EFFECT OF DIETARY ENERGY LEVEL ON PRODUCTIVITY OF GROWING YEARLING MALE BONSMARA, NGUNI AND BRAHMAN CATTLE DURING SUMMER MONTHS

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BY

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A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT FOR THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURE (ANIMAL PRODUCTION), DEPARTMENT OF AGRICULTURAL ECONOMICS AND ANIMAL PRODUCTION, SCHOOL OF AGRICULTURAL AND ENVIRONMENTAL SCIENCES, FACULTY OF SCIENCE AND AGRICULTURE, UNIVERSITY OF LIMPOPO, SOUTH AFRICA

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2015

DECLARATION

I declare that this mini-dissertation hereby submitted to the University of Limpopo for the degree of Master of Science in Agriculture (Animal Production) has not been submitted by me for a degree at this or any other University, this is my own work in design and execution, and that all material contained herein has been duly acknowledged.

Signature…………………… Date……………………….

Miss G.M. CHELOPO

ACKNOWLEDGEMENT

I give all the praise and honour to Almighty God for his mercy and the love He have for me. Great thanks to Almighty God.

Firstly, I will like to thank my mentor Mr. M. M. Ratsaka, for his guidance and support from the beginning to the end of this journey. My deepest and sincerely thanks to my supervisor Prof. J. W. Ng'ambi for his guidance, supervision and support. Their patience, thoughtfulness, and encouragement have been important along this path of my study.

Secondly, I must thank feedlot workers and Mr. O.G. Makgothi (the feedlot manager) for their advice and suggestions and most importantly for their willingness to help whenever there was need, this included their help during all of my animal trials, their care of the experimental animals, and giving me the opportunity to learn from experience and knowledge. I also, want to thank the ARC-OVI residual laboratory staff members for helping me with the chemical analysis. I would like to thank the Gauteng Department of Agriculture and Rural Development in collaboration with Agricultural Research Council and Agricultural Research Council Professional development programme for funding me to conduct this research. I would, also, like to thank the National Research Foundation (NRF) for financial support during the period of my study when I needed it. I would like, also, to thank my parents, late Moshiya Chelopo (Mama) and Jeanette Chilopo (Aunt), my two brothers (Mapotlakene and Thabang), my grandmother (Metse Chelopo), my uncles and my other extended family members for their love and support for instilling in me the desire to work hard and learn new things.

There are many people who have helped and supported me along my journey and my sincerest gratitude to them cannot be adequately put into words, these are my friends and classmates who gave me moral support.

DEDICATION

This work is dedicated to my late mother, Elizabeth Moshiya Chelopo and late grandfather, Mapotlakeng David Chelopo, who always believed in me more than I did myself.

ABSTRACT

A study was conducted to determine the effect of dietary energy level on DM intake, growth rate, feed conversion ratio (FCR), live weight and physiological responses of yearling male Bonsmara, Nguni and Brahman cattle during the summer season.The experimental diets were isonitrogenous but with different dietary energy levels. A complete randomized design was used in all the experiments. The dietary treatments were ME_{10} (10 MJ ME/kg DM), ME_{12} (12 MJ ME/kg DM) and ME_{13} (13 MJ ME/kg DM).

Dietary energy level had no affect (P>0.05) on feed intake and live weight of Bonsmara, Nguni and Brahman cattle. Dietary energy levelalso had no effect (P>0.05) on growth rates of Bonsmara and Nguni cattle; however, it affected (P<0.05) growth rate in Brahman cattle. Brahman cattle on Diet ME_{13} had higher (P<0.05) growth rates than those on ME_{12} and ME_{10} diets.

Breed had an effect (P<0.05) on some performance parameters of the cattle. Bonsmara cattle had higher (P<0.05) DM intakes per metabolic weight than Nguni and Brahman cattle in all the dietary treatments. However, Nguni and Brahman cattle had similar (P>0.05) DM intakes per metabolic weight. Bonsmara cattle had higher (P<0.05) growth rates than Nguni and Brahman cattle in all the dietary treatments, the least being Nguni cattle. Feed conversion ratios were similar (P>0.05) between cattle breeds fed Diets ME_{12} and ME_{13}; however, breed affected (P<0.05) FCR when the cattle were fed on a low energy diet of 10 MJ ME/ kg DM. Bonsmara and Nguni cattle had similar (P>0.05) FCR values when fed on Diet ME_{10}. Similarly, Nguni and Brahman cattle on Diet ME_{10} had similar (P>0.05) FCR values. Bonsmara cattle had better (P<0.05) FCR values than Brahman cattle when fed on Diet $ME_{10.}$

Bonsmara cattle had similar (P>0.05) DM intakes, growth rates and FCR in all the dietary treatments with increase in ambient temperature. Brahman cattle had similar (P>0.05) feed intake with an increase in ambient temperature for all the dietary energy levels. Growth rates were higher (P<0.05) in Brahman cattle fed a high energy diet (ME_{13}) than those fed on low energy diets (ME_{10} and ME_{12}). Feed conversion ratios were also improved (P<0.05) with an increase in dietary energy

levels at high ambient temperature. Generally, a diet high in energy level had improved FCR of the cattle with an increase in ambient temperatures.

Dietary energy level had no effect ($P>0.05$) on nutrient digestibility and body temperature of the cattle. Cortisol level was similar ($P>0.05$) in both Bonsmara and Nguni cattle fed diets differing in energy levels; however, dietary energy level had an effect ($P<0.05$) on the cortisol level of Brahman cattle. Cortisol level was better ($P<0.05$) in Brahman cattle fed on diets low in energy (ME_{10} and ME_{12}) than those fed on a diet high in level (ME_{13}).

It is concluded that dietary energy level had no effect ($P>0.05$) on feed intake, digestibility and live weight of yearling Bonsmara, Nguni and Brahman cattle during summer months. However, dietary energy level had effect on growth, FCR and Cortisol level of growing cattle. Similarly, cattle breeds responded differently to increase in dietary energy level.

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CHAPTER 1

INTRODUCTION

1.1 Background

In South Africa livestock farming is the only viable agricultural activity in a large part of the country. The gross value of beef production is dependent on the number of cattle slaughtered (DAFF, 2012), and this is dependent on productivity and management of the animals. Beef is produced throughout South Africa (DAFF, 2012) however feeding and management under high ambient temperatures becomes a challenge to producers. High temperatures raise the concern of heat stress in cattle (Morrison, 1983).High ambient temperature increases body temperature and results in hyperthermia and, therefore, reduces the performance of the animal. Heat stress in cattle occurs when heat gain becomes higher than an animal's ability to lose heat (Silanikove, 2000). The approximate ambient thermal-comfort zone for cattle is between 4 and 24^{o}C (Hahn, 1997; West, 1999). Within this temperature range, the animal is at its optimal productivity with a body temperature of between 38.4 and 39.1ºC (Morrison, 1983). Livestock performance is affected by heat stress.Animals that are having difficulty in losing body heat resort to decreasing their metabolic heat by lowering feed intake (Nardone *et al*., 2006). This kind of physiological response to high ambient temperature results in lowered production or growth (Morrison, 1983). In the worst case, heat stress may increase the chances of illness and may even cause death (Sunil-Kumar*et al*., 2011).

Under heat stress, growth performance differs across cattle breeds (Laborde *et al*., 2001). The nutritional needs of cattle breeds with different growth performances may be different. Naturally, high ambient temperatures compromise the quality of the end products. This is because heat stressed animals reduce their feed intake and this leads to reduction in nutrient intake, in attempt to reduce heat increment. Heat stress reduces dry matter intake (DMI) by 12 %(O'Brien *et al*., 2010).

The effects of ambient temperature on intake and productivity differ between breeds (Young, 1975). Heat stress has been found to affect growth performance of growing cattle (Silanikove, 1992); however the interrelationships between heat stress and dietary energy level and their impact on optimal performance of various breeds under high ambient temperature are insufficient and inconclusive.

Knowledge and understanding of nutrition for beef cattle under high ambient temperature is extremely important for production because of the effect of consumed nutrients and environmental temperature on the overall performance of growing cattle. Appropriate feeding helps alleviate the combined effect of high ambient temperature and metabolic head load (Dikmen *et al*., 2012).

High energy content diets have been found to have the highest heat increment (Gaughan*et al*., 2002; Mader, 2003; Arias *et al*., 2011). However, reports show that low energy diets yield negative energy balance (Rhoads *at al*., 2009). Dikmen *et al*., (2012) reported that better feeding strategies may help in improving the welfare of feedlot cattle. It is, therefore, important that both ambient temperatures and nutritional conditions should be well managed to avoid negative effect on beef cattle production.

1.2 Problem statement

Scholtz *et al*. (2010) predicted that climate change will become more extreme in the African countries. As predicted by Ashdown (2007), atmospheric temperature will rise by a minimum of 2.5^{o}C by 2030. Ambient temperature is the factor that has the largest direct effect on livestock performance (Scholtz *et al.,* 2010). Cattle throughout the world are repeatedly exposed to heat stress during summer months. Animals that are having difficulties in losing body heat resort to decreasing their metabolic heat by lowering feed intake (Nardone *et al*., 2006). This kind of physiological response to high ambient temperature results in lowered production or growth rate and may even lead to death (Sunil-Kumar *et al*., 2011). Thus, heat stress may result in decreased production of beef cattle and, therefore, may affect the society's goals of poverty reduction, food security and human health (FAO, 2014).

There is currently insufficient information on the nutritional requirements of different cattle breeds being fattened under highambient temperature. Maintaining optimal dietary management will help in managing heat stress and hence improving performance of the animals. Thus, for optimal productivity both diet and environment must be considered. This type of study is especially important for farmers.

1.3 Motivation of the study

Data on the effect of dietary energy level on growing Nguni, Bonsmara and Brahman cattle under high ambient temperature is limited and not conclusive. Norris *et al*. (2002) outlined that the performance of cattle breeds differs with diets and Scholtz *et al*. (2013) reported that the response to heat stress depends on the breed of cattle. Knowing dietary energy requirements for growing Nguni, Bonsmara and Brahman cattle under high ambient temperature will help in the formulation of diets that will optimize productivity of the animals.

This study will determine the suitable dietary energy levels for optimal feed intake, growth rate, and feed conversion ratio of growing Nguni, Bonsmara and Brahman cattle under high ambient temperature conditions. Results generated from this study will be valuable to farmers keeping beef cattle in high ambient temperature regions, and also in the formulation of diets that will improve the productivity of the animals under such conditions.

1.4 Objective

The objective of this study will be to determine the effect of dietary energy level on feed intake, digestibility, growth rate, feed conversion ratio, live weight, body temperature and cortisol level of growing yearling male Bonsmara, Nguni and Brahman cattle during summer months

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The effect of heat stress has been long recognised and that breeds differ in their ability to cope with the problem (Olson *et al*., 2003; Silanikove, 2000). Blackshaw & Blackshaw (1994) reviewed physiological mechanisms for coping with heat stress.Heat stress includes increased internal body temperature, a more rapid respiratory rate (Gaughan *et al*.,1996) and greater vasodilation with increased blood flow to the skin surface (West, 1999). Animals also tend to increase their metabolic rate, decrease nutrient intakeas a way of decreasing metabolic heat production (West, 1999). This, in turn, affects the growth rate and sometimes may cause death (Morrison, 1983). Dewell (2010) confirmed that compared to other animals, cattle cannot dissipate their heat load very effectively. However, there is evidence indicating that increased concentration of energy in a diet improves growth rates of cattle under heat stress (Fuquay, 1981). Gaughan *et al*. (1996) also concluded in their review that an increase in heat load causes an increase in energy requirement. The effect of heat on body temperature is not only determined by climate but also by the availability of feed and water (Finch, 1986). Nutritional imbalance and deficiencies may contribute to heat stress in cattle, as reported by West (1999) that excess of degradable dietary protein increases the energy production.The excess N is excreted as Urea. The quality of food alters the concentration of metabolic heat – load. High ambient temperatures affect cattle directly and indirectly, therefore, to maintain productivity under high ambient temperature environmental conditions and diets should be managed accordingly.

2.2 Nutrient requirement and growth in beef cattle

There are many factors affecting dry matter intake including animal weight, condition, stage of production, environmental conditions, forage quality and amount and type of the feed offered. Nutrient requirements vary depending on many animal and environmental factors. Different breeds, also, have different nutrient requirements and those nutrient levels required vary with seasons. Energy is not a nutrient per se, but a quality associated with the nutrient content of feedstuffs and mixed diets, which include fats, carbohydrates and protein that an animal utilizes as a source of energy. Of all the nutritional needs, energy is one of most critical component which may affect performance of the animal (Moehn *et al*., 2005). The energy requirements of an animal consist of the requirement for maintenance and the requirement for production (Jabbar *et al*., 2013). It may be important to increase nutrient density of the diet under high ambient temperature (West, 2003) to maintain high nutrient intake. Growth performance is a very important factor in beef cattle production, the faster the animal grows the less time it will spend at the feedlot.Heat stressed cattle consume less feed than those that are under normal environmental temperature and this subsequently affects growth performance and productivity.

2.3 Performance of cattle under ambient heat stress

High ambient temperatures affect cattle differently (NRC, 1996). There is evidence that metabolic rate of indigenous breeds is lower than those of exotic breeds (Silanikove, 2000). Therefore, indigenous breeds in tropical and subtropical environments perform better as compared to breeds from temperate regions (Scholtz, *et al*., 2010). There are cattle breeds which are heat-tolerant and those which are heat-intolerant. Heat tolerant breeds are those breeds that experience less increase in body temperature under high ambient temperatureswhereas; heat-intolerant breeds are those with sharp increase in body temperature under high ambient temperature. Genetic mechanisms influence the adaptation of the animal to heat stress (Finch, 1986). Genetic makeup of a breed influences the level of response and the ability to adapt.Nutritional and health status of the animal can influence the degree of vulnerability to environmental stressors (Hahn, 1997).Coat colour and type and morphology of sweat glands influence the differences in response to heat stress between the breeds. For example, the coat colour of cattle is directly related to the amount of heat absorbed from solar radiation (Becerril, *et al*., 1993). Under tropical conditions with high levels of solar radiation animals with light-coloured hair coat and dark pigmented skin are better adapted (Olson, 1999). Sleek and dense coated cattle are associated with low body temperature and high growth rate; this means that a dense flat coat provide greater resistance to heat transfer to the skin (Olson *et al*., 2003;Foster *et al*., 2009). Hansen (2004), also, indicated that cattle from zebu breeds (indigenous in South Africa) are better able to regulate body temperature in response to heat stress than the cattle from a variety of Bos Taurus breeds of European origin.

2.4 Physiological response of cattle to heat stress

Heat stress in cattle is determined by changes in hormone level, body temperature and behaviour (Silanikove, 2000). Restlessness and crowding under shade or at water tanks, panting, and increased salivating are the symptoms of extreme heat stress (Carvalho *et al*., 1995). Respiratory rate is useful indicator of heat load in cattle as it is the first visual response (Gaughan *et al*., 2002). Under heat stress the respiratory rate of cattle reaches above 80 breathes per minute (Silanikove, 2000).However, Gaughan *et al*. (2000) reviewed that the effect of high ambient temperature on respiratory rate was influenced by a number of factors which included age, sex, genotype, level of performance, nutrition, time of feeding and the body condition of the cattle. Thus, heat stress level can also be measured by the level of cortisol. Cortisol is a stress hormone; and an increase in plasma cortisol concentration is the most prominent response of animals to stressful conditions (Silanikove, 2000). Cortisol levels will be higher than normal during periods of elevated environmental temperatures and humidity (Muller *et al*., 1994). It has, however, been shown that multiple shocks and aggressive handling can have significant increases in blood lactose and other indicators of metabolic stress (Liu *et al*., 2006).The procedures of blood collection on calves can rapidly increase the cortisol in the blood stream (Mostl *& Maggs*, 2002). However, Silanikove (2000) indicated that plasma cortisol increases within 20 minutes after the exposure to acute stress and reach peak within 2 hours. Hormonal changes that occur during heat stress affect productivity negatively. This is because plasma growth hormone concentration and growth hormone secretion rate decline with an increase in body temperature. McGuire *et al*. (1991) reported that change in plasma growth hormone is a response to high ambient temperature effect rather than a reduction in nutrient intake. The thyroid hormone under heat stress increases an attempt to reduce metabolic heat production (West, 1999). Many of the behavioural, health and performance disturbances of an animal are attributable to such physiological and metabolic adjustments which finally affect the productivity of the animal.

Rectal temperature can also be used to determine body temperature of an animal (Silankove, 2000); it is, therefore, used to assess the harsh conditions of the thermal environment that affect the performance of the growing beef cattle. An increase of

1^0C in rectal temperature reduces performance in most livestock species (McDowell *et al*., 1976). The rectal temperature of heat-stressed beef cattle is above 39.1 ^{0}C (Hahn, 1999; Morrison, 1983). Silanikove (2000) confirmed that there are differences between breeds in their ability to regulate body temperature. Rectal temperature for exotic breeds is higher than those of indigenous South African breeds (Finch, 1986). Thus, exotic breeds are more sensitive to high ambient temperature than indigenous breeds.

2.5Improving the productivity of beef cattle under high ambient temperature (>25^{0}C)

To maintain homoeothermic balance between the animal and the ambient environment, the animal must exchange heat at a rate that permits balancing the metabolic heat production and energy gain. Cattle become heat stressed when heat gain becomes higher than their ability to lose heat (Silanikove, 2000). Under such conditions animals reduce feed intake to lower heat production. Reduction in feed intake due to high ambient temperature adversely affects productivity. For cattle to be productive, they need feeds that meet their nutrient requirements. Beede & Collier (1986) outlined three approaches that can improve productivity in cattle raised under hot climates. These include physiological modification through shades, genetic development of less heat-sensitive breeds and improved nutritional management schemes. Environmental modifications to deal with heat stress have been developed but the response to environmental modification may be improved by dietary modification. Therefore, feeding and nutritional management should be used as relatively effective methodsto reduce heat stress in cattle.

2.5.1 Feeding and nutritional management

When an animal is at its thermoneutral zone there is no physiological process that requires the expenditure of a considerable amount of energy to maintain normal body temperature. However, nutritional needs of cattle change during heat stress. This is because there is a decrease in DMI when ambient temperatures are high. In such cases, increasing the nutrient density in conjunction with changing nutrient requirements may be helpful (Robinson**,** 2009; West, 2003). However, nutrient excesses such as crude protein should be avoided because they can contribute to

reduced efficiency of energy utilization andtherefore, adding to stress levels (West, 1999; Robinson, 2009). This means that the rations should, therefore, be reformulated to account for the decreased dry matter intake. Gaughan *et al*. (2002) reported that the dry matter intake of cattle decreases when fed diets containing ahigh energy density. However, Robinson (2009) indicated that heat production from the fermentation of individual feedstuffs is dependent on the total fibre content of the diet. The fibre in diets is associated with the most active rumen fermentation and the most heat of fermentation. Lower heat increments were reported in beef heifers fed pelleted diets containing high concentrates with low fibre (Reynolds *et al*., 1991). Therefore, low fibre rations are fed during hot weather, and also more concentrates are fed at the expense of fibrous ingredients (West, 1999). According to Rhoads *et al*. (2009) heat stress results in a negative energy balance since feed intake does not meet energy requirements.
Reduced feed intake is mainly in animals fed roughage-based diets than animals fed concentrate-based diets (West, 1999). This is because concentrates are more digestible than roughages, and the digestibility of the feed has an impact on feed intake and nutrient intake. Concentrates and roughages are two classes of feed ingredients, classified depending on their nutrient composition (NRC, 2000). Concentrates are feeds containing high density of nutrients, usually with low crude fibre content and high in total digestible nutrients; whereas roughages are feeds with low density of nutrients and high crude fibre content (Wright & Lackey, 2008).

Although heat stress causes a decline in DMI, the cattle's energy and protein requirements in high ambient temperature must be met (NRC, 2000).Energy use by cattle is affected by the degree of heat stress through panting to reduce heat gained and, therefore, energy requirement for maintenance increases (NRC, 1996). Slightly increased respiration due to heat stress can also increase the maintenance energy cost by 11 to 25 % (Mader *et al*., 1999). Both carbohydrates and fats are in the energy groups. Energy is required for grazing, producing milk, maintaining temperature, growing, reproducing and digesting feed. It is, however, associated with metabolic processes that create a large amount of heat (West, 1999; McDonald *et al*., 2011). Bahga (2009) also reported that heat stress reduces growth rate in growing calves which may be as a result of low energy generation and impaired metabolism. Dietary energy level reduction will reduce fermentation and the associated heat production (Dewell, 2010). However, Dewell (2010) reported that slight increases in dietary fat (without exceeding 5 % rumen available fat and 7 % total fat in the ration) are helpful. Heat production favours feed ingredients with a lower heat increment, such as concentrates and fats, whereas fibrous ingredients have a higher heat increment (West, 1999).

Reduction in feed intake may result in decreased essential nutrients and metabolisable energy consumed (Beede & Collier, 1986), whereas heat-stressed cattle cannot oxidize body reserves for energy (Baumgard & Rhoads, 2007). Feeding dietary fat probably remains an effective strategy of providing extra energy during heat stress (Baumgard & Rhoads, 2007). Fats as compared to starch, carbohydrates and fibre, have a much lower heat increment in the rumen (Huber *et al*., 1994; Van Soest, 1982). Baumgard & Rhoads (2007) concluded that a reduction in energy intake during heat stress results in the majority of cattle experiencing negative energy balance and this affects the productivity of the animal. Therefore, there is a need to expend energy to maintain homoeothermic balance that is useful for production under heat stress (NRC, 2001). Rhoads *et al*. 2009) heat stress can be defined as a state of negative energy balance since feed intake is not meeting energetic demands of maintenance and production. However Mader & Davis (2004) stated that limiting energy intake can effectively decrease basal metabolic heat production and, therefore, decrease total metabolic heat load of animals subjected to high environmental temperatures.

Arias *et al*. (2011) also indicated that altering ME intake by dilutinga high-concentrate diet with fibre can keep the cattle on feed and could also alter total heat production. However, in most diverse strategies to overcome severity of environmental heat stress fibre has been the nutrient that has been confirmed to have a high heat increment. This is because fibre in diets is associated with the most active rumen fermentation and the most heat of fermentation. Lower heat increments were reported in beef heifers fed pelleted diets containing high concentrates with low fibre (Reynolds *et al*., 1991). Therefore, low fibre rations are fed during hot weather, and also more concentrates are fed at the expense of fibrous ingredients (West, 1999). This has metabolic risks like bloat and acidosis, especially under intensive feeding systems.

Reduction in rate of passage of forage diets during thermal heat stress increases gut fill and, therefore, depresses appetite (Beede & Collier, 1986). However, as mentioned by West (1999), slower passage rate can improve digestibility of nutrients because of the high residence time in the gut.

2.5.2. Impact of energy balance and metabolism

Energy is defined as the ability to do work, which include the animal's daily performance and biochemical processes including walking, chewing, digestion, absorption, maintenance of the body temperature and protein synthesis (McDonald, *et al*.,2011).However, the maintenance of energy is affected by many factors including environmental conditions, breed and body conditions (NRC, 2000). Metabolizable energy (ME) is the energy available to maintain the body functions of the animal (Figure 2.1). Maintenance energy is the amount of feed energy intake that result in no loss or gain of energy from the tissue of an animal's body (NRC, 2000). Maintenance energy depends on metabolizable energy whereas ME depends on intake level, rate of digestion and passage and on the composition of the diet (NRC, 2001).Under high ambient temperature there is an increase in requirement of maintenance energy (Bajagai, 2011). A decrease in feed intake will result in negative energy balances (Brosh *et al*., 1998) because the use of energy varies widely with feed intake (Freetly *et al*., 2006). Energy imbalance is responsible for an increase in heat stress (Brosh *et al*., 1998; Bajagai, 2011).

Decrease in dry matter intake under high ambient temperature is due to the amount of metabolic heat generated from feeds. Different feed ingredients produce different amounts of body heat. Some studies indicate that dry matter intake under high ambient temperature will usually decrease with an increase in energy content of the diet (Young, 1975; Brosh *et al*.,1994), which also contributes to an increase in metabolic heat load. However, according to Blackshaw & Blackshaw (1994) heat in cattle is highly dependent on the balanced nutrients.

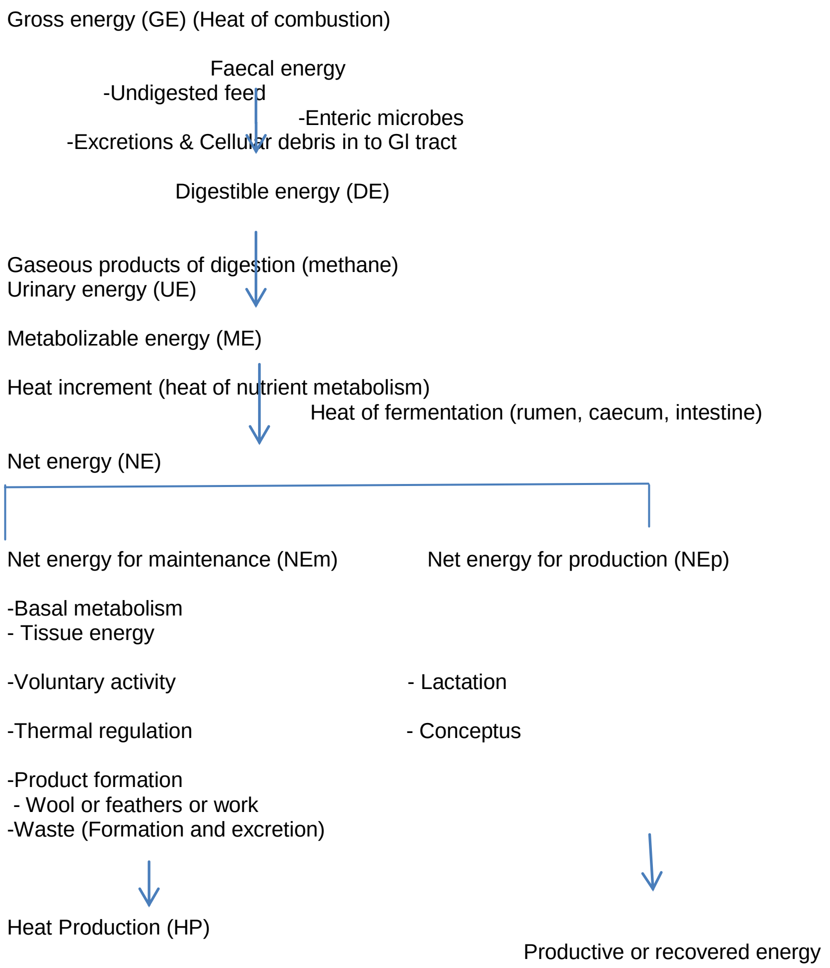

Figure 2.1 Energy utilization by animals (adapted from McDonald *et al*., 2011)

High ambient temperature results in an increase in internal body temperature of cattle and thus reduces the feed intake of the cattle (De Dios & Hahn 1993).This suggests that feeding *ad libitum* maybe useful because cattle consume the highest energy components of their diets during late evening to cope with heat load and utilize metabolizable energy more efficiently and, therefore, this may be useful because there is an increase in energy requirement under high ambient temperatures (Gaughan *et al*., 1996).

Energy metabolism decreases while water and electrolyte metabolism increase during high ambient temperatures (Farooq *et al*., 2010); therefore water and minerals are important nutrients in an animal's diet under high ambient temperatures. This is because under high ambient temperature cattle reduce the bicarbonate concentration in their saliva, thereby reducing the natural buffering activity in the rumen, so the risk of a fall in rumen pH and ruminal acidosis problems are increased (Farooq *et al*., 2010; Beede, 1986).

2.6 Conclusion

The environmental conditions affecting level of voluntary feed intake and the need of balancing dietary energy level have been outlined. Similarly, breed differences have been outlined. However, literature on the effects of dietary energy level on productivity of growing cattle under heat stress is not conclusive. Therefore, further investigations are necessary to determine dietary energy levels for optimal growth performance of growing Nguni, Bonsmara and Brahman cattle during the summer months when ambient temperature are high.

CHAPTER 3

MATERIALS AND METHODS

3.1 Study site

The study was conducted at the Animal Production Institute of the Agricultural Research Council (ARC) at Irene in Pretoria. The site is in the highveld area of South Africa (longitude of 28˚13S, latitude of 25˚55E and altitude of 1524 metres above sea level). Mean summer temperatures ranged between 16 °C at night and 35 °C during the day. Winters are mild and dry with temperatures ranging from a minimum of 5 °C to a maximum of 20 °C (Webb *et al*., 2004).

3.2 Experimental design, treatments and procedures

The study determined the effect of dietary energy level on feed intake, growth, feed conversion ratio (FCR) and physiological responses (body temperature and cortisol levels) of Nguni, Brahman and Bonsmara cattle during summer months. This study was done during summer months of December, 2013 to March, 2014, with daily temperatures ranging from 22 ± 1 to 29 ± 7 ^{o}C. These are considered high ambient temperatures (Hahn, 1997; West, 1999; Gaughan, 2000). Forty five male yearling cattle (18 Nguni, 9 Brahman and 18 Bonsmara male cattle) were used in this study.The initial live weights of the cattle were as follows: Nguni = 141 ± 6 kg, Bonsmara = 220 ± 9 kg and Brahman = 198 ± 6 kg. For each breed, the cattle were randomly allocated to three fattening dietary treatments formulated to have energy levels of 10, 12 and 13 MJ ME/kg DM feed as presented in Table 3.1. Each treatment had three replicates. Each replicate had two animals for Bonsmara and Nguni cattle, while for Brahman it was one animal per replicate. A completely randomized design was used. The diets were based on molasses, cotton seedoilcake meal, wheat bran, hominy chop, lucerne meal, sunflower oil, feed lime, salt, urea and *Eragrotis curvula* hay (Table 3.2). Feed and water were provided *ad libitum* throughout the experimental period. A two-week period for acclimatization was allowed for the cattle to get used to being handled and adapt to the diets and the new environment. The experiment ran for 108 days, from December, 2013 to March, 2014.

Table 3.1 Dietary treatments for the experiment*

Diet code	Diet description
NE_{10}	Growing male Nguni cattle fed a diet containing 10 MJ of ME/kg DM and 12% crude protein
NE_{12}	Growing male Nguni cattle fed a diet containing 12 MJ of ME/kg DM and 12% crude protein
NE_{13}	Growing male Nguni cattle fed a diet containing 13 MJ of ME/kg DM and 12% crude protein
BoE_{10}	Growing male Bonsmara cattle fed a diet containing 10 MJ of ME/kg DM and 12%crude protein
BoE_{12}	Growing male Bonsmara cattle fed a diet containing 12 MJ of ME/kg DM and 12 % crude protein
BoE_{13}	Growing male Bonsmara cattle fed a diet containing 13 MJ of ME/kg DM and 12 % crude protein
BrE_{10}	Growing male Brahman cattle fed a diet containing 10 MJ of ME/kg DM and 12 % crude protein
BrE_{12}	Growing male Brahman cattle fed a diet containing 12 MJ of ME/kg DM and 12 % crude protein
BrE_{13}	Growing male Brahman cattle fed a diet containing 13 MJ of ME/kg DM and 12 % crude protein

* : Laboratory determined ME (NIRA)

3.3 Data collection

The initial live weights of the cattle were taken at the commencement of the experiment. Thereafter, average live weights of the animals were measured at weekly intervals until the termination of the experiment. An electronic weighing scale was used. These live weights were used to calculate growth rates of the cattle. Weekly mean feed intakes were determined until termination of the experiment. Feed intake was determined by calculating the difference in amount of feed offered to animals and the remaining amount or refusals. Daily mean live weights and feed intakes were calculated from the weekly measurements (McDonald *et al*., 2011).

The ambient temperature was recorded three times a day (in the morning, afternoon and evening) throughout the experimental period. Body temperature of each experimental animal was measured using a rectal thermometer (Chung *et al*., 2010). Blood samples were collected to measure the cortisol level. Both body temperature and blood samples were collected fortnightly throughout the experimental period. Blood was collected from the tail of the cattle (Hernández *et al*., 2002). Each animal was sampled in less than 1 min to minimize handling stress. Five millilitres of blood was collected into a vacutainer tube containing coagulant (silicon dioxide). The blood was allowed to clot at room temperature (25°C) for 30 min after withdrawal and thereafter centrifuged at 1000 × g for 15 minutes. Separated serum was stored at –20°C for subsequent analysis (Liu *et al.*, 2006).

Diet digestibility was determined during the last week of the experiment (McDonald *et al*., 2011). It was conducted in specially designed feedlot pens, equipped with separate feed and water troughs. One animal was randomly selected from each replication and transferred to the pen; hence each treatment had three replicates for the measurement of digestibility. The *In vivo* digestibility method was used in this experiment (McDonald *et al*., 2011). A seven-day period for acclimatization was allowed before a three-day collection period. Faeces voided by each of the cattle were collected daily at 09.00 hours and weighed. Both dietary and faecal samples were analysed for dry matter, crude protein, energy, acid detergent fibre and neutral detergent fibre contents.

3.4 Chemical analysis

Dry matter of the feed and feed refusal samples was determined by drying the samples in the oven for 24 hours at a temperature of 105°C. Neutral and acid detergent fibre contents of feeds, feed refusals and faeces were determined according to Van Soest *et al*. (1991). Nitrogen contents of feeds, refusals and faeces were analysed using the Semi-micro Kjeldahl method (AOAC, 2000). Gross energy values for feed and faeces were measured in a bomb calorimeter (AOAC, 2000). Apparent digestible energy content of the diets was calculated by subtracting energy excreted in the faeces from energy in the feed consumed (AOAC, 2000).

The blood cortisol level was determined using an ELISA kit. The procedures followed were outlined by CUSABIO BIOTECH at ARC-OVI residual laboratory (Shutt& Fell, 1985).

Table 3.2Percentage ingredient composition of the diets used in this study.

	Diet code		
	ME_{10}	ME_{12}	ME_{13}
E.curvula hay	21	15	6
Cotton oil cake meal	5	8	4
Hominy chop	10	35	55
Wheat bran	23	18	18
Molasses	10	10	10
Lucerne hay	30	10	5
Urea	0.2	0.2	0.2
Salt	0.4	0.3	0.3
Feedlime	0.15	0.25	0.25
Sunflower Oil	-	3	1
Pre-mix	0.25	0.25	0.25
Total	100	100	100

3.5 Data analysis

Data on feed intake, digestibility, growth rate, feed conversion ratio, live weight, body temperature and cortisol level of yearling male Bonsmara, Nguni and Brahman cattle were analysed using the general linear model (GLM) procedure of the Statistical Analysis System (SAS, 2008). Where there were significant differences (P<0.05) between treatment means, protected Fisher's least significant difference test was applied for mean separation.

CHAPTER 4

RESULTS

Results of the nutrient composition of the diets used in this study are presented in Table 4.1. The diets were isonitrogenous but with different levels of metabolisable energy (ME). The ME levels were 10, 12 and 13 MJ per kg DM for Diets ME_{10}, ME_{12} and ME_{13}, respectively.

Table 4.1 Nutrient composition of the diets used in the study

Nutrient	Treatment		
	ME_{10}	ME_{12}	ME_{13}
Dry matter (%)	90	90	89
ME (MJ/kg DM)	10	12	13
CP (%)	12	12	12
CF (%)	17	16	16
ADF (%)	24	23	23
NDF (%)	44	41	42
Ca (%)	0.45	0.45	0.55
P (%)	0.61	0.66	0.67

* : Laboratory determined ME (NIRA)

The results of the effect of dietary energy level on DM intake, DM intake per metabolic weight (kg/W $^{0.75}$), growth rate, feed conversion ratio (FCR) and live weight of yearling male Bonsmara, Nguni and Brahman cattle are presented in Table 4.2. Dry matter intake per metabolic weight were similar ($P>0.05$) across dietary treatments for all cattle breeds used in this study. Dietary energy level had no effect ($P>0.05$) on growth rate of Bonsmara cattle. However, Bonsmara cattle on Diets ME_{12} and ME_{13} had better ($P<0.05$) FCR values than those on Diet ME_{10}. Bonsmara cattle on Diets ME_{12} and ME_{13} had similar ($P>0.05$) FCR values. There were no differences ($P>0.05$) between treatments in growth rates of Nguni cattle. However, Nguni cattle on Diet ME_{13} had better ($P<0.05$) FCR values than those on Diets ME_{10} and $ME_{12.}$ Nguni cattle on Diets ME_{10} and ME_{12} had similar ($P>0.05$) FCR values. Brahman cattle on Diet ME_{13} had higher ($P<0.05$) growth rates than those on ME_{12} and ME_{10} diets. Similarly, Brahman cattle on Diet ME_{12} had better ($P<0.05$) growth rates than those on Diet ME_{10}. Brahman cattle on Diet ME_{13} had better ($P<0.05$) FCR values than those on Diets ME_{10} and ME_{12}. However, Brahman cattle on Diets

ME_{10} and ME_{12} had similar (P>0.05) FCR values. Initial live weights for Bonsmara, Nguni and Brahman cattle were similar (P>0.05) among all the dietary energy levels. Similarly, there were no differences (P>0.05) in final weight of cattle in all the treatments for Bonsmara, Nguni and Brahman cattle

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The results of the effect of breed on DM intake, growth rate, FCR and live weight of Bonsmara, Nguni and Brahman cattle for Diets ME_{10}, ME_{12} and ME_{13} are presented in Table 4.3. Bonsmara cattle had higher (P<0.05) DM intake per metabolic weight and growth rates than Nguni and Brahman cattle on Diet ME_{10}. However, Nguni and Brahman cattle on Diet ME_{10} had similar (P>0.05) feed intakes per metabolic weight and growth rates. Bonsmara cattle on Diet ME_{10} had better (P<0.05) FCR values than Brahman cattle on the same diet. However, Bonsmara and Nguni cattle had similar (P>0.05) FCR values when fed on Diet ME_{10}. Similarly, Nguni and Brahman cattle on Diet ME_{10} had similar (P>0.05) FCR values.

Bonsmara and Nguni cattle had higher (P<0.05) DM feed intake per metabolic weight than Brahman cattle when fed Diet ME_{12}. However, Brahman and Nguni cattle had similar intake per metabolic weight when fed Diet ME_{12}. Feed conversion ratio values were similar (P>0.05) among the cattle breeds on Diet ME_{12}. Brahman cattle had higher DM feed intake per animal than Nguni and Bonsmara cattle fed Diet ME_{13}. Nguni and Bonsmara cattle had a similar (P>0.05) DM feed intake per animal when fed Diet ME_{13}. There were significant differences in growth rates among the cattle breeds. Nguni cattle had better (P<0.05) growth rates than Bonsmara and Brahman cattle when on Diet ME_{13}.There were no differences (P>0.05) in growth rates between Bonsmara and Brahman cattle on Diet ME_{13}. There were similar (P>0.05) FCR values for Bonsmara, Nguni and Brahman cattle offered Diet ME_{13}. Bonsmara cattle had higher (P<0.05) initial and final live weights than Nguni and Brahman cattle offered Diet ME_{10}. Similarly, Brahman cattle had higher (P<0.05) initial and final live weights than Nguni cattle when offered Diet ME_{10}. Initial live weights were higher (P<0.05) for Bonsmara and Brahman cattle than Nguni cattle on Diets ME_{12} and ME_{13}. However, initial live weights were similar (P>0.05) for Bonsmara and Brahman cattle offered Diets ME_{12} and ME_{13}.

Table4.2 Effect of energy level on diet DM intake (kg/animal/day), DM intake per metabolic weight ($kg/W^{0.75}$), growth rate (kg/animal/day) and feed conversion ratio (FCR) (kg feed/kg live weight gain) of yearling male Bonsmara, Nguni and Brahman cattle

Breed	Variable	Treatment			SEM
		ME_{10}	ME_{12}	ME_{13}	
Bonsmara	DM Intake	9.18^a	8.78^a	8.65^a	0.608
	Intake ($kg/W^{0.75}$)	0.13^a	0.13^a	0.13^a	0.003
	Growth	1.81^a	1.77^a	1.94^a	0.170
	FCR	5.08^a	4.99^b	4.51^b	0.478
	Initial Lwt (kg)	226^a	223^a	211^a	18.278
	Final Lwt (kg)	338^a	334^a	333^a	20.021
Nguni	DM Intake	7.20^a	5.93^a	6.27^a	1.341
	Intake ($kg/W^{0.75}$)	0.13^a	0.12^a	0.12^a	0.007
	Growth	1.39^a	1.14^a	1.48^a	0.292
	FCR	5.28^a	5.24^a	4.25^b	0.450
	Initial Lwt (kg)	137^a	139^a	146^a	26.322
	Final Lwt (kg)	224^a	211^a	239^a	26.321
Brahman	DM intake	6.66^b	7.42^a	7.06^a	1.079
	Intake ($kg/W^{0.75}$)	0.11^a	0.12^a	0.11^a	0.014
	Growth	1.14^c	1.39^b	1.61^a	0.181
	FCR	5.78^a	5.39^a	4.38^b	0.502
	Initial Lwt (kg)	193^a	202^a	198^a	31.303
	Final Lwt (kg)	265^a	298^a	294^a	35.225

^{a,b,c}: Means in the same row not sharing a common superscript are significantly different ($P < 0.05$)

SEM: Standard error of the means

Lwt: Live weight

Table 4.3 Effect of cattle breed on diet DM intake (kg/animal/day), DM intake per metabolic weight (kg/$W^{0.75}$), growth rate (kg/animal/day) and feed conversion ratio (FCR) (kg feed/kg live weight gain) of Nguni, Brahman and Bonsmara cattle for the three diets differing in energy levels

Treatment	Variable	Cattle breed			SEM
		Bonsmara	Nguni	Brahman	
ME_{10}	DM Intake	9.18^{a}	7.20^{b}	6.66^{b}	1.507
	Intake (kg/$W^{0.75}$)	0.13^{a}	0.12^{b}	0.11^{b}	0.007
	Growth	1.81^{a}	1.39^{b}	1.14^{b}	0.292
	FCR	5.08^{b}	5.28^{ab}	5.78^{a}	0.477
	Initial Lwt (kg)	226^{a}	137^{c}	193^{b}	21.333
	Final Lwt (kg)	338^{a}	224^{c}	265^{b}	30.208
ME_{12}	DM Intake	8.78^{a}	5.93^{c}	7.42^{b}	0.733
	Intake(kg/$W^{0.75}$)	0.13^{a}	0.13^{a}	0.11^{b}	0.004
	Growth	1.77^{a}	1.14^{c}	1.39^{b}	0.198
	FCR	4.99^{a}	5.24^{a}	5.39^{a}	0.471
	Initial Lwt (kg)	223^{a}	136^{b}	210^{a}	21.333
	Final Lwt (kg)	334^{a}	211^{c}	298^{b}	22.948
ME_{13}	DM Intake	6.27^{b}	7.40^{b}	7.06^{a}	0.697
	Intake(kg/$W^{0.75}$)	0.13^{a}	0.12^{b}	0.12^{b}	0.053
	Growth	1.94^{a}	1.48^{b}	1.61^{b}	0.185
	FCR	4.51^{a}	4.25^{a}	4.38^{a}	0.471
	Initial Lwt (kg)	211^{a}	146^{b}	198^{a}	22.129
	Final Lwt (kg)	333^{a}	239^{c}	294^{b}	23.422

[a,b,c]: Means in the same row not sharing a common superscript are significantly different ($P<0.05$)

SEM: Standard error of the means

Lwt: Live weight

Bonsmara and Brahman cattle had higher ($P<0.05$) final live weights than Nguni cattle fed ME_{12} diet. Final live weights were higher ($P<0.05$) for Bonsmara cattle than Brahman and Nguni cattle when fed Diet ME_{13}. Similarly, Brahman cattle had higher final live weights than Nguni cattle on Diet ME_{13}.

The results of the relationship between ambient temperature and feed intake, growth rate and FCR of yearling male Bonsmara cattle fed diets having different energy levels are presented in Figures 4.1, 4.2 and 4.3. Bonsmara cattle had similar ($P>0.05$, SEM = 0.364) dry matter intake for all the dietary energy levels with increase in ambient temperature. Similarly, weight gains of Bonsmara cattle fed on diets with different energy levels had similar trends as the ambient temperature increased. Feed conversion ratio trends were also similar for Bonsmara cattle fed on diets with different energy levels as the ambient temperature increased.

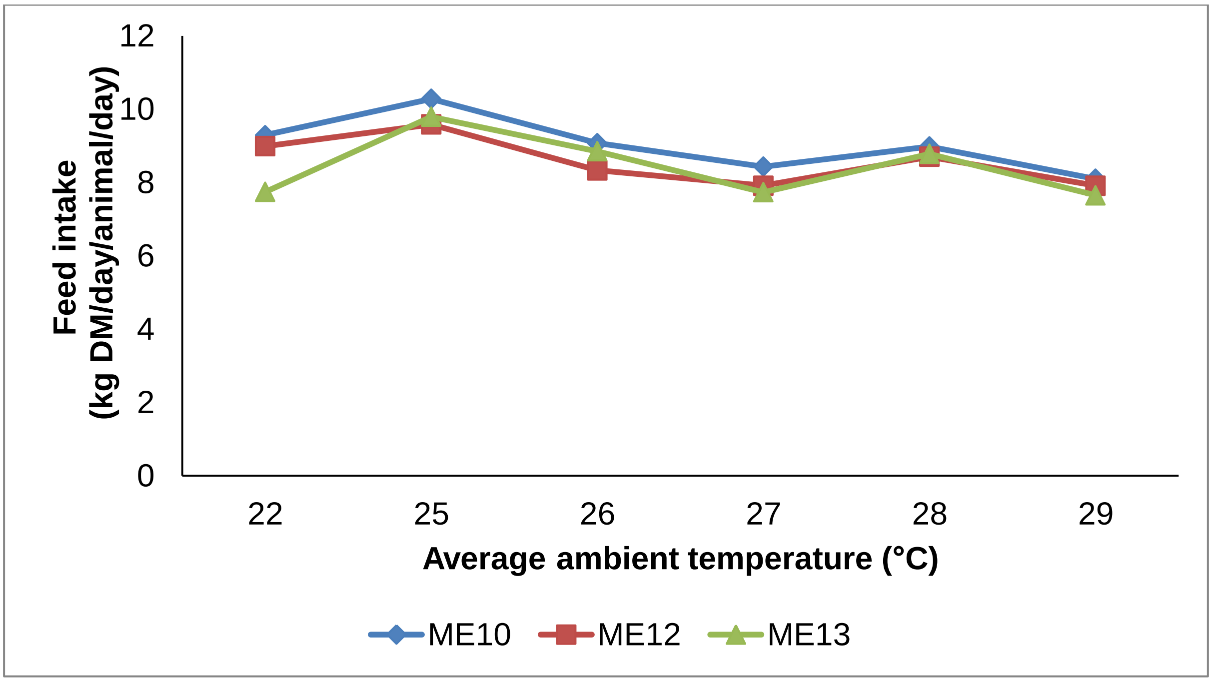

Figure 4.1 The relationship between ambient temperature and feed intake of yearling male Bonsmara cattle fed diets having different energy levels

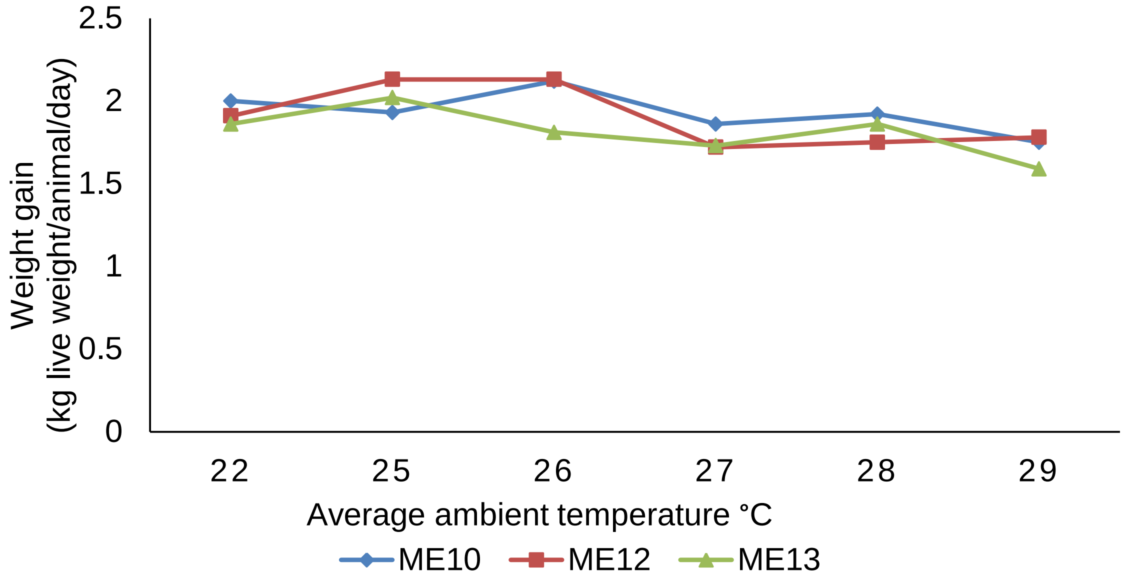

Figure 4.2 The relationship between ambient temperature and weight gain of yearling male Bonsmara cattle fed diets having different energy levels

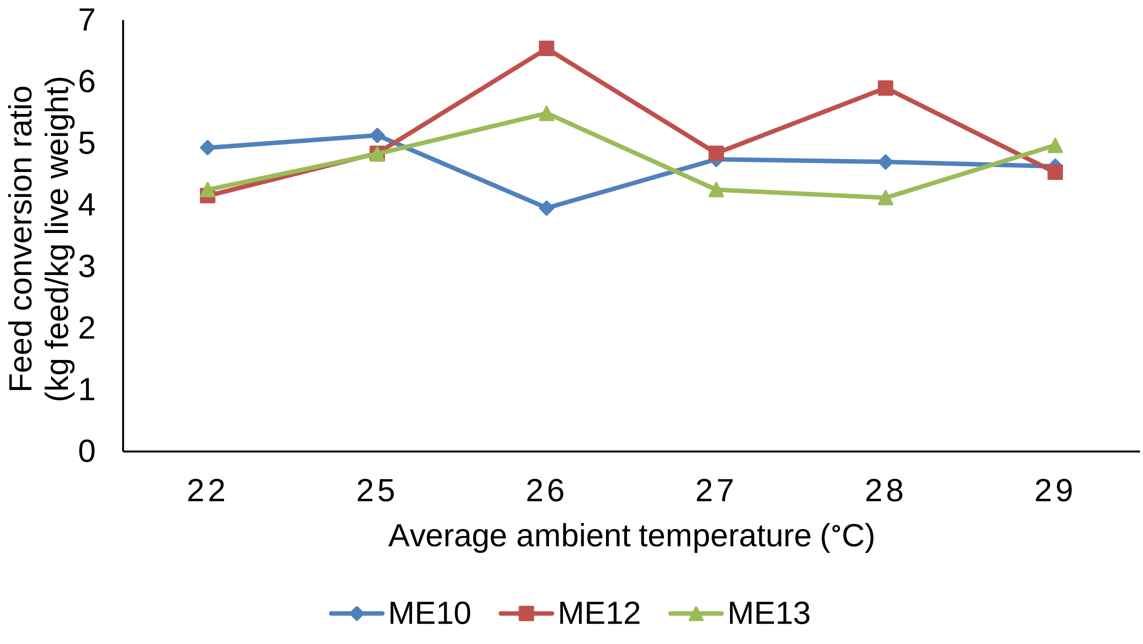

Figure 4.3 The relationship between ambient temperature and feed conversion ratio of yearling male Bonsmara cattle fed diets having different energy levels

The results of the relationship between ambient temperature and feed intake, growth rate and FCR of yearling male Brahman cattle fed diets having different energy levels are presented in Figures 4.4, 4.5 and 4.6. Dry matter intake of Brahman cattle fed diets having different energy levels followed similar trends as ambient temperature increased (Figure 4.4). At ambient temperatures of 27, 28 and 29 °C, weight gains of Brahman cattle on Diet ME_{13} were higher ($P<0.05$, SEM = 0.350) than those on Diets ME_{10} and ME_{12}(Figure 4.5).Similarly, at ambient temperatures of 27, 28 and 29 °CBrahman cattle on Diet ME_{12} had better ($P<0.05$, SEM = 0.350) weight gains than those on Diet ME_{10}(Figure 4.5).At ambient temperatures of 25, 27 and 29 °C, FCR was better ($P<0.05$, SEM = 1.286) for Brahman cattle on Diet ME_{13} than for those on Diets ME_{10} and ME_{12}(Figure 4.6). Similarly, at an ambient temperature of 28 °C Brahman cattle on Diet ME_{12} had better ($P<0.05$, SEM = 1.286) FCR values than those on Diet ME_{10}.

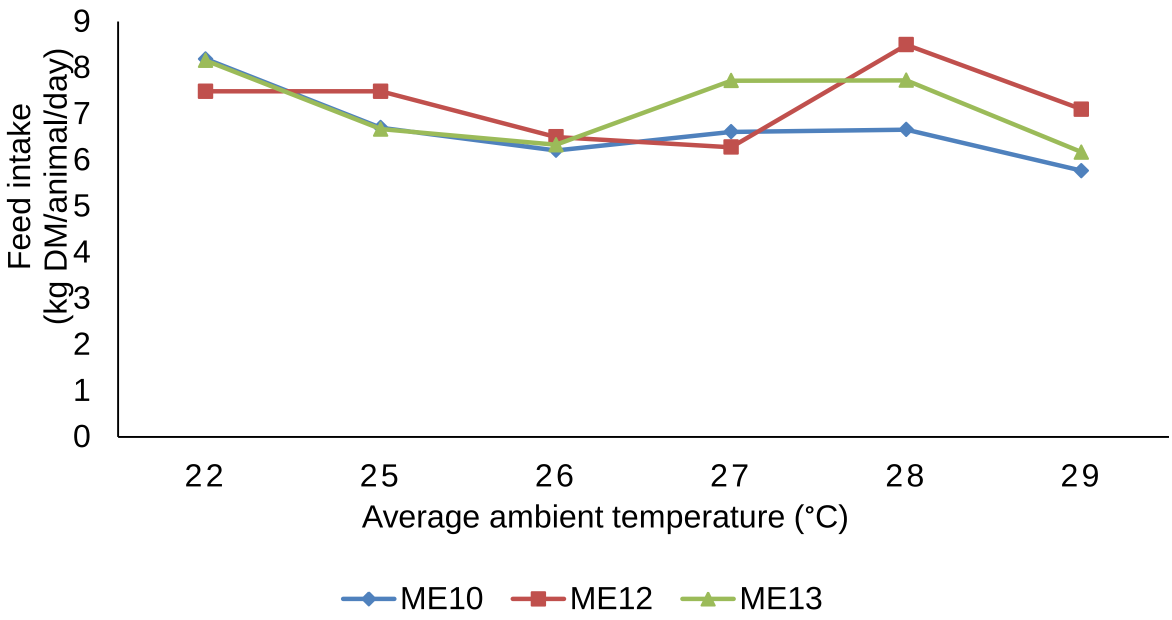

Figure 4.4 The relationship between ambient temperature and feed intake of yearling male Brahman cattle fed diets having different energy levels

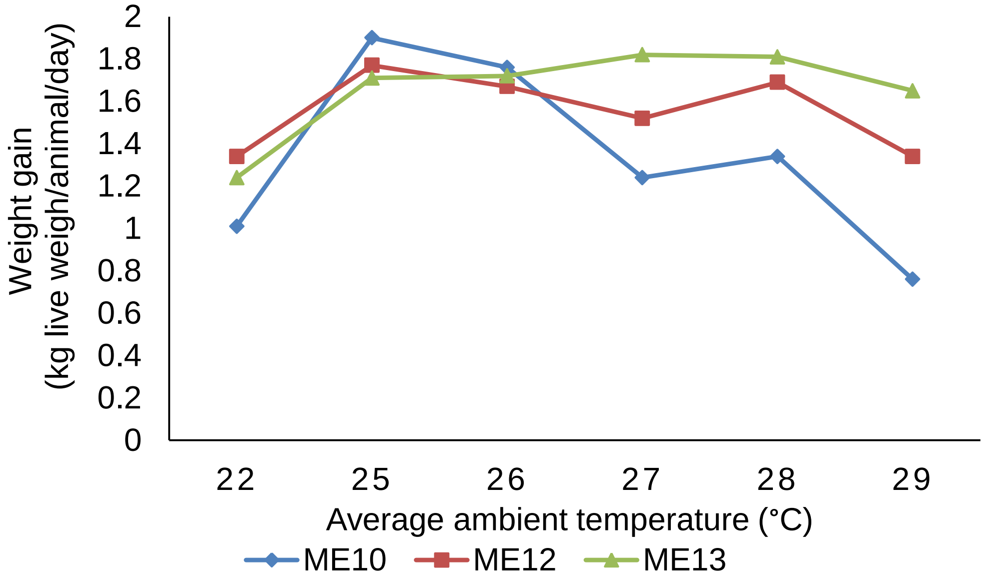

Figure 4.5 The relationship between ambient temperature and weight gain of yearling male Brahman cattle fed diets having different energy levels

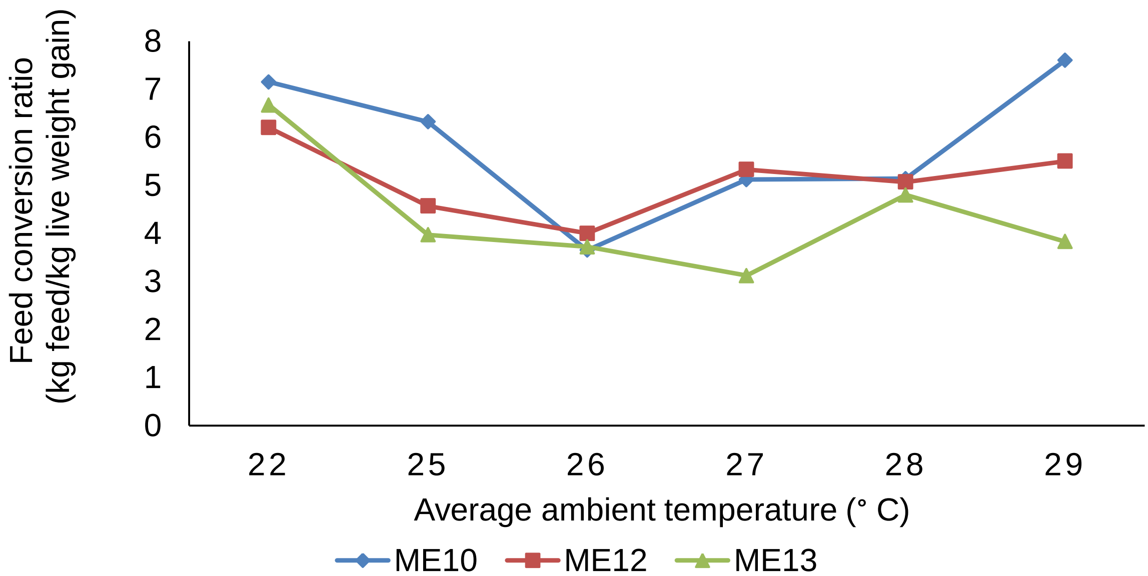

Figure 4.6 The relationship between ambient temperature and feed conversion ratio of yearling Brahman cattle fed diets having different energy levels

The results of relationship between ambient temperature and feed intake, growth rate and FCR of yearling male Nguni cattle fed diets with different energy levels are presented in Figures 4.7, 4.8 and 4.9. Nguni cattle had similar (P>0.05, SEM = 0.301) dry matter intakes (Figure 4.7). Nguni cattle fed on Diet ME_{13} had better weight gains than those fed on Diets ME_{10} and ME_{12} at all ambient temperature levels expect at 26 and 29 °C (Figure 4.8). Weight gains for all cattle were similar (P<0.05, SEM = 0.358) at an ambient temperature of 29 °C. Similarly FCR trends were observed in Nguni cattle fed on different dietary energy levels (Figure 4.9). However, Nguni cattle fed on Diet ME_{13} had better (P<0.05, SEM = 1.330) FCR at ambient temperatures of 22, 27 and 28 °C than those on ME_{10} and ME_{12}diets. Similarly, Nguni cattle fed on Diet ME_{12} had better (P<0.05) FCR values at ambient temperature of 22, 27 and 28 °C than those on Diet ME_{10}.

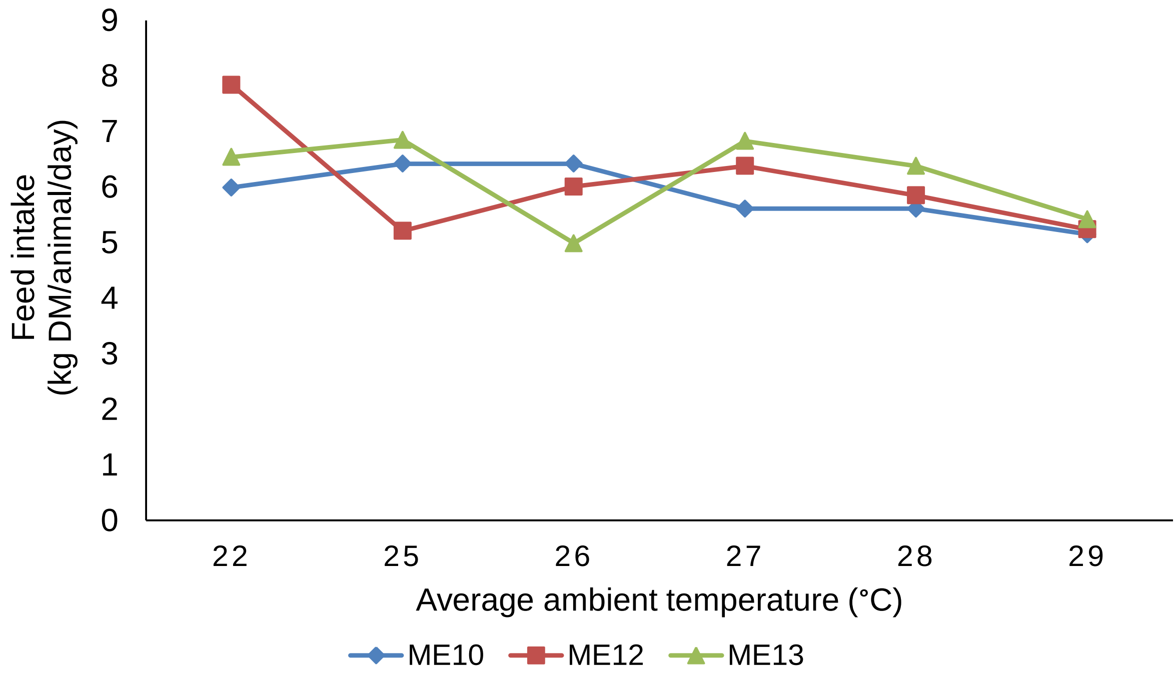

Figure 4.7 The relationship between ambient temperature and feed intake of yearling male Nguni cattle fed diets having different energy levels

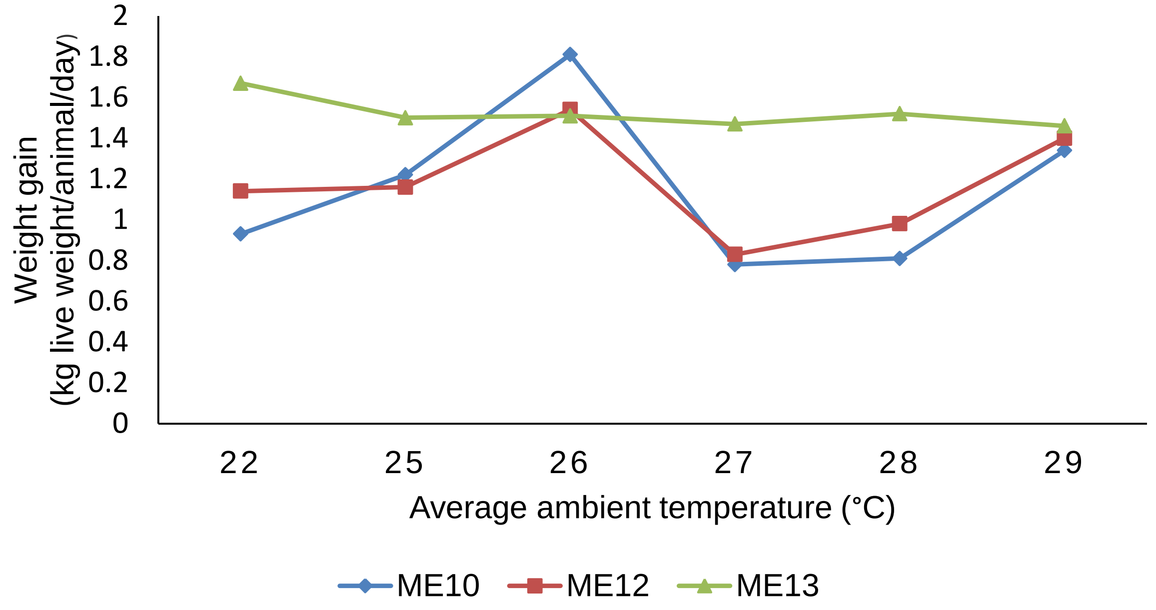

Figure 4.8 The relationship between ambient temperature and weight gain of yearling male Nguni cattle fed diets having different energy levels

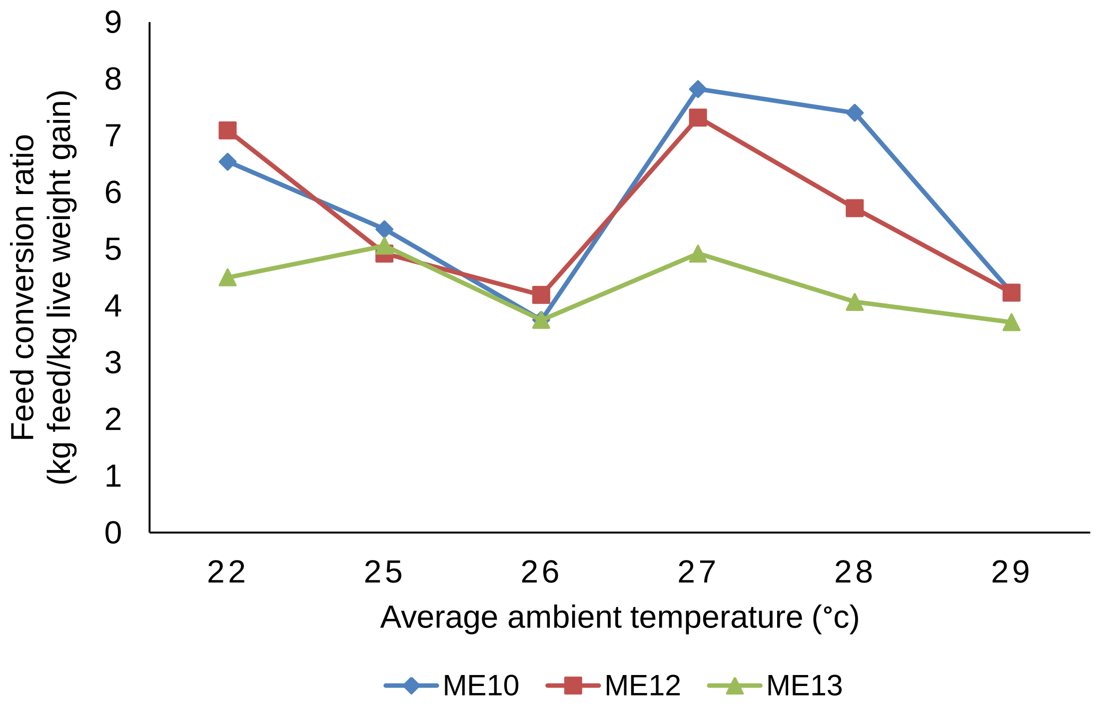

Figure 4.9 The relationship between ambient temperature and feed conversion ratio of yearling male Nguni cattle fed diets having different energy levels

The results of the effect of dietary energy level on nutrient digestibility of yearling male cattle are represented in Table 4.3. Dietary energy level had no effect (P>0.05) on nutrient digestibility in Bonsmara, Nguni and Brahman cattle.

Table 4.3 Effect of dietary energy level on nutrient digestibility in yearling male Bonsmara, Brahman and Nguni cattle

Breed	Variable	Treatment			SEM
		ME_{10}	ME_{12}	ME_{13}	
Bonsmara	DM (%)	69.59	72.87	77.87	7.027
	Protein (%)	75.91	75.56	76.13	5.833
	Energy (%)	76.54	91.62	94.31	38.124
	Ether extract (%)	93.47	90.44	87.58	3.453
	Calcium (%)	46.12	37.97	52.15	16.016
	Phosphorus (%)	54.82	66.54	56.21	12.110
Brahman	DM (%)	69.63	74.68	79.68	9.189
	Protein (%)	73.58	76.48	78.00	6.038
	Energy (%)	72.00	90.80	93.54	22.353
	Ether extract (%)	90.93	92.17	91.30	2.388
	Calcium (%)	49.47	40.64	57.53	18.055
	Phosphorus (%)	54.15	50.35	52.24	14.633
Nguni	DM (%)	67.78	63.06	72.73	5.924
	Protein (%)	71.06	74.91	75.82	11.874
	Energy (%)	54.37	61.41	77.35	24.795
	Ether extract (%)	91.96	93.7	89.81	1.134
	Calcium (%)	53.89	56.19	69.91	12.042
	Phosphorus (%)	56.87	55.21	54.07	8.889

SEM: standard error of the means

The results of the effect of dietary energy level on body temperature and cortisol level of yearling male Bonsmara, Brahman and Nguni cattle are presented in Table 4.4. Dietary energy level had no effect (P>0.05) on body temperature and cortisol level of Bonsmara and Nguni cattle. Similarly, dietary energy level did not affect (P>0.05) body temperature of Brahman cattle. However, dietary energy level had an effect (P<0.05) on the cortisol level of Brahman cattle. Brahman cattle on Diet ME_{13} had higher (P<0.05) cortisol levels than those on Diets ME_{10} and ME_{12}. Cattle on Diets ME_{10} and ME_{12} had similar (P>0.05) cortisol levels.

Table 4.4 Effect of dietary energy level on body temperature (°C) and cortisol level (ng/ml) of yearling male Bonsmara, Nguni and Brahman cattle during the summer months of December, 2013 to March, 2014

Breed	Variable	Treatment			SEM
		ME_{10}	ME_{12}	ME_{13}	
Bonsmara	Body Temperature	39.00^a	39.44^a	39.10^a	0.614
	Cortisol level	137.89^a	162.05^a	127.05^a	59.121
Nguni	Body Temperature	38.94^a	38.94^a	39.01^a	0.138
	Cortisol level	169.58^a	145.76^a	121.87^a	60.631
Brahman	Body Temperature	39.08^a	39.04^a	38.88^a	0.430
	Cortisol level	69.26^b	49.85^b	118.75^a	38.960

[a,b]: Means in the same row not sharing a common superscript are significantly different (P<0.05)

SEM: Standard error of the means

CHAPTER 5

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1 Discussion

The diets used in this study were formulated to be isonitrogenous with different energy levels. The ME levels of the diets ranged from 10 to 13 MJ of ME/kg DM. The diets were formulated to meet the nutrient requirements of growing beef cattle as recommended by NRC (1996).

This study was done during summer months when the ambient temperature was ranging from 22 ± 1 to 29 ± 7 ^{o}C.These are considered as high ambient temperatures for cattle (West, 1999; Gaughan, 2000). Dietary energy level had no effect on DM intake and growth of yearling male Bonsmara and Nguni cattle raised during the summer months of December, 2013 to March, 2014. However, an increase in dietary energy level improved FCR of male Bonsmara and Nguni cattle. Similarly, an increase in dietary energy level improved DM intake, growth rate and FCR of Brahman male cattle. Thus, the responses in DM intake, growth and FCR to dietary energy level were dependent on the breed of cattle. Jabbar*et al*. (2009), Fiaz *et al*. (2012) and Jabbar *et al*. (2013) also observed that dietary energy levelhad no influence on diet DM intake of Buffalo cattle. The present intakes are, also, in agreement with those reported by Aghaziarati *et al*. (2011) in Holstein cattle. However, this is contrary to the findings of Bethard *et al*. (1997) who found that DM intake was high in heifers receiving diets high in energy value. Similarly, Gaughan *et al*. (1996) found that an increase in dietary energy level improved DM intake of feedlot cattle. However, Berry *et al*. (2004) reported higher DM intakes in feedlot cattle fed low energy diets than those fed on high energy diets.

Dietary energy level did not have an influence on growth rate of Bonsmara and Nguni cattle. Lingyan *et al*. (2014), also, observed that dietary energy level had no effect on growth of Angus × Chinese Xiangxi yellow cattle. Growth rates in Brahman cattle increased with an increase in dietary ME level. Bahga *et al*. (2009) also found that a reduction in dietary energy level decreased growth rate of crossbred cattle under high ambient temperature. Coulter *et al*. (1997) reported an increase in weightgain of Angus, Simmental X Hereford, Simmental X Angus and Simmental X Angus gain in cattle with an increase in dietary energy level.The contradictions might possiblybe due to breed and species differences.

Feed conversion ratio was improved with an increase in dietary ME level for all the breeds. Similar results have been reported by the NRC (2001) who found that diets high in energy resulted in cattle having better FCR values. Similarly, Fiaz *et al. (*2012) and Jabbar *et al*. (2013) also observed better FCR values with an increase in dietary energy level. A number of authors (Bahga, 2009; Yasothai, 2014) suggested that diets high in energy supplied more energy and other nutrients and hence there was a reduction in DM intake and an improvement in growth of cattle. The improvement in efficiency with an increase in energy level might be due to availability of excess energy for growth of cattle. However, this is contrary to the findings of Hicks *et al*. (1990) and Mader *et al*. (2002) who observed that decreasing the ME content of a diet when the cattle were exposed to high ambient temperatures improved feed efficiency.

At each dietary energy level there were differences between cattle breeds in terms of DM intakes per metabolic weights and growth rates. Thus, breed had effect on DM intake. Bonsmara cattle tended to have better DM intakes per metabolic weight than Nguni and Brahman cattle at dietary energy levels of 10, 12 and 13 MJ of ME/kg DM. Frylinck *et al*. (2005), also, observed significant differences in feed intake between breeds, where Brahman cattle had the lowest feed intake per live weight unit compared to Bonsmara and Nguni cattle. Contrary to the findings of the current study Nkrumah *et al*. (2006) and Basarab *et al* (2003) observed no significant differences in feed intake between Angus, Hereford, Limousin, Gelbuvied and Charolais breeds of cattle.

Higher DM intakes per metabolic weight and growth rates resulted in Bonsmara cattle having higher final live weights than Nguni and Brahman cattle. These growth rate results are similar to the findings of Wheeler *et al*. (1996) and Block *et al*. (2001) who observed that large framed Bonsmara cattle had higher growth rates than small framed Nguni cattle. These authors attributed this to breed differences. However, Sprinkle *et al.* (1998), Short *et al*. (1999) and Laborde *et al*. (2001) observed no differences in growth rates between Simmental, Charolais, Longhorn and Angus breeds. Similarly, Muchenje *et al*. (2008) reported no differences in growth rate between Nguni, Bonsmara and Angus cattle. Du Plessis & Haffman (2004) reported similar growth rates between Nguni, Bonsmara, Afrikaner and Simmentalcross breeds. Du Plessis & Hoffman (2004) pointed out that similar growth rates between cattle breeds are only observed during the high growth rate phase. Muchenje *et al*. (2008) also observed significant differences in final live weights between cattle breeds. Similarly, Wheeler *et al*. (2004) reported significant differences in final live weights between Nguni, Angus and Bonsmara cattle, with Nguni cattle being the lightest.

Feed conversion ratios were different between cattle breeds when offered a diet having 10 MJ of ME per kg DM.However, Bonsmara, Brahman and Nguni cattle had similar FCR when fed diets containing 12 or 13 MJ of ME per kg DM. Frylinck *et al*. (2005) observed significant differences in FCR between Bonsmara crosses and Nguni cattle. They reported poorer FCR in Nguni cattle compared to Bonsmara cattle. However, Luseba (2013) observed similar FCR in weaned Bonsmara X Brahman X Nguni crosses. This was consistent with the results reported by Basarab *et al*. (2003) and Nkrumah *et al*. (2006).

Dietary energy level had no effect on nutrient digestibility. These results are similar to those of Fiaz *et al*. (2012) and Singh *et al*. (2009) who observed that dietary energy level had no effect on DM, CP, CF and EE digestibility in Sahiwal and Bhadawari cattle, respectively. Mahgoub & Lu (2000) and Singh *et al*. (2013) also reported an increase in DM and CP digestibility by Omani growing and Muzzafarnagari lambs, respectively, with increase in dietary energy level.

Dietary energy level had no influence on body temperature of Bonsmara, Nguni and Brahman cattle. Reuter *et al*. (2008), also, found that dietary energy level did not affect rectal temperature in feedlot steers. However, Mader (2003) and Arias *et al*. (2011) observed that increases in dietary energy level increased body temperature of Angus and Angus cross cattle. Brosh *et al*. (1998) and Arias *et al*. (2011) concluded that an increase in energy intake above that required for high production is the main cause of increase in heat load in growing cattle than the ambient temperature.

Cortisol levels were similar for both Bonsmara and Nguni cattle fed on different dietary energy levels. However, cortisol level was better (less stressed) in Brahman cattle fed on low dietary energy levels (ME_{10} and ME_{12}) than those fed on high energy level (ME_{13}). No literature was found on the effect of energy level on cortisol response in cattle. Reuter *et al*. (2008), also, did not find any literature on the subject. However, Kiyma *et al*. (2004) and Singh *et al*. (2013) observed variations in cortisol level of lambs fed diets differing in dietary energy levels; where higher cortisol levels were observed with increase in dietary energy levels. This was similar to the finding of the present study for Brahman cattle, where cortisol level increased with an increase in dietary energy level. The differences in cortisol level in Brahman cattle may be due to differences in stress response, possibly related to different dietary energy utilization by Brahman cattle. Brahman cattle are known to become stimulated more quickly. Previous studies indicate that Brahman steers have high cortisol level than Angus and Angus X Hereford steers (Hammond & Olson, 1994; Hammond *et al*., 1996)

5.2 CONCLUSIONS

Dietary energy level had no effect on feed intake, digestibility and live weight of male yearling Bonsmara, Nguni and Brahman during summer months. However, increase in dietary energy level improved the growth rates and feed conversion ratios (FCR)of the cattle. Dietary energy level had no effect on body temperature of the cattle. Cortisol level of Bonsmara and Nguni cattle was, also, not affected by dietary energy level; however, cortisol level in Brahman cattle was increased with an increase in dietary energy level. This may, possibly be due to breed differences in coping with summer temperatures and increased metabolic rate with an increase in dietary energy level.

Generally Bonsmara cattle had a better DM intake per metabolic weight, growth rate and final live weight when offered low (ME_{10}), medium (ME_{12}) and high (ME_{13}) energy diets than Nguni and Brahman cattle. When offered low and high energy diets Nguni and Brahman cattle had similar DM intakesper metabolic weight, FCR and growth rate. However, when offered a medium energy diet Brahman cattle had better growth rates and final live weights than Nguni cattle. Nguni cattle had better DM intake per metabolic live weight than Brahman cattle.

5.3 RECOMMENDITIONS

Dietary energy level has an impact on productivity of feedlot cattle during summer months. However, cattle breeds differ in their ability to cope with summer temperatures and dietary utilization. It is, than, recommended that when formulating cattle diets for summer months, dietary energy level should be considered depending on the breed.

The results are indicating no differences in most of the parameters tested. This might be due to the breeds used in this study. They are all adapted to the environment in South Africa. Thus, they have less indented stress differences. Another study with exotic breeds like Hereford and Simmental might yield different results under the same conditions.

CHAPTER 6

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