Effects of Acacia karroo supplementation on the quality of meat from Xhosa lop-eared goats

By

Simthembile NGAMBU

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Faculty of Science and Agriculture
Department of Livestock and Pasture Science
University of Fort Hare
P/Bag X1314
Alice
South Africa
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Alice, South Africa

Supervisors: Professor V. Muchenje
Dr U. Marume
Declaration

I, Simthembile Ngambu, declare that this dissertation has not been submitted to any University and that is my original work conducted under supervision of Prof. V. Muchenje and co-supervisor Dr. U. Marume. All assistance towards the production of this work and all the references contained herein have been duly accredited.

__________________________                                                      _____________________
Simthembile Ngambu                                      Date

Approved as style and content by:

__________________________                                                      _____________________
Prof. V. Muchenje                                      Dr. U. Marume

September 2011
Abstract

Effects of *Acacia karroo* supplementation on meat quality of Xhosa Lop-Eared goats

The objective of the study was to determine the effects of *A. karroo* supplementation on the quality of meat from Xhosa lop-eared goats. Eighteen castrated 4-month-old Xhosa lop-eared male kids were kept at the University of Fort Hare Farm until slaughter. At the beginning of the experiment the goats had a mean body weight of $13.5 \pm 0.31$ kg (mean ± S.E.) and a mean body condition score (BCS) of $3.3 \pm 0.16$ (mean ± S.E.). From birth until weaning the kids were kept on natural pastures with their mothers. After weaning the goats were housed in an open sided barn for a period of 60 days, and were fed 500 g/head/day of *Medicago sativa* hay covering their maintenance and growth needs. For the purpose of the experiment, the goats were randomly divided into two balanced treatment groups of nine goats each, supplemented group (AK) and non-supplemented group (NS). The supplemented group received an additional 200g per head per day of fresh *A. karroo* leaves collected each day for two months. Supplementary feed was given to the goats individually in feeding troughs. The kids were slaughtered at 60 days old and samples for meat quality assessment were taken from the *Longistimus dorsi* muscle. The effect of *A. karroo* supplementation on meat quality measurements such as ultimate pH, colour and cooking losses of meat from indigenous Xhosa lop-eared goats were determined. The effect of *A. karroo* supplementation on the consumer sensory characteristic scores of the meat from the indigenous Xhosa lop-eared breed was also determined. There was a significant effect of the *A. karroo* supplementation on the meat quality measurements except for *L* and *a* colour coordinates. Meat from the *A. karroo* supplemented goats had lower pH and cooking loss scores than that of the non-supplemented goats. *Acacia karroo* supplementation improves meat tenderness and juiciness. There were no significant effects of *A. karroo* supplementation on the flavour and off-
flavours of the meat from the supplemented goats. However, thermal preparation and consumer background had a significant effect on the meat sensory characteristics. The cooked meat had significantly higher sensory scores than the roasted meat. Female consumers reported higher sensory scores than male consumers. Consumers of different tribes and ages also reported significantly different sensory scores of meat from indigenous Xhosa lop-eared goats. Therefore, this study indicated that A. karroo supplementation can be fed to the Xhosa lop-eared goats to improve their meat quality.

**Keywords:** meat quality, thermal preparation, meat sensory scores, *Longistimus dorsi*, chevon.
List of abbreviation

\( a^* \) = Redness

AK = *Acacia karroo*

ACT = Amount of connective tissue,

AI = aroma intensity;

ATF = Off-flavour score.

\( b^* \) = Yellowness

BCS = body condition score

C.M = Cooking method,

C=Cooked,

CL= Cooking losses

F= Female,

IJ = Initial juiciness;

NS= not supplemented,

\( L^* \) = lightness

M= Male,

MFT = Muscle fibre and overall tenderness,

NS= Not Significant

OF = Overall flavour score,

R= Roasted
SJ = sustained juiciness,
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CHAPTER 1: INTRODUCTION

1.1 Background

Of the 6 441 000 goats that are found in South Africa, about 3 million, dominated by indigenous genotypes, are found in rural areas of the Eastern Cape Province (Shabalala & Mosima, 2002). Goats play a major role in the provision of meat (Simela, 2005), manure, milk, mohair and cash from sales of goats and their by-products (Thornton et al., 2002; Rumosa-Gwaze, Chimonyo, & Dzama, 2009). They are also used in traditional ceremonies (Ayalew, Rischkowsky, King, & Bruns, 2003; Rumosa-Gwaze et al., 2009).

Communal goat production is among the activities used for quick and easy income for communal households. The advantage of goats in low income households is that they are both grazers and browsers and therefore, can effectively utilize a wide range of feed resources with minimal supplementation. There are a number of constraints facing smallholder goat production. Underfeeding has been said to be the major source of problems such as diseases, poor growth and reproduction. Browsable plants have been observed to be a good source of feed, particularly protein, for goats in resource poor areas. Besides being a source of protein, brown species such as *acacia* species contain some polyphenolic compounds with an acaricidal effect on disease causing pathogens in the gastrointestinal tract such as gastrointestinal parasites (Xhomfulana, Mapiye, Chimonyo, & Marufu, 2009). *Acacia karroo* is among plant species which is abundant in most communal rangelands and is preferred by goats for browsing. This plant species is easily accessible by farmers and can be prepared and fed as leaf meal (Mapiye et al., 2009). *Acacia karroo* contains up to 230g/kg CP and can be considered as a cheap source of proteins in communal goat and beef production (Mapiye et al., 2009).
Additional protein supplementation (Hoste et al., 2005; Hoste, Torres-Acosta, & Aguilar-Caballero, 2008) primarily through the use of protein sources such as *A. karroo* leaf meal (Mapiye et al., 2009) in ruminant nutrition, improves animals’ body weights and body condition scores (Arsenos et al., 2009). An improved body weight leads to heavier carcasses, thus improving the quality and quantity of meat produced (Arsenos et al., 2009). Feeding on *A. karroo* leaf meal has been reported to improve nutritional status, growth performance and carcass traits in cattle (Mapiye et al., 2009).

Goat meat has been established as lean meat with desirable fatty acids (Safari, Mushi, Mtenga, Kifaro, & Eik, 2009) and favourable nutritional quality (Simela, 2005), as they deposit a relatively higher quantity of polyunsaturated fatty acids compared to other ruminants (Safari et al., 2009). Consumer meat sensory characteristics are used to evaluate meat quality on the basis of meat palatability parameters such tenderness, juiciness, colour and flavour (Tshabalala, Strydom, Webb, & de Kocka, 2003), which are strongly affected by quantity and composition of fat in the meat (Muchenje et al., 2009) and pH (Priolo, Micol, & Agabriel, 2001). Meat sensory characteristics tend to be affected by meat quality measurements such as pH and cooking losses. Higher ultimate pH values produce meat that is darker in colour (Priolo et al., 2001), and negatively affect meat tenderness, thus that can be attributed to low glycogen reserves caused by poor animal diet (Safari et al., 2009).

### 1.2 Justification

The overwhelming use of sheep in many research studies has resulted in the scarcity of relevant information on goats (Hoste et al., 2005). There is a necessity to conduct such studies on goats, as naturally, they do not behave in the same way as sheep do in their growth and development, resulting to a difference in their meat sensory characteristics (Arsenos et
The Xhosa lop-eared genotype will be used in the study, since it is among goat genotypes recommended for meat production, given that it has a big framed body and is highly resistant to parasitic infections (Xazela, Chimonyo, Muchenje, & Marume, 2011).

Studies have been conducted on goats focusing on the effect of dietary supplementation on growth and meat quality of indigenous goats (Marume, 2010), consumer sensory evaluation of meat from South African goat genotypes fed sunflower cake (Xazela et al., 2011) and correlations among sensory characteristics from four different goat breeds (Ngambu, Muchenje, Chimonyo, & Marume, 2011). Simela (2005) also conducted a study on meat characteristics and acceptability of chevon from South African indigenous goats. In addition, the effect of A. karroo leaf meal supplementation on the meat quality of Nguni beef steers has been established (Mapiye et al., 2009). However, no studies have been conducted on the effect of A. karroo supplementation on meat sensory characteristic scores of Xhosa lop-eared goat breed. Hence, there is a necessity to conduct this study on the effect of A. karroo supplementation on meat sensory characteristics of Xhosa lop-eared goat breed.

1.3 Objectives

The major objective of the study was to determine the effect of A. karroo supplementation on the quality of meat from Xhosa lop-eared goats. The specific objectives were:

1. To determine the effect of A. karroo supplementation on ultimate pH, colour and cooking losses of meat from goats;

2. To determine the effect of A. karroo supplementation on consumer sensory characteristics of meat from goats;
1.4 Hypotheses

1. There is no effect of *A. karroo* supplementation on ultimate pH, colour and cooking losses of meat from goats;

2. There is no effect of *A. karroo* supplementation on consumer sensory characteristics of meat from goats.
1.5 References


CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Goat production constitutes an important subsystem of animal production, especially in semi-arid and arid areas (Simela, 2005). Productivity indicators such as sales and home slaughter reveal that goat productivity in smallholder areas is low. This could be due to negative perceptions of chevon by consumers (Webb, Casey, & Simela, 2005). The majority of consumers do not accept chevon in their day-to-day consumption because they perceive it as smelly (Simela, 2005). South African urbanites associate chevon with traditional and religious ceremonies rather than with daily consumption (Simela et al., 2008; Rumosa-Gwaze, Chimonyo, & Dzama, 2009). Despite the generally negative perception of chevon, consumers and trained taste panelists in sensory studies have found that chevon is desirable and of satisfactory quality (Simela, 2005). Sensory evaluations have shown that goat meat is acceptably palatable and desirable to consumers.

Diet has been shown to be one of the main factors influencing carcass yield and qualities in many livestock species (Wood et al., 2008), specifically in goats (Warmington & Kirton, 1990; Webb et al., 2005). Feed accounts for the highest single cost of the majority of livestock meat production operations. Goat meat production requires a high quality and balanced diet of mainly proteins. Conventional feeds are expensive and are out of the reach of resource poor farmers. Therefore, profitable goat meat production can only be achieved by optimizing the use of high quality forage and browse instead of more expensive concentrate feeds (Matthew & Jean-Marie, 2002). Browse trees such as A. karroo are gaining importance as a protein supplement for grazing ruminants because they are widespread and abundantly available during the dry season (Mokoboki, Ndlovu, Ngambi, Malatje, & Nikolovav, 2005).

This chapter will place emphasis on the sensory and consumer evaluation of meat and the sensory characteristics of chevon such as meat juiciness, tenderness and flavour. The meat
quality measurements and the use of browse plants such as *A. karroo* as supplement in ruminants and specifically, in goats and its effect on chevon quality will be dealt.

### 2.2 *Acacia karroo* as a supplement on meat producing goats

#### 2.2.1 Browse trees to grass species preference by goats

Goats are known to be browsers (Moleele, 1998; Ngwa *et al.*, 2000; Omphile *et al.*, 2003). They thrive better on tree leaves, while grazing is not a major component in their diets (Budisatria *et al.*, 2010). Goats held under communal farming commonly have a wide range of different types of feeds available to them, as they generally prefer to alternate between different feeds (Abdel-Moneim & abd-Alla, 1999). Goat feed preference is affected by season and nutritional needs. They prefer browsing than grazing during summer and increase preference when nutritional needs are covered (Provenza, 1995). The effect of season on feed preference is shown in Table 2.1.
Table 2.1: Effect of season on goat browse to grass consumption

<table>
<thead>
<tr>
<th>Month</th>
<th>Shrubs (%)</th>
<th>Forbs (%)</th>
<th>Grasses (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer</td>
<td>84</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>Winter</td>
<td>79</td>
<td>13</td>
<td>8</td>
</tr>
<tr>
<td>Annual means</td>
<td>82</td>
<td>11</td>
<td>7</td>
</tr>
</tbody>
</table>

Adapted from Ramirez (1999)
According to Ramirez (1999), grasses represented the group of plants that were less consumed by goats (Table 2.1) throughout the year. In winter, goats select the highest amount of grasses, probably because of the growth of grasses during this period. Papachristou and Nastis (1993) experimentally demonstrated that goats exhibit very rapid seasonal shifts between shrubs, grasses and forbs, depending on their availability and their seasonal nutritive value. Similar results on the preference of grass to browse species were also reported in earlier studies (Pfister & Malechek, 1986).

The ability of ruminants to select feed depends greatly on past experience, as familiar feed is always preferred to new feed. Goat preference for shrubby species is also affected by the abundance of shrubby species in particular zones and accessibility (le Houerou, 1980). Goats rely on browse species, which do not decline in quality to the same degree as herbaceous species (Sanona et al., 2007), to supplement the protein, minerals and vitamins in their diet (le Houerou, 1980). The nutritive value of browse species is known to be high, with lower variation over time, when compared to grasses (Fadel Elseed et al., 2002).

2.2.2 Intake of browse plants (Acacia karroo) by goats

Goats prefer the leaves and twigs of trees containing condensed tannins (CT) and digest them better than other forage eating ruminants (Villena & Pfister, 1990; Lee, Lee, Lee, 1990; Silanikove, 2000). Goats are primarily browsers, and in most areas browse constitutes 60-80% of goat diets (Kababya, 1995). They are able to consume larger amounts of tannin-rich browse than sheep under similar conditions (Gilboa, Nir, Nitsan, Silanikove, & Perevolotsky, 1995; Silanikove, Gilboa, Perevolotsky, & Nitsan, 1996). They inevitably select the leaves in preference to the stems, as leaves have much higher concentration of CT.
The voluntary intake and leaf selection of tannin plants such as *A. karroo* is, however, highly disturbed by the presence of thorns (Mapiye, Chimonyo, Marufu, & Dzama, 2011), which restrict the accessibility of the leaves and phenolic compounds (Teague, 1989). Reduced intake, degradability and nutrient availability (Mokoboki *et al*., 2005), as well as the intestinal absorption of proteins and carbohydrates (Giner-Chavez, 1996) are associated with the Phenol compounds present in tannin plants.

Robbins *et al.* (1987); Silanikove, Nitsan, and Perevolotsky (1994); Silanikove *et al.* (1996) established a relationship between the intake of a high level of tannin forage plants, palatability, digestibility and nitrogen (N) retention in small ruminants. Unfortunately; the relationship that was found produced negative effects of tannins in ruminants as it resulted in reduced feed intake, palatability, low rate of evacuation of digesta out of the rumen and toxic effects (Kumar & Singh, 1984; Provenza, 1995). Tannins increase the-N-content of faeces and decrease urinary N output (Waghorn & McNabb, 2003). The low intake of *ad libitum* browse containing tannins by goats can further be improved by the provision of polyethylene glycol (PEG) (Waghorn, 2008). Villalba, Provenza, and Banner (2002) reported that access to PEG resulted in an increased intake of a pelleted tanniniferous diet by sheep and goats. Recently, the use of PEG to diminish the negative effects of condensed tannins offers good potential to improve goat production (Waghorn, 2008).

Condensed tannins are secondary plant compounds generally regarded as toxic to animals when consumed in large amounts (Rojas *et al*., 2006). Normally, animals consuming tannin-rich feeds appear to develop defensive mechanisms against tannins (Makkar, 2003) given that, under very high levels of tannin intake by animals, the tannin compounds might
negatively affect protein utilization (Pell, Mackie, Mueller-Harvey, & Ndlovu, 2001). However, they can produce toxicity and can even cause death (Garg et al., 1992). Animals in tropical and dry environments are more prone to this, since trees and shrubs are an important source of fodder for livestock (Topps, 1992) though they tend to contain higher amounts of tannin than temperate plants (Rojas et al., 2006). Niezen, Waghorn, Raufaut, Robertson, and McFarlane (1994) reported that levels of condensed tannins vary between different plant species.

2.2.3 Nutritive value of browse plants and beneficial effect on meat quality of goats.

According to Mandal (1997), nutritive value is a function of feed intake (FI) and the efficiency of extraction of nutrients from the feed during digestion. Fodder trees and shrubs represent an enormous potential source of protein for ruminants in the tropics (Ngongoni, Mapiye, Mwale, & Mupeta, 2007). Some of these species are highly digestible, providing nutrients to rumen microorganisms (Umunna, Nsahlai, & Osuji, 1995) and can increase voluntary intake. The main features of browse plants are their high crude protein (CP) (100–250 g/kg DM) and mineral contents (Mokoboki et al., 2005; Devendra & Sevilla, 2002), however they have antihelmintic properties (Xhomfulana, Mapiye, Chimonyo, & Marufu, 2009) and a high content of secondary plant metabolites (Monforte-Briceño, Sandoval-Castro, Ramírez-Avilés, & Capetillo, 2005).

The Acacia species are reported to be a valuable source of forage for ruminants where feed quality is a production constraint (Goodchild & McMeniman, 1994). This could be attributed to the fact that the Acacia species can easily meet nutrient requirements, mainly proteins (Aganga, Tsopito, & Adogla-Bessa, 1998; Kahiya, Mukaratirwa, & Thamsborg, 2003;
Mokoboki et al., 2005) and minerals (Aganga et al., 1998; Mokoboki et al., 2005) relative to other palatable indigenous plants without condensed tannins.

According to Rubanza, Shem, Otsyina, and Fujihara (2005), the concentration of crude protein in leaves of the majority of fodder trees and shrubs is above 10% even in the dry season when it tends to decrease. Generally, calcium and potassium contents are higher than other minerals. The role of trees and shrubs in the supply of vitamins is indirectly demonstrated by the fact that browsers such as goats contract photophobia, which many large ruminants such as cattle are prone to during the dry season. In ruminants dietary condensed tannins (2–3%) have been shown to impart beneficial effects (Hoste, Jackson, Athanasiadou, Thamsborg, & Hoskin, 2006) that are associated with their anthelmintic properties and antioxidant effects (Saura-Calixto, Serrano, & Goñi, 2007). The dietary tannins reduce the wasteful protein degradation in the rumen by the formation of a protein-tannin complex (Barry, 1987; Min & Hart, 2003).

The complex appears to dissociate post-ruminally at a low pH where, apparently, the protein becomes available for digestion (Cossalter, 1986). However, free condensed tannins would probably be available to form a complex with digestive enzymes such as pepsin and also with the protein of gut wall. In addition, tannin plants such as A. karroo improve the nutritional status, growth performance and carcass traits (Mapiye et al., 2009), and reduces nematode burdens (Niezen et al., 1998; Xhomfulana et al., 2009) in ruminants. Tannin plants affect the biology of the H. contortus especial in larval stage three. In that way, it controls the parasitic populations (Niezen et al., 1998).
2.3 Meat quality measurements

2.3.1 The effect of browse plant diet on the meat colour of goats

The first impression consumers have of any meat product is its colour, thus, colour is of most importance (Faustman & Cassens, 1990; Glitsch, 2000; Mancini & Hunt, 2005). Meat colour varies from the deep purplish-red of freshly cut beef to the light gray of faded cured pork. Moreover, meat discoloration limits the shelf life after retail preparation (Jeyamkondan, Jayas, & Holley, 2000). The colour of meat can be controlled if factors that influence it, such as meat pH and diet, are understood (Priolo et al., 2005). Higher pH values produce meat that is darker in colour (Priolo, Micol, & Agabriel, 2001).

In the study conducted by Priolo et al. (2005), it was reported that tanniniferous fed small ruminants produce meat of a light colour compared to other animals given same diet, but with eliminated tannin effect. The same results were reported by Verna, Pace, Settineri, Di Giacomo, & Nanni (1989) on lambs fed the strain containing the higher level of tannins. Tannins from different plant species have similar effects on lamb meat colour (Priolo, Ben Salem, Atti, & Nefzaoui, 2002). The effect of tannins on meat colour could be due to a reduced microbial biosynthesis of vitamin B$_{12}$ which is a precursor for the synthesis of haeme pigments (Vasta, Nuddab, Cannas, Lanza, & Priolo, 2008).

2.3.2 The effect of diets containing browse plants on goat meat cooking losses

Cooking loss, which is one of the parameters of meat quality, refers to the reduction in weight of meat during the cooking process (Jama et al., 2008). Among factors affecting cooking loss is animal species (Pike, Smith, Carpenter, & Shelton, 1973), water holding capacity (Adam, Atta, & Ismail, 2010) and fat content (Lawrie, 1998). Cooking losses are possibly stimulated
by the limited fat content and water holding capacity (Lawrie, 1998). The water-holding capacity of fresh meat is its ability to retain inherent water. It is a very important meat quality attribute that has an influence on product yield, which in turn has economic implications, but is also important in terms of consumption quality. Early postmortem activities including rate and extent of pH decline, proteolysis and even protein oxidation are factors that affect the ability of meat to retain moisture (Huff-Lonergan & Steven, 2005).

Higher cooking losses are an indication of a decrease in water holding capacity. It is because of these cooking losses that chevon has been found less juicy than other animal species such as sheep (Pike et al., 1973). Adam et al. (2010) reported no effect of diet on cooking losses. The same author reported cooking losses on an average of 34.2% and this is assumed to be attributed to other production parameters such as animal species and breed.

2.4 Sensory and consumer evaluation of meat

Diet has been shown to be one of the main factors influencing carcass yield and qualities in many livestock species (Warmington & Kirton, 1990; Webb et al., 2005; Wood et al., 2008). Ruminants supplemented by browse plants produce meat of a light colour compared to other diet (Priolo et al., 2005). Browse plants such as Acacia species can easily meet nutrient requirements, mainly proteins and minerals (Kahiya et al., 2003; Mokoboki et al., 2005) which could lead to developing marbled meat muscles. However, meat sensory characteristics such as tenderness, juiciness and flavour are produced. The sensory evaluation of meat is a scientific discipline used to measure, analyse, and interpret meat quality. Meat quality is, therefore, perceived by the senses of flavour, aroma, juiciness and tenderness and are highly affected by diet (Arsenos et al., 2009), breed (Muchenje et al., 2008) age (Simela,
2005) and animal species (Stone & Sidel, 1993). Meat sensory characteristics can be evaluated by objective methods i.e. instrumental or sensorial, with trained panels and by subjective methods with a consumer panel (AMSA, 1995). According to Risvik (1995), there is a fundamental difference in the sensory evaluation performed by trained or instrumental analysis and that performed by a consumer panel.

Consumer meat evaluation permits the evaluation of different treatments as well as determining their effect on a particular characteristic. It can also tell about the acceptability of the meat (Destefanis, Brugiapaglia, Barge, & DalMolin, 2007). For this reason, consumer opinion is a key factor in establishing meat value, as it justifies purchase decisions. Therefore, consumer meat evaluation for meat quality is suggested (Destefanis et al., 2007).

The use of consumers from different backgrounds is encouraged when sensory evaluation of meat is being conducted, given that consumers from different countries, different segments affluence with different preferences and reasons (Sveinsdóttir et al., 2009). The differences between and within countries might be explained by different consumption patterns of chevon. For example, in countries such as South Africa, chevon is assumed to be more suitable for traditional activities (Mahanjana & Cronje, 2000). While some countries discriminate against goat meat, in tropical regions, goat meat is preferred to beef (Dhanda, Taylor, Murray, & McCosker, 1999).

Meat evaluation using consumer panels is considered disadvantageous because it is time consuming, expensive and difficult to organise (Harris, 1976; Boccard et al., 1981; Brady & Hunecke, 1985; Platter et al., 2003). As a result, many attempts have been made to invent instrumental methods of assessing meat sensory characteristics (Boccard et al., 1981), whose results can predict sensory characteristics mainly tenderness obtained by a taste panel (Lawrie & Ledward, 2006).
Instrumental analysis of meat can permit the evaluation of different treatments as well as determine their effect on a particular characteristic. The Texture Profile Analysis (TPA) and the Warner-Bratzler Shear Force (WBSF) are among the invented instruments for meat sensory evaluation (Caine, Aalhus, Best, Dugan, & Jeremiah, 2002). Previous reports indicate that the TPA and WBSF have similar capabilities to evaluate sensory characteristics of meat, primarily tenderness. However, there is limited information comparing these two instrumental methods under similar test conditions (Caine et al., 2002). The pH meter and calorimeter are used for measuring meat pH and meat colour respectively. These instruments are indirect measures of some meat sensory characteristics. Among those is meat juiciness for meat pH and meat tenderness for meat colour.

2.4.1 Sensory characteristics of chevon

The sensory properties of meat have an impact on consumer appreciation of the meat. This also determines their perception of its acceptability and quality (Simela, 2005). Sensory properties are pivotal in this respect because consumers need to be entirely satisfied with the sensory properties before other elements become relevant. The acceptability of meat can be predicted from tenderness, juiciness and flavour. Tenderness has been identified as the most important factor influencing the acceptability of beef. Juiciness and flavour have a greater effect on consumer satisfaction as toughness increases (Miller et al., 2001).

2.4.1.1 Meat tenderness

Tenderness appears to be the most important sensory characteristic of meat and a predominant quality determinant (Sebsibe, 2006). Meat tenderness is rated as the most important attribute of eating quality and is the factor that determines the consumers continued interest in the meat (Simela, 2005). It is a function of the collagen content, heat stability and
the myofibrillar structure of muscle (Muchenje et al., 2009). Factors affecting meat
tenderness include animal species, breed (Muchenje et al., 2008), diet (Arsenos et al., 2009),
age (Simela, 2005), aging, fatness and muscle location (Sebsibe, 2006).

Goats may have less intramuscular fat because they deposit more fat around visceral organs
than in the muscles and this results in poor tenderness (Swan, Esguerra, & Farouk, 1997).
Tenderness varies, mainly due to changes in the myofibrillar protein structure of muscle in
the period between animal slaughter and meat consumption (Muir, Wallace, Dobby, &
Bown, 2000). This happens when the carcass is refrigerated too hastily immediately after
slaughter. The muscle fibres contract severely, resulting in cold-shortening which will require
a force to shear the fibres after cooking (Razminowicz, Kreuzer, & Scheeder, 2006).
Tenderness is also affected by the degree to which the meat is cooked (Simela, Webb,
Bosman, & Pienaar, 2002). It has been shown that, during cooking, (between 52°C and 70°C)
collagen shrinks.

Tenderness improves with muscle ageing (Simela, 2005). Sarcomere length, connective
tissue and the proteolysis of myofibrillar proteins are said to explain most of the variation
observed in tenderness of aged meat (Muchenje et al., 2009). However; proteolysis is the
main biochemical factor contributing to the variation in tenderness (Muchenje et al., 2009).
Therefore, ageing can be intentionally used to decrease shear force values during post-
mortem storage. Meat muscle tenderness can also be determined from the content and state of
the connective tissue and the structure and state of the myofibrils (Simela, Webb, & Bosman,
2003). Connective tissue contributes to meat toughness. Effect of Myofibrillar to meat
tenderness depends on the extent of shortening during rigor development and proteolysis
during conditioning (Simela, 2005).
The breed and the animal species greatly affect variety in meat tenderness (Muchenje et al., 2008). There is variation among animal species such as sheep and goats and among breeds within a species (Sebsibe, 2006). Variation among breeds reared in the same environment and slaughtered at the same age, weight, and degree of finish suggests a genetic cause for some tenderness variation (Sebsibe, 2006). In beef, there is a heritability value of 60% for tenderness suggesting that heredity may be a major influence (Sebsibe, 2006).

2.4.1.2 Meat juiciness

Meat juiciness is one of the major parameters considered in the assessment of meat quality (Muchenje et al., 2008). Meat juiciness is the wetness during first bite and sustained juiciness due to the fat in the meat. The sensation of juiciness in chevon is closely related to the quantity and composition of intramuscular fat (Muchenje et al., 2008) and the age of the animal (Simela, 2005). Chevon has been reported to be less juicy, especially for sustained juiciness (Tshabalala, Strydom, Webb, & de Kocka, 2003), given that goat carcasses have a low fat content. Within animal species, meat juiciness is affected by the age of the animal given that goat carcasses ranging from 10 to 25kg were juicier than older goats with carcasses ranging from 15 to 30kg (Simela et al., 2008).

Muchenje et al. (2008) reported that meat juiciness is high in well marbled carcasses. This agrees with Webb et al. (2005) who reported that meat juiciness is directly related to the intramuscular lipids and moisture content of the meat. Juiciness can also be determined by the sensory evaluation from the measures of water in the meat such as water holding capacity and cooking losses (Simela, 2005). The water holding capacity is defined as the ability of
meat to retain its water during the application of external forces, such as cutting, heating, grinding or pressing (Lawrie & Ledward, 2006).

2.4.1.3 Aroma and meat flavour

Flavour is a general term used to define the taste and aroma of the meat during chewing (Moody, 1983). Meat flavour consists of taste-active compounds, flavour enhancers and aroma components (Stelzleni & Johnson, 2007). Flavour and aroma are two complex attributes of meat palatability (Calkins & Hodgen, 2007). The natural flavour of meat can be influenced by the animal species (Lee et al., 2004), the age of an animal (Melton, 1983), the lipid content (Miller, Moeller, Goodwin, Lorenzen, & Savell, 2000), the gender, diet (Sitz, Calkins, Feuz, Umberger, & Eskridge, 2005), meat pH (Calkins & Hodgen, 2007) and the thermal treatment (Webb et al., 2005). The animal species is the most important genetic factor, and the feed source is the most important environmental factor (Carmack, Kastner, Dikeman, Schwenke, & Garcia Zepeda, 1995).

There are large numbers of compounds in meat, and their complex interactions influence the perception of the meat. Many of these compounds are transformed primarily during cooking and storage (Calkins & Hodgen, 2007). Lipids play several roles in flavour development. They act as a solvent for the volatile compounds that develop during production, handling, and thermal processing (Moody, 1983). They undergo thermal oxidative change to produce compounds that influence beef flavour and react with components of lean tissue to give distinct flavour compounds (Mottram & Edwards, 1983).

Meat flavours also develop during the Maillard reaction where pH plays a role (Calkins & Hodgen, 2007). This reaction produces glycosylamine which is rearranged and dehydrated to
form furfural, furanone derivatives, hydroxyketones, and dicarbonyl compounds. All of these compounds contribute to flavour development (Calkins & Hodgen, 2007). Flavour intensity increases with the age of an animal although reports disagree on which age group are the most acceptable (Simela et al., 2003). Flavour was found to be the most important factor affecting consumer meat buying habits and preferences when tenderness was held constant as it is the most considered (Sitz et al., 2005).

2.5 Summary

Browse plants such as the *A. karroo* can be used to escape diet problems faced by communal goat meat producers. This is supported by the fact that the *A. karroo* can provide meat nutrient requirements for growth and can also improve carcass traits in ruminants, thus improving meat quality. Meat sensory characteristics are the major components used to decide on meat quality. These sensory characteristics are affected by several factors. Among these are diet, thermal preparation and consumer background. However; the use of browse plants were proved to be a key solution in ruminant supplementation. The levels of tannin in browse plants provided to ruminants have to be monitored, given that excess tannin consumption has anti-nutritional effects. Browse plants affect the meat quality of ruminants such as pH, colour and cooking losses. Browse plant fed to ruminants produce bright red meat colour. The bright red meat colour could be attributed to the potential of browse plants to provide proteins and minerals that are utilised as energy during lactic acid production to monitor muscle pH. The desirable muscle pH produced affects both meat colour and cooking losses.
2.6 References


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3 Chapter 3

Effect of *Acacia karroo* supplementation on ultimate pH, colour and cooking losses of meat from indigenous Xhosa lop-eared goats

Abstract

The objective of the study was to determine the effect of *A. karroo* supplementation on ultimate pH, colour and cooking losses of meat from indigenous Xhosa lop-eared goats. Eighteen castrated 4-month-old kids were used for the study and were kept at the University of Fort Hare, Honeydale farm until slaughter. The kids were subdivided in two treatment groups *A. karroo* supplemented (AK) and non-supplemented (NS). The supplemented goats were given 200g per head per day of fresh *A. karroo* leaves. The kids were slaughtered on day 60 and sample cuttings for meat quality assessment were taken from the *Longistimus dorsi* muscle. *Acacia karroo* supplemented goats produced higher *b*\(^*\) (yellowness) value, but had no significant effect on *L*\(^*\) (lightness) and *a*\(^*\) (redness) of the meat from goats. *Acacia karroo* supplementation also affected meat pH and cooking losses (*P < 0.05*). The meat from the *A. karroo* supplemented goats had lower ultimate pH and cooking loss than the meat from the non-supplemented goats. Therefore, *A. karroo* supplementation improves the quality of meat from goats.

Keywords: meat quality, cooking losses, meat pH, meat colour, *Acacia karroo* supplementation, chevon.
3.1 Introduction

The use of goats as meat animals has increased in recent years, as evidenced by the increased demand for goat meat by consumers (Gipson, 1999; Simela, 2005; Rumosa-Gwaze, Chimonyo, & Dzama, 2009). The major advantage of chevon is its lower fat content compared to other types of red meat (Park, Kouassi, & Chin, 1991). Meat quality is a highly subjective issue. Strikingly, there are no universally accepted criteria for defining meat quality throughout the world (Monin, 2004). A decision on good meat quality is dependent on the consumer and may vary according to culture (Borggaard & Andersen, 2004; Xazela, Chimonyo, Muchenje, & Marume, 2011). There are a number of important traits that consumers consider to decide on meat quality. At purchase point, consumers consider meat colour as an important meat quality indicator. Beef and mutton are expected to be bright red, while pork is expected to be more or less pink (Monin, 2004).

Meat colour, pH and cooking losses are also among measurements that are used to determine the quality of meat. Meat quality measurements are said to be affected by diet and thermal preparation. Under-feeding, which is a result of the inadequate availability of high quality feed in poorly resourced goat producers is the major diet defect in goat productivity (Collins-Luswet, 2000). However; browse plants such as the Acacia species are reported to be an enormous potential source of protein supplementation (100–250 g/kg DM) for ruminants in the tropics (Ngongoni, Mapiye, Mwale, & Mupeta, 2007) and can easily meet nutrient requirements, mainly proteins (Aganga, Tsopito, & Adogla-Bessa, 1998; Devendra & Sevilla, 2002; Kahiya, Mukaratirwa, & Thamsborg, 2003; Mokoboki, Ndlovu, Ngambi, Malatje, & Nikolovav, 2005), minerals (Aganga et al., 1998; Mokoboki et al., 2005) and they have antihelmintic properties (Xhomfulana, Mapiye, Chimonyo, & Marufu, 2009).
In studies conducted by Priolo et al. (2005); Yayneshet, Eik, and Moe (2008); Marume (2010), it was reported that tanniniferous-fed small ruminants produce meat of a lighter colour than other animals given same diet with no tannin effect. Tannins from different plant species have similar effects on lamb meat colour (Priolo, Ben Salem, Atti, & Nefzaoui, 2002). The effect of tannins on meat colour could be the result of a reduced microbial biosynthesis of vitamin B\textsubscript{12} which is a precursor for the synthesis of haeme pigments (Vasta, Nuddab, Cannas, Lanza, & Priolo, 2008). Meat colour is indirectly affected by meat pH. Meat pH also influences meat quality indicators such as meat tenderness, shelf-life and meat flavour (Honikel, 2004; Muchenje et al., 2008). Meat pH plays a role in the development of flavours in the Maillard reaction (Calkins & Hodgen, 2007). Diet is among the factors that affect levels of pH in meat (Calkins & Hodgen, 2007). Properly fed animals will retain the recommended energy which will be converted after slaughter to produce a recommended pH range of 5.5 to 6.0 (Calkins & Hodgen, 2007). Supplementation with browse plants, particularly A. karroo leaves, improves the body condition score, slaughter weight (Mapiye et al., 2009) and average daily gain (Nyamukanza & Scogings, 2008).

High pH levels were reported to decrease meat flavour intensity (Mottram & Madruga, 1994). Meat pH is also said to affect meat cooking losses (Jama et al., 2008). As pH increases in meat, the proteins have increased water binding properties. During cooking fewer water-soluble proteins are lost from high pH meat since there is less cooking loss (Miller, 2001). Excessive drip is generally considered undesirable (Monin, 2004). The conversion of muscle to meat has a significant effect on its microstructure and its quality traits. Among these is its water-holding capacity (WHC) (Palka, 2004). The lower the cooking losses, the better the
juiciness of the meat (Sebsibe, 2006). Cooking losses are also affected by the ratio of muscle to fat of the carcass (Yu et al., 2005).

Acacia karroo has been reported to improve the quality of meat from Nguni cattle (Mapiye et al., 2009). The Xhosa lop-eared goat breed, which is big framed (Bakare & Chimonyo, 2011), has been used since it is among the indigenous goat breeds known to produce meat (Xazela et al., 2011). While Marume (2010) determined the nutrient composition and anthelminthic effects of A. karroo, there are no studies which have been done to evaluate its effect on meat quality measurements of Xhosa lop-eared goats. Therefore the objective of the current study is to determine the effect of A. karroo supplementation on the quality of meat from indigenous Xhosa lop-eared goats.

3.2 Materials and methods

3.2.1 Study site description

The study was conducted at the University of Fort Hare Honeydale Farm. The farm is 520 m above sea level and is located 32.8° S and 26.9° E. The farm receives an average annual rainfall of 480 mm and has a mean annual temperature of 18.7 °C. It is situated in the False Thornveld of the Eastern Cape (Acocks, 1975). The topography of the area is generally flat with a few steep slopes. The vegetation is a mixture of several trees, shrubs and grass species. The predominant plant species on the farm are A. karroo, Themeda triandra, Panicum maximum, Digitaria eriantha, Eragrostis spp., Cynodon dactylon and Pennisetum clandestinum.
3.2.2 Animal management

Eighteen castrated 4-month-old goats with a mean body weight of 13.5 ± 0.31 kg (mean ± S.E.) and a mean body condition score (BCS) of 3.3 ± 0.16 (mean ± S.E.) were kept with their mothers on natural pastures and after they were moved to open sided barns where they were fed on 500g/head/day of medicago sativa hay. The goats were then randomly split into two balanced treatment groups, one of which was supplemented while the other was not. The supplemented group was fed individually with an additional 20g/head/day of fresh daily collected A. Karoo leaves on feeding troughs.

3.2.3 Collection and nutrient composition of the Acacia karroo browse plant

Fresh leaves of A. karroo were hand harvested each day and dried for the determination of nutritional composition such as DM, crude protein (CP), Crude fibre (CF), ether extract (EE) and tannin levels in the leaves. The dried leaves were fed to goats individually in feeding troughs for the period of 60 days. The Folin-Ciocalteau assays described by Terrill, Rowan, Douglas, & Barry (1992) were performed to determine the total polyphenolic content of the dried A. karroo whilst the butanol-HCl assay as described by Giner-Chavez et al. (1997) was done to determine the condensed tannins (CT). The Approximate analysis and tannin levels of A. karroo leaves are shown in Table 3.1.
Table 3.1: Nutritional composition of the experimental diets (% DM basis)

<table>
<thead>
<tr>
<th>Component</th>
<th>Acacia karroo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter</td>
<td>91.9</td>
</tr>
<tr>
<td>Crude protein</td>
<td>23.2</td>
</tr>
<tr>
<td>Crude fibre</td>
<td>25.9</td>
</tr>
<tr>
<td>Neutral detergent fibre</td>
<td>50.2</td>
</tr>
<tr>
<td>Acid detergent fibre</td>
<td>28.9</td>
</tr>
<tr>
<td>Ether extract</td>
<td>3.95</td>
</tr>
<tr>
<td>Calcium</td>
<td>4</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.08</td>
</tr>
<tr>
<td>Ash</td>
<td>5.1</td>
</tr>
<tr>
<td>CT (Butanol-HCL assay)</td>
<td>2.1</td>
</tr>
<tr>
<td>Total Phenolics (Folin assay)</td>
<td>0.5</td>
</tr>
</tbody>
</table>
3.2.4 Slaughter procedure

After 8 weeks, all the goats were humanely slaughtered complying with the local regulations of animal welfare. In the morning of the day of slaughter, the goats were transported from the Honeydale farm to the Adelaide commercial abattoir which is 60 km away. The goats were electrically stunned and immediately bled. The carcases were kept in the refrigerator overnight at a temperature of -4°C. Sample cuttings for meat tasting were made from the Longistimus dorsi muscle.

3.3 Meat quality Measurements

The meat colour was measured through instrumental colour measurements using the colour-guide 45/0 BYK-Gardener GmbH. The instrumental meat colour measurements represented by three coordinates: $L^*$ (lightness), $a^*$ (redness) and $b^*$ (yellowness) were measured on the Longistimus dorsi muscle using the colour-guide 45/0 BYK-Gardener GmbH machine with 20 mm diameter measurement area and illuminant D65-day light, 10°standard observer. The final meat colour value was calculated as the average value for the three readings taken from the colour guide. The guide was calibrated before use with the green standard.

The meat pH was measured on the Logistimus dorssi muscle after 24hrs using the pH meter (CRISON pH25, CRISON instruments SA, Spain) which was calibrated using pH 4, pH 7 and pH 9 standard solutions before measurements.

Cooking losses (CL) were measured in the Logistimus dorssi muscle, kept for 24hours. The meat muscles were allowed to defrost and their weight before cooking was recorded. Samples of meat from each treatment were then roasted for a period of 10 minutes on each side to make 20 minutes in total and cooled. After cooling, the sample weights were recorded. Cooking loss was calculated using the following formula: Cooking loss % = [(weight before cooked – weight after cooked) ÷ weight before cooked] × 100.
3.4 Statistical analysis

The general linear model procedure of the SAS (2003) program was used to analyse the effect of *A. karroo* supplementation on meat quality. Turkey’s HSD procedure was used for the comparison of means. The model used was as follows:

Model: \( Y_{ij} = \mu + D_i + E_{ij} \)

Where: \( Y_i \) = response variable (meat pH, cooking losses and meat colour)

\( \mu \) = overall mean common to all observations

\( D_i \) = effect of *A. karroo* supplementation

\( E_{ij} \) = random error.
3.5 Results

3.5.1 The effects of Acacia karroo supplementation on meat quality measurements of the Xhosa Lop-eared goat breed.

The effect of *A. karroo* supplementation on meat quality is shown in Table 3.2. The ultimate pH (pHₐ) of meat from the *A. karroo* supplemented goats was significantly lower (P < 0.05) than that from the non-supplemented goats. There were no significant differences (P > 0.05) in the L* and a* values of meat from the *A. karroo* supplemented goats and non-supplemented goats. *Acacia karroo* supplementation produced meat that was more yellow than the one from non-supplemented goats. Meat from the non-supplemented goats had higher (P < 0.05) cooking losses than the one from the *A. karroo* supplemented goats.
Table 3.2: Effect of *A. karroo* supplementation on meat quality attributes of Xhosa lop-eared goats

<table>
<thead>
<tr>
<th>Parameters</th>
<th>AK</th>
<th>NS</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultimate pH</td>
<td>5.4 ± 0.55</td>
<td>6.6 ± 0.55</td>
<td>*</td>
</tr>
<tr>
<td>Cooking loss</td>
<td>27.4 ± 4.41</td>
<td>33.6 ± 4.41</td>
<td>*</td>
</tr>
<tr>
<td>Colour</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$L^*$</td>
<td>44.1 ± 1.95</td>
<td>39.8 ± 1.95</td>
<td>NS</td>
</tr>
<tr>
<td>$a^*$</td>
<td>12.5 ± 1.90</td>
<td>8.2 ± 1.90</td>
<td>NS</td>
</tr>
<tr>
<td>$b^*$</td>
<td>10.1 ± 0.64</td>
<td>4.4 ± 0.64</td>
<td>*</td>
</tr>
</tbody>
</table>

AK= *Acacia karroo* supplementation, NS= Non-supplemented

$L=\text{Lightness of the meat colour, } a^*=\text{redness of meat, } b^*=\text{Yellow meat colour.}$

*= Significant difference (P< 0.05)


3.6 Discussion

*Acacia karroo* had a positive influence on meat pH of the supplemented goats. This is due to its high nutritive value mainly proteins and minerals (Ngongoni, Mapiye, Mwale, & Mupeta, 2007; Mapiye *et al*., 2009; Marume, 2010) on goat muscle development, given that the nutritional level of an animal’s diet can be influential on its ability to maintain productivity (Albers *et al*., 1987). The adequate amount of proteins (Ngongoni *et al*., 2007) in *A. karroo* browse plant improved the ability of the goats to retain desirable muscle energy (Marume, 2010). The retained muscle energy, the result of the high average daily gain and slaughter weight of *A. karroo* supplemented goats (Mapiye *et al*., 2009), have assisted in lactic acid development, resulting in the lower pH of the supplemented goats than that of the non-supplemented goats.

These results suggest that the consumption of tannin browse plant species has a positive influence on chevon pH. This, however, contradicts the results reported by Priolo *et al*. (2002), who reported that the consumption of tannin plants will not affect chevon pH. This argument may have arisen because of the type of browse plant used, given that; the browse plants differ in tannin content. The other reason could be the season in which the browse plant was consumed, as natural pastures vary in their chemical composition and structure with the seasons (Bakare & Chimonyo, 2011). Goats adapt to the changes that occur in the chemical composition and structure of vegetation with the seasons (Silanikove, 2000). This also suggests further research to establish the cause of the difference in the effect of browse plants on chevon pH, since this was not investigated in the current study. Meat pH affects meat colour and it has been reported that higher pH values produce meat that is darker in colour (Priolo, Micol, & Agabriel, 2001).
A number of studies have been published reporting the effect of diet on meat quality, particularly meat colour (Nyamukanza & Scogings, 2008). Priolo and Vasta (2007) reported that tanniniferous fed ruminants produce meat of a light colour. The effect of tannins on meat colour can be explained as a reduced microbial biosynthesis of vitamin B_{12} which is a precursor for the synthesis of haeme pigments. Diet has been reported to have an influence on slaughter weight and the cold dress weight of four goat breeds (Xazela et al., 2011). However; in the current study *A. karroo* supplementation does not influence the $L^*$ value of supplemented goats. The two groups; the *A. karroo* supplemented and non-supplemented groups had similar results on the $L^*$ value and this can be attributed to the effect of the intensive production system used. Intensively fed ruminants have been reported to produce light colour in meat (Vestergaard, Oksbjerg, & Henckel, 2000). Mapiye, Chimonyo, Dzama, Strydom, and Muchenje (2010) also reported no differences in water holding capacity, tenderness and cholesterol values of meat from Nguni cattle supplemented with *A. karroo* and those relied on rangelands.

Therefore, the $L^*$ value in the current study seems to be affected by external factors such as age and gender which were not considered in the current study, since the age of an animal affects meat quality (Simela, 2005). A similar situation applied in $a^*$-coordinate where *A. karroo* supplemented goats were not significantly different from the non-supplemented goats. However; the positive effect of *A. karroo* on the redness ($a^*$) of meat from Nguni cattle was reported (Mapiye et al., 2010). The argument arising could be attributed to the effect of animal species. The other reason supporting the difference in $a^*$ can be associated with the variation in the nutrient content of *A. karroo* leaves which is attributed to differences in
climate, season and stage of growth in which the plants were harvested (Rubanza, Shem, Otsyina, & Fujihara, 2005).

They can differ according to the environmental factors such as the season of grazing (Bakare & Chimonyo, 2011). Likewise; in the current study, the effect of A. karroo supplementation on meat colour was observed in yellowness. Higher \( b^* \) values of meat from the supplemented goats imply that A. karroo supplementation has improved the yellow colouring of chevon. The findings agree with the report by Priolo and Vasta (2007) who reported that tannins can be responsible for the differences found in meat colour. Moreover, the improvement observed from the A. karroo supplemented goats was attributed to additional dietary protein, energy and mineral intake (Mapiye et al., 2009). In addition, the use of A. karroo as a supplement might increase the proportions of desirable fatty acids (Mapiye et al., 2011) which could, therefore, interfere in the yellow colouring of the meat. Furthermore; increase in fat and muscle marbling could affect the muscle cooking losses (Yu et al., 2005).

The cooking loss levels of the supplemented goats in the current study were slightly higher than those reported by Jama et al. (2008) which averaged 23% but lower than those reported by Razminowicz, Kreuzer, and Scheeder (2006) which averaged 30%, while the cooking losses of the non-supplemented goats were higher than those of Razminowicz et al. (2006) from steers reared in pasture. Low cooking losses in the supplemented goats is attributed to the effect of reported pHu in this study which, however, improves the potential of proteins deposited from the A. karroo supplement (Marume, 2010) to retain more water in the meat (Miller, 2001). The ability of ultimate pH to influence muscle capability to retain natural water has been reported by Bruce, Stark, and Beilken (2003). Therefore, a muscle of lower water holding capacity is associated with higher cooking losses hence lower juiciness and a
less tender muscle (Sheard, Nute, Richardson, & Wood, 2005). The low amount of cooking losses in the current study can also be attributed to the fact that goats produce lean meat and they are the major sources of proteins (Devendra, 1981; Simela, 2005) therefore, water holding capacity will be improved. The results have shown that the meat has a higher water holding capacity which therefore suggests juicier meat. Levels of fat in meat generally affect cooking losses (Yu et al., 2005; Jama et al., 2008). Goats store fat in visceral organs and the carcass is generally lean (Park et al., 1991; Simela, 2005) and that supports lower cooking losses.

3.7 Conclusion

The current study revealed that A. karroo supplementation improves the quality of meat from goats. These findings can be practically implemented by emerging goat producers since A. karroo is easily accessible and the plant species is preferred by goats across seasons. The physico-chemical meat quality attributes tend to affect meat sensory characteristics, such as tenderness and juiciness. It is therefore important to also study the effects of the A. karroo supplementation on meat sensory characteristics.
3.8 References


Chapter 4

The effect of *Acacia karroo* supplementation and thermal preparation on consumer sensory scores of meat from indigenous Xhosa lop-eared breed

Abstract

The objective of the current study was to determine the effect of *A. karroo* supplementation and thermal preparation on consumer sensory scores of meat from indigenous Xhosa lop-eared breed. Eighteen castrated 4-month-old Xhosa lop-eared kids were kept at the University of Fort Hare Farm until slaughter. Sample cuttings for meat tasting were made from the *Longistimus dorsi* muscle. *Acacia karroo* supplementation improves meat tenderness and juiciness. There were no significant effects of *A. karroo* supplementation on meat flavour of the supplemented goats. Thermal preparation and consumer background had a significant effect (*P*< 0.05) on meat sensory characteristics. Results from this study show that *A. karroo* supplementation and thermal preparation have an effect on meat quality attributes such as tenderness and juiciness.

**Key words:** boiling, roasting, protein supplement, meat tenderness, thermal preparation, goat meat, consumer background.
4.1 Introduction

Consumer decision on the quality of meat is based on meat palatability components such as tenderness, juiciness and flavour (Tshabalala, Strydom, Webb, & de Kocka, 2003; Muchenje et al., 2008; Xazela, Chimonyo, Muchenje, & Marume, 2011). There is a relationship between meat sensory characteristics and meat quality measurements such as pH, colour and cooking losses (Muchenje et al., 2008). Sensory characteristics are used by consumers to decide on meat quality and there is a relationship between sensory characteristics and consumer acceptability (Muchenje et al., 2008). Some of the factors that affect meat palatability components are diet (Arsenos et al., 2009), breed (Muchenje et al., 2008), age (Simela, 2005), aging, fatness and muscle location (Sebsibe, 2006). Meat juiciness is the wetness during first bite and sustained juiciness likely due to fat in meat. Its sensation in chevon is closely related to the quantity and composition of the intramuscular fat (Muchenje et al., 2008) and age of an animal (Simela et al., 2008). Meat juiciness together with flavour and meat tenderness accounts for the overall eating quality. Flavour is the most important component of the eating quality of meat after cooking and is affected by lipid content (Webb, Casey, & Simela, 2005; Calkins & Hodgen, 2007), cooking method, age and gender (Webb et al., 2005), oxidation, myoglobin, and pH (Calkins & Hodgen, 2007).

Meat tenderness is a function of the collagen content, heat stability and the myofibrillar structure of the muscle (Muchenje et al., 2009) and is the most important sensory characteristic of meat (Strydom, Naude, Smith, Scholtz, & van Wyk, 2000; Sebsibe, 2006). Tenderness varies with the animal species (Muchenje et al., 2008), while the consumer sensory characteristics have shown that is less in goats since they have less intramuscular fat because they deposit more fat around visceral organs than in the carcass (Swan, Esguerra, & Farouk, 1997).
The consumer background is important and needs to be considered in the assessment of preference and quality of meat (Worch Lê & Punter, 2010). Dyubele, Muchenje, Nkukwana, & Chimonyo (2010) reported no significant effect of consumer age and gender on meat sensory characteristics. However, there is a significant difference in the perception of consumer tribes of meat sensory characteristics (Dyubele et al., 2010). The way consumers perceive meat depends on several factors including the animal’s diet. The cooking method is also among the factors affecting consumers’ decision on the quality of meat. Nour, Gomide, Mills, Lemenager, and Judge (1994) reported that the cooking method affects meat quality attributes such as cooking losses and thawing.

Many studies have been conducted on the effect of diet on the meat quality of ruminants (Priolo et al., 2005; Muchenje et al., 2008; Mapiye et al., 2009). Acacia karroo is among browse plants which have been studied (Mapiye et al., 2009; Mapiye, Chimonyo, Dzama, Strydom, & Muchenje, 2010; Marume, 2010; Bakare & Chimonyo, 2011). It is a browse plant which is characterised by its high crude protein (CP) and mineral contents (Devendra & Sevilla, 2002; Kahiya, Mukaratirwa, & Thamsborg, 2003; Mokoboki, Ndlovu, Ngambi, Malatje, & Nikolovav, 2005). Acacia karroo supplementation has been reported to improve nutritional status, growth performance and carcass traits (Mapiye et al., 2009; Arsenos et al., 2009). This leads to heavier carcasses thus improving quality and quantity of meat produced (Arsenos et al., 2009).

Xazela et al. (2011) have studied the sensory characteristics of meat from four goat breeds while authors such as Marume (2010) and Bakare & Chimonyo (2011) have conducted studies on the Xhosa lop-eared goat breed. Of these authors, none have studied the effect of A. karroo supplementation and thermal preparation on meat sensory characteristics of the Xhosa lop-eared goat breed. Hence, the objective of the current study was to determine the
effect of *A. karroo* supplementation and thermal preparation on consumer sensory scores of meat from Xhosa lop-eared goat breed.

4.2 Materials and method

4.2.1 Study site description

Study site is as described in Chapter 3, Section 3.2.1

4.2.2 Collection and nutrient composition of *Acacia karroo* browse plant

Collection and nutrient composition of *Acacia karroo* browse plant was as described in Chapter 3, Section 3.2.2.

4.2.3 Animal management

Animal management was as described in Chapter 3, Section 3.2.3.

4.2.4 Slaughter procedure

Slaughter procedure was as described in Chapter 3, Section 3.2.4.

4.2.5 Meat sample preparation

Meat sensory evaluation was done on meat from *A. karroo* supplemented goats and non-supplemented goats. Meat sampling was done on the *Logistimus dorssi* muscle. The meat samples were prepared using two thermal treatments: boiling and roasting. An average period of 45 minutes was used for cooking and roasting of the meat. Salt was added to taste.
4.2.6 Meat sensory evaluation

Meat sensory evaluation was done from boiled and roasted meat. A meat consumer sensory characteristics evaluation was done by individuals from different tribes (Xhosa, Shona, Ndebele and Zulu), different age groups (≤ 20, 21-25, 26-30, ≥ 30) and gender (female, male). Tasters were taught how to evaluate the meat samples and complete the available forms. The tasters were requested to rinse their mouth with drinking water after each taste so as to limit a crossover of the treatments.

A meat sensory characteristic evaluation form containing an eight-point rating scale of meat characteristics was used to give scores to different meat sensory characteristics. Sensory characteristics that were evaluated were: aroma intensity (AI) where score 1 is extremely bland and score 8 is extremely intense, initial impression of juiciness (IJ) at score 1 extremely dry and score 8 = extremely juicy, sustained impression of juiciness (SJ) at score 1 is extremely dry and score 8 is extremely juicy, first bite (FB) at score 1 is extremely tough to score 8 being extremely tender), muscle fibre and overall tenderness (MFT) at score 1 being extremely tough and score 8 is extremely tender, overall flavour intensity (OF) at score 1= extremely bland to score 8 = extremely intense, amount of connective tissue (ACT) at score 1= extremely abundant to 8 = none, and off-flavour (ATF) at score 1= none and score 8 = extremely intense.
4.2.7 Statistical analysis

The general linear model procedure of the SAS (2003) program was also used to determine the effects of A. karroo, age, gender, tribe and thermal preparation on meat sensory characteristics of goats. The model is:

\[ Y_{ijkl} = \mu + D_i + C_j + T_k + G_l + A_f + (C_j \times D_i) + (C_j \times T_k) + (C_j \times G_l) + (C_j \times A_f) + E_{ijkl} \]

Where \( Y_{ijk} \) = response variable (aroma intensity, initial impression of juiciness, first bite, sustained impression of juiciness, fibre and overall tenderness, amount of connective tissue, overall flavour intensity and relevant a-typical flavour),

\[ \mu = \text{overall mean common to all observations} \]
\[ D_i = \text{effect of A. karroo supplementation} \]
\[ C_j = \text{effect of thermal treatment (boiled, fried)} \]
\[ T_k = \text{effect of tribe (Xhosa, Shona, Zulu, Sesotho)} \]
\[ G_l = \text{effect of consumer gender (Male, Female)} \]
\[ A_f = \text{effect of consumer age} \]
\[ (C_j \times T_k) = \text{effect of thermal treatment and tribe} \]
\[ (C_j \times G_l) = \text{effect of thermal treatment and gender} \]
\[ (C_j \times A_f) = \text{effect of thermal treatment and age} \]
\[ (C_j \times D_i) = \text{effect of thermal treatment and A. karroo supplementation} \]
\[ E_{ijkl} = \text{random error}. \]
4.3 Results

Table 4.1 shows the effect of *A. karroo* supplementation on the sensory characteristics of meat from Xhosa lop-eared goats. Meat from the supplemented goats had significantly higher sensory scores than the one from non-supplemented goats. There were no significant effects of *A. karroo* supplementation on meat flavour and off-flavour scores. Table 4.2 shows the effect *A. karroo* supplementation and thermal preparations (cooked and roasted meat) on sensory characteristics of meat from goats. The highest scores for meat juiciness and tenderness were recorded in cooked meat from *A. karroo* supplemented goats. Roasted meat had the lowest sensory scores across treatment groups. The cooked meat from supplemented and non-supplemented goats had higher sensory scores than the roasted meat.

The effects of thermal preparation and consumer gender on meat sensory characteristics are shown in Table 4.3. Female consumers gave higher sensory scores for all sensory characteristics for both cooked and roasted meat. Both male and female consumers gave higher sensory scores for the cooked meat than the roasted meat. Table 4.4 shows the effect of tribe and thermal preparation on the sensory characteristics of meat from Xhosa lop-eared goats. The highest sensory scores for aroma intensity, first bite, and amount of connective tissue and sustained impression of juiciness in cooked meat were given by the Shona consumers while the Zulu consumers gave high sensory scores for overall flavour, off-flavour and muscle fibre and overall tenderness from cooked meat. Ndebele and Xhosa consumers gave the highest scores for initial juiciness and muscle fibre and overall tenderness respectively from the cooked meat.
Table 4.1: Effects of *A. karroo* supplementation on meat sensory characteristics of Xhosa lop-eared goat breed.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>AK</th>
<th>NS</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>AI</td>
<td>4.3 ± 0.30</td>
<td>4.5 ± 0.30</td>
<td>NS</td>
</tr>
<tr>
<td>IJ</td>
<td>4.9 ± 0.24</td>
<td>3.8 ± 0.24</td>
<td>*</td>
</tr>
<tr>
<td>FB</td>
<td>4.5 ± 0.26</td>
<td>4.1 ± 0.26</td>
<td>*</td>
</tr>
<tr>
<td>SJ</td>
<td>5.1 ± 0.24</td>
<td>4.2 ± 0.24</td>
<td>*</td>
</tr>
<tr>
<td>MFT</td>
<td>4.5 ± 0.23</td>
<td>4.1 ± 0.23</td>
<td>*</td>
</tr>
<tr>
<td>ACT</td>
<td>3.9 ± 0.24</td>
<td>3.9 ± 0.24</td>
<td>NS</td>
</tr>
<tr>
<td>OF</td>
<td>4.2 ± 0.27</td>
<td>4.3 ± 0.27</td>
<td>NS</td>
</tr>
<tr>
<td>ATF</td>
<td>2.2 ± 0.29</td>
<td>3.2 ± 0.29</td>
<td>NS</td>
</tr>
</tbody>
</table>

AI = aroma intensity; IJ = Initial juiciness; SJ = Sustained juiciness, MFT = Muscle fibre and overall tenderness, ACT = Amount of connective tissue, OF = Overall flavour score, ATF = Off-flavour score. AK = *Acacia karroo* supplemented, NS = not supplemented.

* = Significant different (P < 0.05), NS = not significant (P > 0.05)
Table 4.2: Effect of *A. karroo* supplementation and cooking methods on sensory scores of Xhosa lop-eared goat genotype.

<table>
<thead>
<tr>
<th>Sensory characteristics</th>
<th>Treatments</th>
<th>Not supplemented</th>
<th>Acacia <em>karroo</em> supplemented</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Cooked</td>
<td>Roasted</td>
</tr>
<tr>
<td>Aroma intensity</td>
<td>4.9 ± 0.41</td>
<td>4.1 ± 0.41\textsuperscript{a}</td>
<td>4.6 ± 0.41\textsuperscript{b}</td>
</tr>
<tr>
<td>Overall flavour</td>
<td>4.6 ± 0.37</td>
<td>4.0 ± 0.38\textsuperscript{a}</td>
<td>4.4 ± 0.37\textsuperscript{ab}</td>
</tr>
<tr>
<td>Initial impression of juiciness</td>
<td>4.8 ± 0.33 \textsuperscript{b}</td>
<td>2.7 ± 0.33\textsuperscript{a}</td>
<td>5.1 ± 0.33\textsuperscript{b}</td>
</tr>
<tr>
<td>Sustained impression of juiciness</td>
<td>5.2 ± 0.33 \textsuperscript{b}</td>
<td>3.2 ± 0.33\textsuperscript{a}</td>
<td>5.5 ± 0.33\textsuperscript{b}</td>
</tr>
<tr>
<td>First bite</td>
<td>5.1 ± 0.36</td>
<td>2.9 ± 0.37\textsuperscript{a}</td>
<td>5.8 ± 0.36\textsuperscript{c}</td>
</tr>
<tr>
<td>Amount of Connective Tissue</td>
<td>4.4 ± 0.34 \textsuperscript{b}</td>
<td>3.3 ± 0.34\textsuperscript{a}</td>
<td>4.3 ± 0.34\textsuperscript{b}</td>
</tr>
<tr>
<td>Muscle Fibre and Tenderness</td>
<td>4.8 ± 0.32 \textsuperscript{b}</td>
<td>3.4 ± 0.32\textsuperscript{a}</td>
<td>5.3 ± 0.31\textsuperscript{b}</td>
</tr>
<tr>
<td>Off-flavour score</td>
<td>3.4 ± 0.40</td>
<td>2.9 ± 0.41\textsuperscript{a}</td>
<td>3.2 ± 0.40\textsuperscript{ab}</td>
</tr>
</tbody>
</table>

\textsuperscript{abcd} Means with different superscripts in the same row are significantly different (*P* < 0.05).
Table 4.3: The effect of gender group and cooking method on meat sensory characteristics of the Xhosa lop-eared goat genotype

<table>
<thead>
<tr>
<th>Sensory characteristics</th>
<th>Gender</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Cooked</td>
<td>Roasted</td>
</tr>
<tr>
<td>Aroma intensity</td>
<td></td>
<td>5.5 ± 0.39&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.6 ± 0.40&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Overall flavour</td>
<td></td>
<td>4.7 ± 0.36&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.5 ± 0.37&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>Initial impression of juiciness</td>
<td></td>
<td>5.3 ± 0.32&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.7 ± 0.32&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sustained impression of juiciness</td>
<td></td>
<td>5.5 ± 0.32&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.1 ± 0.32&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>First bite</td>
<td></td>
<td>5.5 ± 0.35&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.7 ± 0.35&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Amount of Connective Tissue</td>
<td></td>
<td>4.3 ± 0.32&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.8 ± 0.33&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Muscle Fibre and Tenderness</td>
<td></td>
<td>5.1 ± 0.30&lt;sup&gt;c&lt;/sup&gt;</td>
<td>4.0 ± 0.31&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Off-flavour score</td>
<td></td>
<td>3.6 ± 0.39&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.8 ± 0.39&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>abc</sup> Means with different superscripts in the same row are significantly different ($P < 0.05$).
Table 4.4: sensory scores for the effect of tribe and cooking method on meat sensory characteristics of the Xhosa lop-eared goat breed

<table>
<thead>
<tr>
<th>Sensory characteristics</th>
<th>Tribes</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Xhosa</td>
<td>Shona</td>
<td>Zulu</td>
<td>Ndebele</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cooked</td>
<td>Roasted</td>
<td>Cooked</td>
<td>Roasted</td>
<td>Cooked</td>
<td>Roasted</td>
</tr>
<tr>
<td>AI</td>
<td>4.9 ±0.25b</td>
<td>4.6 ±0.25b</td>
<td>5.9 ±0.68c</td>
<td>4.7 ±0.79b</td>
<td>4.8 ±0.61b</td>
<td>3.7 ± 0.55a</td>
</tr>
<tr>
<td>OF</td>
<td>4.9 ±0.23b</td>
<td>4.5±0.23ab</td>
<td>5.0 ±0.62b</td>
<td>4.4±0.72ab</td>
<td>5.1 ±0.56b</td>
<td>3.7 ± 0.51a</td>
</tr>
<tr>
<td>IJ</td>
<td>5.1 ±0.21b</td>
<td>3.4 ±0.21a</td>
<td>5.0 ±0.55b</td>
<td>3.5 ±0.64a</td>
<td>5.9 0.49c</td>
<td>3.2 ± 0.45a</td>
</tr>
<tr>
<td>SJ</td>
<td>5.6 ±0.20b</td>
<td>3.7 ±0.21a</td>
<td>6.1 ±0.55c</td>
<td>4.0 ±0.63a</td>
<td>5.9±0.49bc</td>
<td>3.5 ± 0.44a</td>
</tr>
<tr>
<td>FB</td>
<td>5.9 ±0.22c</td>
<td>2.9 ±0.22a</td>
<td>6.1 ±0.60c</td>
<td>3.5 ±0.69a</td>
<td>5.8 ±0.54c</td>
<td>3.6 ± 0.49a</td>
</tr>
<tr>
<td>ACT</td>
<td>4.7±0.21bc</td>
<td>3.3 ±0.21a</td>
<td>5.3 ±0.56c</td>
<td>3.9 ±0.65a</td>
<td>4.6 ±0.50b</td>
<td>3.8 ±0.45ab</td>
</tr>
<tr>
<td>MFT</td>
<td>5.8 ±0.19c</td>
<td>3.3 ±0.19a</td>
<td>5.7 ±0.52c</td>
<td>3.8±0.61ab</td>
<td>5.8 ±0.47c</td>
<td>3.4 ± 0.43a</td>
</tr>
<tr>
<td>ATF</td>
<td>3.4±0.24bc</td>
<td>3.0 ±0.25b</td>
<td>3.7 ±0.66c</td>
<td>4.4 ±0.77d</td>
<td>4.3 ±0.59d</td>
<td>3.7 ± 0.54c</td>
</tr>
</tbody>
</table>

Means with different superscripts in the same row are significantly different (P < 0.05).,
AI = aroma intensity; IJ = Initial juiciness; SJ = sustained juiciness, MFT = Muscle fibre and overall tenderness, ACT = Amount of connective tissue, OF = Overall flavour score, ATF = Off-flavour score.
Consumer age group had a significant effect on the meat sensory scores across thermal preparations (Table 4.5). The sensory scores for cooked meat were generally higher than those for roasted meat across age groups. The consumer age group between 26-30 years old gave the highest sensory scores for aroma intensity, initial juiciness, sustained juiciness, muscle fibre and overall tenderness from the cooked meat. The highest sensory scores for overall flavour and off-flavours from the cooked meat were given by consumer age group between 21-25 years and consumers less than 20 years old respectively while the highest sensory scores for first bite and amount of connective tissue from the cooked meat were given by consumers more than 30 years old.
Table 4.5: The effect of age and cooking method on meat sensory characteristics of Xhosa lop-eared goat genotype

Sensory characteristics | AGE
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≤20</td>
<td>21-25</td>
<td>26-30</td>
<td>≥30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cooked</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AI</td>
<td>5.3±0.51&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>4.7±0.50&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.0±0.42&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.9±0.42&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.7±0.63&lt;sup&gt;c&lt;/sup&gt;</td>
<td>4.1±0.64&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.2±0.51&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.1±0.52&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>OF</td>
<td>4.5±0.46&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.9±0.46&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.9±0.38&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.9±0.39&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.8±0.58&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.9±0.59&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.4±0.47&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>4.6±0.48&lt;sup&gt;bc&lt;/sup&gt;</td>
</tr>
<tr>
<td>IJ</td>
<td>5.6±0.41&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.9±0.41&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.5±0.34&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.4±0.34&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>5.7±0.51&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.6±0.52&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.3±0.42&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.2±0.42&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>SJ</td>
<td>5.6±0.41&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.4±0.41&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.2±0.34&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.7±0.34&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.2±0.51&lt;sup&gt;d&lt;/sup&gt;</td>
<td>4.3±0.52&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.8±0.41&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>3.5±0.43&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>FB</td>
<td>5.6±0.45&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>2.9±0.45&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.3±0.37&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.3±0.37&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.7±0.56&lt;sup&gt;d&lt;/sup&gt;</td>
<td>3.9±0.57&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.0±0.46&lt;sup&gt;d&lt;/sup&gt;</td>
<td>3.2±0.46&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>ACT</td>
<td>4.1±0.42&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>3.7±0.41&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.6±0.35&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>3.7±0.35&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.5±0.52&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.4±0.53&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.9±0.43&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.6±0.43&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>MFT</td>
<td>5.4±0.39&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.5±0.39&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.7±0.32&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.6±0.32&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.4±0.49&lt;sup&gt;c&lt;/sup&gt;</td>
<td>4.2±0.49&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.4±0.39&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.2±0.40&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>ATF</td>
<td>4.3±0.49&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.5±0.49&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.6±0.41&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.8±0.41&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.8±0.62&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.1±0.63&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.6±0.50&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.0±0.51&lt;sup&gt;bc&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>abcd</sup>Means with different superscripts in the same row are significantly different (P < 0.05). AI = aroma intensity; IJ = Initial juiciness; SJ = sustained juiciness, MFT = Muscle fibre and overall tenderness, ACT = Amount of connective tissue, OF = Overall flavour score, ATF = Off-flavour score.
4.4 Discussion

Supplementation with dietary protein particularly from browse trees in the diet of ruminants produces carcasses of good quality (Arsenos et al., 2009; Mapiye et al., 2009). In the current study, the positive effect of A. karroo supplementation on meat sensory characteristics, particularly meat tenderness and juiciness from the supplemented goats is attributed to the effect of A. karroo nutrient composition (Mapiye et al., 2009). The A. karroo browse plant is reported to be a good source of proteins and minerals (Mokoboki et al., 2005; Ngongoni, Mapiye, Mwale, & Mupeta, 2007) which are the dietary requirements for the development of meat sensory attributes.

Meat juiciness is directly related to the intramuscular fat content of the meat (Webb et al., 2005), however, it is highly affected by animal species (Tshabalala et al., 2003; Muchenje et al., 2008). In the current study, meat juiciness had generally lower sensory scores across treatment groups. This could be because chevon has been reported to be less juicy, especially for sustained juiciness (Tshabalala et al., 2003), since goat carcasses have low fat content (Simela, 2005). But, the meat juiciness scores from the A. karroo supplemented goats were significantly higher (P< 0.05) than the meat juiciness scores of meat from the non-supplemented goats. The difference, in the improvement in meat juiciness scores from the A. karroo supplemented goats could be attributed to the effect of A. karroo supplementation since it is known to improve the resilience of meat producing animals (Arsenos et al., 2009; Marume, 2010) and is a source of proteins (Mokoboki et al., 2005).

In the current study, there was no significant effect of A. karroo supplementation on meat flavour. Several authors have reported diverse results on the effect of diet on meat flavour. Bowling et al. (1978); Melton (1983); Berry, Leddy, Bond, Rumsey, & Hammond (1988)
reported a significant effect of diet on meat flavour while Bidner, Montgomery, Bagley, and McMillin (1985); French et al. (2001) reported no significant effect of diet on meat flavour. The variety of results could be due to the variety of feedstuff used, such as silage and pasture (Melton, 1983), corn diets to corn silage diets (Berry et al., 1988), grass and grain-fed (French et al., 2001). The results may be influenced by the type and intensity of fatty acid developed. For example, when levels of polyunsaturated fatty acids (PUFA) become too high, off-flavours can develop, especially during cooking (Elmore, Campo, Enser, & Mottram, 2002).

There was a significant effect of thermal preparation on meat sensory characteristics scores. Highest sensory scores for cooked meat, not the roasted meat reported in the current study could be attributed to the difference in cooking losses from the two thermal preparations. This could be the result of the extent to which protein denaturing takes place and is assumed to be higher in roasted meat than in cooked meat (Garcia-Segovia, Andres-Bello, & Martinez-Monzo, 2006). Therefore, with higher protein losses there will be higher cooking losses since protein was reported to increase water binding properties (Jama et al., 2008). However, lower sensory scores could result since higher cooking losses result in lower juiciness and less tender muscle (Sheard et al., 2005). Dyubele et al. (2010) also reported a significant effect of thermal preparation on sensory scores of chicken where the roasted meat had higher sensory scores than the cooked meat. The argument could be attributed to the effect of animal species (Muchenje et al., 2008). Differences observed on meat sensory characteristics between cooked and roasted meat can be associated with consumer experience and familiarity with a particular thermal preparation of meat (Sveinsdóttir et al., 2009; Xazela et al., 2011). Normally, communal home meat preparation is through cooking. Therefore, with the lack of experience of roasted meat, consumers might not properly identify
differences among sensory characteristics of roasted meat. The effect of consumer background was also studied in the current study.

There is also a significant effect of consumer age, gender and thermal preparation on meat sensory scores. Highest sensory scores recorded by female consumers in the current study is in agreement with findings by Simela (2005), Dyubele et al. (2010), Xazela et al. (2011) who all reported a significant effect of consumer gender on sensory characteristics, where females reported higher scores of meat juiciness than males consumers.

Different tribes reported different intensity in sensory scores across sensory characteristics of cooked meat. This can, however, be associated with consumer familiarity with and availability of goat meat (Sveinsdóttir et al., 2009) and the influence of the consumer’s country of origin (Shabalala & Mosima, 2002). Preference for animal species for meat production is directly affected by consumer background (Sañudo, Alfonso, San Julian, Thorkelsson, & Valdimarsdottir, 2007). The differences between and within countries might be explained by different consumption patterns of chevon. However, its consumption is affected by religious restrictions (Jaturasitha, 2004). For instance in some countries such as South Africa consumption of chevon is assumed as to be as more suitable for traditional activities (Mahanjana & Cronje, 2000; Ayalew, Rischkowsky, King, & Bruns, 2003; Rumosa-Gwaze, Chimonyo, & Dzama, 2009).
4.5 Conclusion

*Acacia karroo* supplementation significantly improved the tenderness and juiciness of meat from goats. However, there were no significant effects of *A. karroo* supplementation on chevon flavour and off-flavours. Thermal preparation affected meat quality attributes, where cooked meat had higher sensory scores than the roasted meat. Background had an effect on the consumer’s perception of meat quality attributes.
4.6 References


5  Chapter 5

General discussion, conclusion and recommendations

5.1 General discussion

The objective of the study was to determine the effects of *A. karroo* supplementation on quality of meat from Xhosa Lop-Eared goats. The effect of *A. karroo* supplementation on meat pH, colour and cooking losses of meat from goats were determined in Chapter 3 while the effect of *A. karroo* supplementation and thermal preparation on meat sensory scores of meat from goats was determined in Chapter 4.

There were no significant differences on the $L^*$ and $a^*$ colour coordinates of the meat from *A. karroo* supplemented goats and non-supplemented goats. However, the supplemented goats had a higher $b^*$ value than the non-supplemented goats and this suggest that *A. karroo* supplementation improved the yellow colouring of chevon. The findings agree with the report by Priolo and Vasta (2007), who reported that tannins can be responsible for the differences found in meat colour.

*Acacia karroo* supplementation had a significant effect on meat pH$_u$ of Xhosa lop-eared goats, where the meat pH$_u$ of the *A. karroo* supplemented goats was significantly lower than that of non-supplemented goats. Cooking losses in the meat from the *A. karroo* supplemented goats was lower than that of the meat from the non-supplemented goats. The lower cooking losses could also be attributed to the effect of *A. karroo* supplementation which is regarded as a source of protein (Ngongoni, Mapiye, Mwale, & Mupeta, 2007) contributing in retaining more water within a meat muscle (Miller, 2001). Goats are also known to produce lean meat with a reasonable amount of protein and in that way, the effect of animal species could
contribute to the lower cooking losses reported in the current study (Simela, 2005; Muchenje et al., 2008). Meat from the A. karroo supplemented goats had higher tenderness and juiciness scores than meat from the non-supplemented goats. The improved meat juiciness and tenderness could be attributed to the lower meat cooking losses reported in Chapter 3 due to the effect of A. karroo supplementation (Sheard, Nute, Richardson, & Wood, 2005). The improved meat juiciness has also been influential in the improved meat tenderness since these two meat attributes are positively correlated (Ngambu, Muchenje, Chimonyo, & Marume, 2011). The sensory scores of the meat quality attributes were also reported to be affected by the cooking method (Dyubele, Muchenje, Nkukwana, & Chimonyo, 2010).

The thermal preparation of meat is an important tool in the sensory perception of meat by consumers (Jama et al., 2008). In the current study, thermal preparation had an effect on meat quality attributes, where cooked meat had higher sensory scores than the roasted meat. Consumer gender, tribe and age had a significant effect on meat quality attributes (Dyubele et al., 2010; Xazela, Chimonyo, Muchenje, & Marume, 2011). Female consumer’s gives higher sensory scores than the male consumers. Both male and female consumers reported higher sensory scores for the cooked meat than the roasted meat.

Shona and Zulu consumers reported higher sensory scores for the majority of sensory characteristics from the cooked meat than the roasted meat. The majority of meat sensory characteristics from the roasted meat had significantly lower sensory scores than that of the cooked meat across different tribes. The consumer age group between 26-30 years old reported the cooked meat with the highest sensory scores of all the other age groups.
5.2 Conclusion

*Acacia karroo* supplementation had a significant effect on meat colour, \( \text{pH}_u \) and cooking losses. *Acacia karroo* supplementation improves physico-chemical meat quality and meat sensory attributes such as tenderness and juiciness. The cooked meat had higher sensory scores than the roasted meat and therefore, cooking can be said to improve the eating quality of meat. Consumers of different genders, tribes and ages had different perceptions of meat sensory characteristics across thermal preparations. All the different categories of consumers gave higher sensory scores for the cooked meat than the roasted meat.

5.3 Recommendations

Based on the findings from this study, the use of *A. karroo* as a supplement by farmers for meat producing small ruminants is recommended especial after grazing. Proper feed monitoring such as weighing has to be considered given that, in excess quantities, browse plants can negatively affect protein degradability and availability. *Acacia karroo* is a low cost source of protein feed; therefore it can be used as a tool over increased feeding inputs for poor resourced livestock producers. This will, however; improve small ruminant production, ensuring merit output especially for the smallholder farmers through high quality carcasses.

The following areas need further research investigations:

- Goat consumption of the *A. karroo* browse plant between leaf meal supplementation and own browsing. This is important for scientist to consider because
browsing is the culture of goats, therefore, consumption and preference can be disturbed when they are provided leaf meal instead of browsing themselves.

- The recommended daily allowance of the *A. karroo* browse plant consumption for goats to shift from protein bind caused by excess consumption.

- The meat production performance of different livestock species supplemented by *A. karroo*. 
5.4 References


Appendix: meat sensory evaluation form

Sensory analysis of Chevon

Age: ≤ 20------, 21-25------, 26-30------, ≥ 30------

Tribe: Xhosa------, Zulu------, Shona------, Ndebele------, Other------

Gender: Male------, Female------

Name:…………………………………..                                    Date:………………

Please evaluate the following samples of chevon for the designated characteristics.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Rating scale</th>
<th>Cooking method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Cooked</td>
</tr>
<tr>
<td><strong>1 Aroma intensity</strong></td>
<td>1= Extremely bland</td>
<td>AK</td>
</tr>
<tr>
<td></td>
<td>2= Very bland</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3= Fairly bland</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4= Slightly bland</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5= Slightly intense</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6= Fairly intense</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7= Very intense</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8= Extremely intense</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Take a few short sniffs as soon as you remove the</td>
<td></td>
</tr>
<tr>
<td></td>
<td>foil. Typical beef aroma</td>
<td></td>
</tr>
<tr>
<td><strong>2 Initial impression of juiciness</strong></td>
<td>1= Extremely dry</td>
<td>AK</td>
</tr>
<tr>
<td></td>
<td>2= Very dry</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3= Fairly dry</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4= Slightly dry</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5= Slightly juicy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6= Fairly juicy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7= Very juicy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8= Extremely juicy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The amount of fluid exuded on the cut surface</td>
<td></td>
</tr>
<tr>
<td></td>
<td>when pressed between the thumb and forefinger</td>
<td></td>
</tr>
<tr>
<td><strong>3 First bite</strong></td>
<td>1= Extremely tough</td>
<td>AK</td>
</tr>
<tr>
<td></td>
<td>2= Very tough</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3= Fairly tough</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4= Slightly tough</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5= Slightly tender</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6= Fairly tender</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7= Very tender</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8= Extremely tender</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The impression that you form on the first bite</td>
<td></td>
</tr>
<tr>
<td><strong>4 Sustained impression of juiciness</strong></td>
<td>1= Extremely dry</td>
<td>AK</td>
</tr>
<tr>
<td></td>
<td>2= Very dry</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3= Fairly dry</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4= Slightly dry</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5= Slightly juicy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6= Fairly juicy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The impression of juiciness that you form as you</td>
<td></td>
</tr>
<tr>
<td></td>
<td>start chewing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td>Scores</td>
</tr>
<tr>
<td>---</td>
<td>-------------</td>
<td>-------</td>
</tr>
</tbody>
</table>
| 5 | Muscle fibre & overall tenderness  
Chew sample with a light chewing action | 1= Extremely tough  
2= Very tough  
3= Fairly tough  
4= Slightly tough  
5= Slightly tender  
6= Fairly tender  
7= Very tender  
8= Extremely tender | AK  
NS |
| 6 | Amount if connective tissue (Residue)  
The chewiness of the meat | 1= Extremely abundant  
2= Very abundant  
3= Excessive amount  
4= Moderate  
5= Slight  
6= Traces  
7= Practically none  
8= None | AK  
NS |
| 7 | Overall flavour intensity  
This is the combination of taste while chewing and swallowing-referring to the typical beef flavour | 1= Extremely bland  
2= Very bland  
3= Fairly bland  
4= Slightly bland  
5= Slightly intense  
6= Fairly intense  
7= Very intense  
8= Extremely intense | AK  
NS |
| 8 | A- Typical flavour intensity | 1= None  
2= Practically none  
3= Traces  
4= Moderate  
5= Slightly intense  
6= Fairly intense  
7= Very intense  
8= Extremely intense | AK  
NS |
Please evaluate the following off-flavour characteristics.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Cooking method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cooked</td>
</tr>
<tr>
<td>1 LIVER/BLOODY</td>
<td>AK</td>
</tr>
<tr>
<td>2 COOKED VEGETABLE</td>
<td>AK</td>
</tr>
<tr>
<td>3 PASTURE/GRASSY</td>
<td>AK</td>
</tr>
<tr>
<td>4 ANIMAL-LIKE/KRAAL (MANURE)</td>
<td>AK</td>
</tr>
<tr>
<td>5 METALLIC</td>
<td>AK</td>
</tr>
<tr>
<td>6 SOUR</td>
<td>AK</td>
</tr>
<tr>
<td>7 UNPLEASANT</td>
<td>AK</td>
</tr>
<tr>
<td>8 GOAT ODOUR</td>
<td>AK</td>
</tr>
</tbody>
</table>