best in the group with the most expensive ration (low roughage and commercial rations), this group also realised the biggest profit due to the shorter feeding time and faster growth.

The study found that the heavier the animals are when arriving at the feedlot, the shorter the feeding period was, and the calves reached marketability quicker. The ADG was also better, and the carcass weight at slaughter was heavier. The animals that were the heaviest on arrival at the start of the trial were slaughtered first at 105 days on feed. Although the animals slaughtered at 105 days were significantly heavier, they were not significantly older than the other groups at the start of the test. The animals in the 120- and 135-day slaughter groups never reached the weights of the first slaughter group, despite growing for 2-4 weeks longer. The ADG for the groups slaughtered after 105, 120 and 135 days were 1.51, 1.23 and 1.10 kg/day respectively.

Arrival weight had a marked influence on the test length and the margin over feed costs, favouring the heavier calves. The results indicate that the minimum weight on arrival should be close to 200kg, with an absolute minimum of 180kg. Growth and carcass weights of the calves with higher arrival weights were heavier at slaughter and met the market requirements.

Carcass weight and dressing percentage were also significantly better ($P < 0.05$) for the animals in the first slaughter group (105 days) than for the animals in the 120- and 135-day groups respectively. The dressing percentage of the animals on the commercial ration was 56.5%, which was not significantly better than the dressing percentage of the high (roughage) ration animals. However, the commercial ration animals started out slightly (9-10 kg) heavier, although significantly heavier at the corrected starting weight of 201 kg than the other groups and needed on average 3 to 5 days longer to reach marketability than the calves on the other rations.

It seems that the average slaughter weight for Nguni calves tend to be lower compared to composites generally used in feedlots. Some significant differences in starting weight and age were evident in calves originating from different provinces, but these differences were not significant at the end of the test, neither were the carcass traits, as animals were slaughtered at different days on test.

Although ration had a significant effect on ADG, it was negated by other factors such as the test length and arrival weight, contributing to the differences in feedlot profitability. Although the low roughage and commercial rations were not the cheapest per ton, they were the most profitable to feed in this case. Nguni cattle also performed profitably on the (normal) commercial diet.

Significant differences in feedlot performance could be attributed to the source of animals. Individual herds were obviously restricted in region or province. Although not necessarily proven by this trial, these differences can be due to genetic merit, but also environmental conditions prior to being fed in a feedlot.

In this study the RTU measurements compared well with previous studies and could be used to predict slaughter weight of Nguni cattle. There were no excessive health fallouts that occurred during the period of the trial.

Reasons used by feedlots to discriminate against the Nguni, such as it not being able to reach the required carcass weight before starting to fatten, does not justify the lower price paid for Nguni calves. Nguni farmers need to be reminded why they farm with Nguni cattle, namely that they are the most suitable breed for their farming conditions, especially in adverse climatic extremes.

As the objective of this study was to determine the most suitable ration and performance of Nguni calves under feedlot conditions, the results indicated that Nguni calves can be fed profitable in the feedlots with a low and commercial roughage ration.

5.2 RECOMMENDATIONS

The results indicate that the precondition for minimum weights to be considered on arrival (or at the end of preconditioning or backgrounding phase) must be close to 200kg, with a minimum weight of 180kg. The heavier calves at the beginning of the feedlot phase had a shorter feeding period and reached marketability quicker. They were also more profitable to feed.

Further studies should investigate possible interactions between origin and ration, and the differences between animals in the different test lengths. This can determine why some animals are more suited, as reflected in their ADG.

The effect of the ration might also become clearer if animals below acceptable arrival weights are omitted. An example will be to exclude animals with an arrival weight below 160kg.

Genetic differences were not considered during the current study and should be investigated further. Genomic studies will also be a recommendation. The data lends it particularly well to the study of the relationship between RTU measurements on the live animals and carcass traits, and for the development of selection indices.

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ADDENDUM A
An investigation into the precision feeding of Nguni steers under feedlot conditions

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Abstract

The aim of this study was to investigate the optimal finishing of Nguni steers using different feeding regimes. The rations that were evaluated were: Nguni Starter (High roughage), Nguni Grower (Medium roughage), Nguni Finisher (Low roughage) and Feedlot Grower Commercial (Low roughage). The trial was run at the Sernick feedlot near Edenville. Two hundred Nguni male calves, sourced from 24 different herds from five provinces, were randomly divided into four groups of 50 each. They were backgrounded in the pre-conditioning phase for 32 days and received *ad lib Eragrostis* grass. After 105, 120 and 135 days in the feedlot, the calves were slaughtered according to their weight, body condition and visual appearance. Animals with the highest initial weights were slaughtered first (105 days on feed). They had the highest final- and carcass weights. Calves on the Commercial ration did significantly better than the calves on the other rations for ADG (1.34 kg/d vs 1.24-1.27 kg/d), total gain (159.1 kg vs 147-150 kg), end weight (7 to 11 kg heavier) and had a mean carcass weight of 204 kg vs 196-198 kg for the other treatment groups. The carcass weights and dressing percentage for the groups slaughtered after 105, 120 and 135 days were significantly better for the 105-day group than for the 120 and 135-day groups. Arrival weight had a marked influence on test length and margin over feed costs, favouring the heavier calves. Various carcass traits were also measured. Results indicate that preconditioning to reach minimum weights close to 200 kg to be considered at arrival (or at the end of preconditioning or backgrounding phase) for the profitable feeding of Nguni calves in a feedlot. Although the low roughage and commercial rations were more expensive, they were the most profitable to feed. Nguni calves performed profitably on the (normal) commercial diet in the feedlot.

Keywords: Carcass weights, different rations, growth rates

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Introduction

The feedlot industry produces approximately 75% of all beef produced in South Africa. This is approximately 1.35 million head of cattle per annum (SAFA, 2018). Economic, management and genetic factors can affect the profitability of feedlots and this must be integrated to make decisions that will enhance the profit potential of a feedlot system. Producers are in control of management and genetic factors which can have an influence on the average daily weight gained (ADG), feed conversion ratio (FCR) and therefore efficiency in feedlots. These factors can be summarised as the type of animals in terms of genetic merit differences, weights, the nutritional background of the animal, nutritional management and health (AMT, 2016).

It is generally accepted that feedlot cattle will be more profitable than feeding cattle on pastures, mainly due to faster and more efficient growth. Furthermore, feedlot cattle have significantly higher final weights, warm and cold carcass weights, warm and cold dressing percentage, average daily gain, intramuscular fat content and back fat thickness measurements than organic and conventional pasture cattle (Esterhuizen *et al*., 2008).

Feedlots ideally prefer weaner calves weighing around 220 kg that grow at a rate of *ca* 1.7 kg/day with good feed efficiency and temperament. It is also required for them to have positive feed margins, which can only be obtained with high growth rates and low feed costs per kilogram gain (Sernick, 2016). Lower final weights and perceived bad feed conversion ratio (FCR) may be some of the reasons why feedlots discriminate against Nguni cattle and pay less per kilogram live weight for weaners purchased than for other breeds (Botha, 2014). This is a dilemma for beef producers relying on the Nguni breed as the basis of their production of weaners. This also influences the viability of the Nguni stud breeders as it negatively affects the marketability of Nguni seed stock animals. The aim of the investigation is to determine the reasons for the discrimination against Nguni cattle by feedlots. This study also aims to investigate the optimal finishing of Nguni steers and determine what feeding regimes would result in the highest profit.

Materials and methods

Two hundred Nguni male calves were sourced from different registered herds in South Africa. Most of the calves were intact males while only seven calves were castrated. These herds were from five provinces and originated from 24 herds which vary between three and 26 animals per herd. Almost 50% of the animals originated from the Eastern Cape, 16 % from the Free state, 16 % from the Northern Cape, 13 % from the North West Province and 7 % from the Western Cape. Most of the animals were stud animals, although some were appendix A or B animals (F1 and F2 upgrades), while grade animals were also included in the trial. The animals were randomly allocated into four groups (stratified for weight) and tested on four different rations. Each group consisted of 50 animals and each herd was equally represented under each ration. The mean age of the calves was *ca* 10 months and ranged between six and 14 months of age. The mean weight on arrival was 165 ± 30kg. The trial commenced in July 2016 during winter. The animals were backgrounded in the pre-conditioning phase for 32 days and received *ad lib Eragrostis* grass with the starter ration. The feedlot phase commenced in August 2016 after which the random division into the four different treatment groups (rations) took place. Animals had free access to fresh water (standard procedure for SA Feedlots).

The four main feeding regimes (groups) were as follows:
Group 1: Starter (High roughage ration)
Group 2: Grower (Medium roughage ration)
Group 3: Finisher (Low roughage ration)
Group 4: Commercial feedlot grower (Low roughage ration)
The chemical composition of the different rations is presented in Table 1.

Table 1 Chemical composition of rations on dry matter intake (DMI) basis

Parameter	CLR	LR	MR	HR
Dry material (%)	87	86	86	86
Metabolizable energy (MJ/kg)	11.6	11.5	10.9	10.4
Crude protein (CP)	14.3	14.2	14.7	14.4
Neutral resistant fiber (%)	22.5	23.3	28.5	33.6
Fat (%)	4.7	4.4	4.1	4.0
Calcium (%)	0.75	0.71	0.72	0.74
Phosphorus (%)	0.37	0.37	0.36	0.35

Commercial low roughage diet – Control (CLR), Low roughage diet (LR), Medium roughage (MR), High roughage diet (HR)

Animals were slaughtered when they reached a marketable carcass weight and uniform condition (A2 carcass classification). They were slaughtered at three dates, namely after 105, 120 or 135 days, respectively, on the test. The animals that were deemed to be ready to be slaughtered, were selected for slaughtering on the first and second occasions – after 105 days and 120 days on test according to their weight, body condition and visual appearance for slaughtering. All remaining animals were slaughtered after 135 days on the test, irrespective of body weight or condition.

Animals were measured and weighed for several traits (age and weight at the start of the test, average daily gain [ADG], total weight gained, ADG and weight gain at 99 days, age and weight at end of the test, carcass weight and dressing percentage). Real-time ultrasound scanning (RTU) were conducted and subsequent traits measured on day 72 in the feedlot. The data was therefore statistically analysed. The measurements that were taken was EMA (ribeye area), subcutaneous rump fat thickness (fat covering – P8), subcutaneous rib fat thickness between the 12th – 13th rib and marbling (intramuscular fat percentage).

Data were statistically analysed using the PROC General Linear Model procedure of SAS (SAS, 2013). "Least Squares Means" were also calculated for the traits. Models were fitted for each trait, to test all known effects for significance. As most of the calves were registered stud animals, the data was linked to the Logix database and additional information could be obtained, notably date of birth, which made it possible to calculate the exact ages at measurement.

Results and Discussions

The mean intake per animal per day was 9.31 kg for the high roughage ration, 9.24 kg for the medium roughage ration, 8.80 kg for the low roughage ration and 9.10kg for the commercial low roughage ration. The low- and commercial roughage group had the lowest average intake per animal per day, while the high and medium groups had the highest average intake per day.

From Table 2 it can be depicted that the calves on the commercial ration did better (P <0.05) than the calves on the other rations for ADG to slaughter (1.34 vs 1.24-1.27), total gain to slaughter (159.1 kg vs 147-150 kg), end weight (7 to 11 kg heavier) and carcass weight of 204 kg vs 196-198 kg for the other rations. According to Oosthuizen (2016) the benchmark ADG in South African feedlots is between 1.3 kg/day and 2 kg/day. The ADG obtained from animals fed with the commercial ration, was within the acceptable benchmark range. Dressing percentage was 56.5%, which was not significantly better (P >0.05) than the dressing percentage of the high ration animals. The calves on the commercial ration performed the best, due to the higher ADG, total gain and carcass weights. According to Bosman (2002) the average benchmark for dressing percentage is between 52% and 62%. The dressing percentage of Ngunis fed on the four different rations are therefore in line with the benchmark range.

Table 2 LSM (Least Squares Means) ± SE for the different rations corrected for the effects of Province of origin and Test Length for starting weight, ADG, final weight, total gain, cold carcass weight and dressing percentage

Parameter	High	Medium	Low	Commercial (Low)
Start Weight (kg)	191 ± 3.55 [a]	198 ± 3.77[ab]	192 ± 3.68 [a]	201 ± 3.68 [b]
ADG (kg)	1.24 ± 0.02 [b]	1.27 ± 0.03 [b]	1.27 ± 0.03 [b]	1.34 ± 0.03 [a]
End Weight (kg)	342 ± 2.44 [b]	343 ± 2.51 [b]	339 ± 2.44 [b]	350 ± 2.49 [a]
Total Gain (kg)	147 ± 3.05 [b]	150 ± 3.24 [b]	150 ± 3.16 [b]	159 ± 3.16 [a]
Cold Carcass Weight (kg)	196 ± 1.74 [b]	199 ± 1.77 [b]	198 ± 1.74 [b]	204 ± 1.76 [a]
Dressing %	56.2 ± 0.16 [ab]	55.8 ± 0.17 [b]	55.9 ± 0.17 [b]	56.5 ± 0.18 [a]

[a,b,c] Means with different superscripts within the same row differ significantly at P <0.05.

Muchenje *et al*. (2008b) indicated that, although on natural pasture, the Nguni had the highest (P <0.05) average daily gain from weaning to slaughter comparing to the Bonsmara and Angus. There were significant breed effects in the live weight between these breeds. The Nguni was lighter (P <0.05) at weaning but had a higher (P <0.05) daily gain from weaning to slaughter. It also had a lower (P <0.05) daily loss when the veld condition was poor. This demonstrated the Nguni's ability to perform better than larger frame breeds on natural pasture, particularly if the quality of grazing is low, as is usually the case during dry seasons in rural areas. The dressing percentage was similar (P <0.05) between the Nguni and Angus, but lower (P <0.05) than in the Bonsmara, which had a dressing percentage of 56.9%. Although the Nguni steers had poorer conformation, higher ADG, lower carcass weight and dressing percentage than the other two breeds, the authors concluded that the Nguni can compete favourably with established breeds in terms of productive performance and meat quality (Muchenje *et al*., 2008a).

From Table 3 it is evident that the age of the animals did not differ significantly (P >0.05), but the 105d slaughter group were heavier (P <0.05) at the onset of the test at a corrected mean weight of 229kg, meeting the requirement of the feedlots of a weaner weighing around 220 kg. A total average weight gain of 159 kg and ADG of 1.51 kg/day was recorded. The mean weight at the end of the test for the 105-day slaughter group was 352 kg, with a cold carcass weight of 212 kg and a dressing percentage of 56.5%. The calves that were slaughtered after 120 days had a mean corrected starting weight of 195 kg, while the starting weight of the 135-day group was only 162 kg. Both these groups did not reach average carcass weights of 200 kg, despite having been on the trial for a longer period than the 105-day group. The 120-day group nearly reached 200 kg carcass weight and the 135-day group had the same total gain up to slaughter and dressing percentage than the 120-day group. The best performers were the 105-day group with a starting weight of 229 kg, ADG more than 1.5 kg/day and a total gain of 159 kg over 105 days. Carcass weight was also above 200 kg (212 kg) with a dressing percentage of 56.5 %. The 120- and 135-day groups never reached the weights of the first slaughter group despite being in the feedlot for two to four weeks longer. Carcass weight and dressing percentage were also better (P <0.05) for the 105-day group than for the 120- and 135-day groups respectively.

Table 3 Least square means (LSM) ± SE for Test Length corrected for the effects of Ration and Province for starting weight, ADG, end weight, total gain weight, cold carcass weight and dressing percentage

Parameter	105 days (n = 60)	120 days (n = 67)	135 days (n = 69)
Start weight (kg)	229 ± 3.50 ^{a}	195 ± 3.36 ^{b}	162 ± 3.49 ^{c}
ADG (kg)	1.51 ± 0.02 ^{a}	1.23 ± 0.02 ^{b}	1.10 ± 0.02 ^{c}
End weight (kg)	352 ± 3.43 ^{a}	344 ± 2.10 ^{a}	334 ± 2.84 ^{b}
Total Weight Gained (kg)	159 ± 3.01 ^{a}	147 ± 2.89 ^{b}	149 ± 3.00 ^{b}
Cold Carcass Weight (kg)	212 ± 2.01 ^{a}	197 ± 1.47 ^{b}	189 ± 1.78 ^{c}
Dressing %	56.51 ± 0.23 ^{a}	55.86 ± 0.14 ^{b}	55.89 ± 0.20 ^{b}

^{a,b,c} Means with different superscripts within the same row differ significantly at P <0.05.

In the study done by Casey *et al.* (1990), analyses of the growth performance and carcass characteristics of the Afrikaner, Nguni and Pedi bulls indicated that although growth rates did not differ, the Nguni yielded the heavier carcass (P <0.05), a higher dressing percentage (P <0.05) and a more compact carcass and hind quarter (P <0.01). There were no overall differences that could be established between young Afrikaner, Nguni and Pedi bulls.

From Table 4 it is clear that the different rations did not have a significant effect on rump fat, rib fat, marbling and EMA (Eye Muscle Area) as measured by ultrasound scanning on the live animals.

Table 4 Effect of ration composition on RTU measurements after 72 days of feeding (Mean ± SD)

Parameter	High roughage (n = 51)	Medium roughage (n = 49)	Low roughage (n = 50)	Commercial roughage (n = 50)
Rump fat	5.01 ± 1.38^{a}	5.11 ± 1.07^{a}	5.37 ± 1.35^{a}	4.68 ± 1.13^{a}
Rib fat	2.89 ± 0.91^{a}	3.32 ± 0.65^{a}	3.35 ± 0.8^{a}	3.06 ± 0.8^{a}
Marbling	2.77 ± 0.55^{a}	2.71 ± 0.43^{a}	2.68 ± 0.45^{a}	2.57 ± 0.46^{a}
EMA	47.71 ± 5.88^{a}	49.51 ± 5.4^{a}	49.98 ± 7.29^{a}	49.72 ± 6.35^{a}

From Table 5 it is evident that rump and rib fat for the animals tested on 105-day test length was affected (*P* <0.05) compared to the animals that were tested on 120 and 135 days. The 105 days feeding group had the highest (*P* <0.05) rump and rib fat content. There was no effect (*P* >0.05) between the three test length groups for marbling. Eye muscle area also differed (*P* <0.05) between the 105-, 120- and 135-days of feeding. Average eye muscle area for the animals only fed for 105 days was significantly higher while those fed for 135 significantly lower. The same tendency was observed for subcutaneous fat thickness

Table 5 Effect of the different test lengths on rump fat, rib fat marbling and EMA after 105, 120 and 135 days of feeding (Mean ± SD)

Parameter	105 days (*n* = 60)	120 days (*n* = 70)	135 days (*n* = 70)
Rump fat	5.87 ± 1.17^a	4.98 ± 1.19^b	4.36 ± 0.97^c
Rib fat	3.79 ± 0.68^a	3.12 ± 0.68^b	2.64 ± 0.65^c
Marbling	2.73 ± 0.53^a	2.70 ± 0.47^a	2.62 ± 0.45^a
EMA	55.20 ± 4.98^a	49.14 ± 3.97^b	44.17 ± 4.5^c

[a,b,c] Means with different superscripts within the same row differ significantly at *P* <0.05.

Drake (2004) explained that ultrasound may be used to obtain carcass data on finished cattle in a feedlot as a substitute for measuring carcasses. It was stated that for finished cattle, the correlation of ultrasound fat thickness and ribeye area measurements to actual carcass data is greater than 0.80. The ultrasound measurements of marbling are reported as a percentage intramuscular fat in the ribeye muscle and therefore is the quality grade of a carcass mostly determined by the amount of marbling on the cut surface of the ribeye between the 12^{th} and 13^{th} ribs. Cattle were entered at various ages (6, 12 and 18 months) and different initial weights and with various numbers of days on feed. The marbling scores normally increase with more days on feed (Drake, 2004).

Table 6 indicates a highly significant (*r* = 0.60) correlation between weight and subcutaneous rib fat depth. The correlation between eye muscle area (EMA) and weight was also highly significant (*r* = 0.78). The weight was not significantly correlated (*r* = 0.02) to marbling (intra-muscular fat). Age was lowly correlated (*r* = 0.18) with marbling. It can be an indication that older animals had more marbling. Although the correlation is low (*r* = 0.18) it can also be an indication that the animals have not yet started to lay down intra-muscular fat (72 days on test). Rib fat is significantly correlated to rump fat (*r* = 0.59) while weight was lowly correlated (*r* = 0.29) to rump fat at 72 days on the test.

Table 6 Correlations between RTU traits, weight and age at 72 days on test

Parameter	Rib fat	Marbling	EMA	Weight	Age	ADG
Rump fat	0.59*	-0.02	0.41*	0.29*	0.02	0.21*
Rib fat		0.07	0.52*	0.60 *	0.21*	0.39*
Marbling			0.02	0.02	0.18*	0.07
EMA				**0.78***	0.12	0.49*
Weight					0.25*	0.62*
Age						0.14*

* denotes significant (*P<0.05*) Pearson correlation coefficients

Drake (2004) stated that heavier carcasses, on average, produce a larger ribeye and that larger carcasses are more efficient in processing time and labour. There is a range of acceptable carcass weights and therefore many markets have minimum and maximum sizes for specific cuts. It was also found that the ribeye area and fat thickness (rib fat) increases with more days on feed and that there was a low genetic correlation between marbling and fat thickness (Drake, 2004).

Conclusions

The low roughage group had the lowest average intake per animal per day, while the high and medium roughage groups had the highest average intake per day. Although the low roughage (R3 773/ton) and commercial rations (R3 745/ton) were more expensive on a weight basis, the animals fed on these rations were the most profitable. The nett income per animal for the different rations was R256.18 (high roughage ration), R347.80 (medium roughage ration), R680.24 (low roughage ration) and R569.50 (commercial low roughage ration). As the Nguni calves performed the best in the group with the most expensive ration (Low roughage and commercial rations), this group also realized the biggest profit due to the shorter feeding time and faster growth. The heavier the animals are when arriving at the feedlot, the shorter the feeding period. These calves also reached marketability quicker. Arrival weight had a marked influence on the test length and the margin over feed costs, favouring the heavier calves. The results indicate that the minimum weight at arrival should be close to 200 kg with an absolute minimum of 180 kg. Growth and carcass weights of the calves with higher arrival weights were heavier at slaughter and met the market requirements. It seems that the average slaughter weight for Nguni calves tends to be lower compared to composites generally used in feedlots.

Results from the RTU measurements compared well with previous studies and could be used to predict the slaughter weight and carcass characteristics of Nguni cattle. Reasons used by feedlots to discriminate against the Nguni, such as not being able to reach the required carcass weight before reaching the required grading, does not justify the lower price paid for Nguni calves, given that producers adhere to the requirements for arrival weights or backgrounding.

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