Effects of dietary supplementation on physico-chemical and consumer sensory characteristics of chevon from South African indigenous goat genotypes

By

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Declaration

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

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Abstract

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The study was conducted at the University of Fort Hare farm to assess the effect of dietary supplementation on physico-chemical and consumer sensory characteristics of chevon from South African indigenous goat genotypes. Forty-eight 6-month-old Xhosa lop-eared (XLE), Nguni (NGN), Xhosa-Boer cross (XBC) and Boer (BOR) castrated goats with a body weight range from 20 to 25 kg were used in this study. Half of the goats in each genotype were supplemented with 200g/head/day of sunflower cake. The other half of goats in each genotype was not supplemented. The goats were slaughtered at day 90 to determine slaughter weight (SLW), cold dress mass (CDM), meat colour, cooking loss, meat pH and Warner-Bratzler (WB) shear force values. Furthermore, a consumer sensory evaluation of cooked or fried chevon from supplemented and non-supplemented goats was conducted with consumers of different ages, tribes and gender. The XLE and NGN goats had higher pH_{24} ($P < 0.05$) than BOR and XBC goats. Supplemented BOR goats had higher L* values than their non-supplemented counterparts ($P < 0.05$). The other meat quality attributes in XLE and NGN were comparable to those in meat from the Boer goat. Female respondents gave higher ($P < 0.05$) sensory scores than male respondents for both cooked and fried meat on aroma intensity. Shona consumers gave higher ($P < 0.05$) aroma intensity scores than the Xhosa and the Zulu consumers for both cooked and fried meat. In the non-supplemented goats, fried meat for all genotypes was superior ($P < 0.05$) to the cooked meat for initial impression of juiciness. Age and gender of respondents and thermal treatment influenced initial impression of juiciness scores ($P < 0.05$). The quality of chevon from XLE and NGN was comparable to that of the Boer goat, and dietary supplementation improved most meat quality attributes. Chevon from the supplemented goats had higher consumer sensory scores than chevon from the non-supplemented goats.

Keywords: supplementation, meat colour, ultimate pH, consumer sensory evaluation, Xhosa lop eared, Nguni, Boer goats.

List of abbreviations

a* - Redness

b* - Yellowness

BOR - Boer

CDM - Cold dress mass

CL - Cooking loss

L* - Lightness

MP - Metabolisable protein

NGN - Nguni

NS – Non - supplemented

SAS – Statistical Analysis System

SLW - Slaughter weight

WBS - Warner - Bratzler Shear force

XBC - Xhosa Boer cross

XLE - Xhosa lop - eared

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Chapter 1: Introduction

Goats play an important socio-economic role in communal production systems among resource-poor farmers in South Africa. In 1997, there were 6.6 million goats in South Africa, with 64 % in rural areas, and about 3.15 million in the Eastern Cape, with 59 % in rural areas (Coetzee, 1998). Indigenous goats are common in the communal areas than the improved Boer goats, which are mostly found in commercial farms (Mamabolo and Webb, 2005). Indigenous goats have short generation intervals, high prolificacy and require low inputs for moderate levels of production, reach maturity early and easily adapt to a wide range of climatic conditions. They provide meat, milk and fibre and play a key role in achieving food and economic securities for the resource-poor (Sahlu *et al.*, 2004). Red meat consumption in South Africa has been limited mainly to sheep and cattle. Indigenous goats are mostly farmed in communal areas and are also used for cultural activities.

Common indigenous goat genotypes in South Africa include the Nguni, Boer goat and their crosses. The Nguni goat is a small-framed breed that has been reported to be hardy and can thrive under local environmental conditions, utilising available feed resources much more efficiently (Dziba *et al*, 2003; Nyamukanza and Scogings, 2008). The Xhosa lop-eared goat is a large-framed goat breed well known for its attractive coat pattern of various colours. Boer goats are largely used in large-scale commercial farms. They are known for their high meat production and their hardiness to several diseases (Almeida *et al.*, 2007). Indigenous goats are generally hardy and adapted to local production conditions. They are also increasingly becoming important in commercial goat production in South Africa.

Goats, like any animal, require nutrients for body maintenance, growth, reproduction, pregnancy and production of products such as meat, milk and hair. Protein is the most limiting nutrient in goats (Poore and Luginbuhl, 2002). Arsenos *et al*. (2009) reported that dietary protein supplementation in grazing kids enabled them not only to minimize the penalty of gastrointestinal parasitism, but also to produce carcasses of better conformation and fatness. There is, however, limited research on the effect of plane of nutrition on the quality of meat from indigenous goats. Knowing the quality of goat meat will increase the consumption of goat meat and increase the opportunities of commercializing chevon.

Meat quality is a combination of chemical and sensory attributes (Dhana *et al*., 1999; Madruga *et al*., 2009). Consumers focus on how meat can contribute to their personal satisfaction. Consumers expect the meat products on the market to have the required nutritional value, be wholesome, fresh, and lean and have adequate juiciness, flavour and tenderness (Hoffman and Wiklund, 2006). Meat tenderness is, arguably, the most important quality trait for a consumer (Muchenje *et al*., 2009a). Tenderness is based on ease of chewing that is contributed by many factors. Among them, the fibrous nature of muscle contributes to chewing resistance (Gerrard and Grant, 2003). It has been linked to several factors such as the animal's age, sex, live weight, breed (Muchenje *et al*., 2009a) or the muscle location, and slaughter methods. According to Muchenje *et al*. (2008a), the impression that is formed on the first bite of meat and the amount of connective tissue in meat, are also important sensory characteristics.

Meat texture is perceived as a combination of tactile sensations resulting from the interaction of senses with physical and chemical properties, such as toughness, moisture and elasticity. Toughness can be defined as the ease with which meat can be cut and masticated (Beriain *et al.*, 2001). Appearance is the visual identification of meat based on colour, marbling and water holding capacity. The colour of meat is related to the level of pigmentation (myoglobin) present in the muscle. High pre-slaughter stress can lead to a rise in pH which can result in dark colour (Monoley, 1999; Muchenje *et al*., 2008b). Flavour is one of the components of sensory evaluation that affect meat acceptability by consumers. It is a combination of several chemical interactions involving proteins, lipids and carbohydrates (Muchenje *et al*., 2009b) and is a complex attribute of meat palatability (Calkins and Hodgen, 2007).

Preparation and method of eating varies widely between age and culture of consumers. The tradition in Southern Africa is to slaughter goats by severing the jugular vein, collect the blood and dress down the carcass (Casey, 1992). The carcass is cut up and the flesh prepared by boiling. Dzudie *et al*. (2000) reported that roasted loins had higher scores for flavour than those cooked by broiling. Aaslyng *et al*. (2003) concluded that cooking at 90°C oven temperature gave juicier meat than cooking at 190°C. Cooking-time, cooking losses and tenderness seem to be the main characteristics affected by the cooking method (Dzudie *et al*., 2000). Information on the effect of cooking method for chevon, especially the indigenous goats of Southern Africa, is scarce. In addition, a number of studies have been conducted on the palatability and acceptability of chevon, but in most cases, the studies have employed trained taste panels. Consumer perceptions are generally ignored (Simela *et al*., 2008).

1.1. Justification

Consumers are increasingly becoming concerned about healthy and safe products and the demand for these products is escalating. The content and the amount of fatty acid saturation can affect the human health and the degree of fat firmness, which influences the value and acceptability of meat products (Peña *et al*., 2009). Chevon is leaner than meat from most livestock and, therefore, provides health eating (Webb *et al*., 2005). Knowledge of the meat quality of the indigenous breeds increases the opportunities of commercializing chevon. The interactions among diet, breed-type and meat quality in indigenous goats have not been established. Yet goats under the communal production systems are hardly controlled of parasites and receive varying levels of nutrition across the year. There are no studies that have been conducted considering the interaction of breed, diet and consumer acceptability on meat quality.

1.2. Objectives

The broad objective of the study was to determine the effect of dietary supplementation on quality and consumer acceptability of chevon from indigenous goat genotypes of South Africa.

The specific objectives were to:

1. Determine the effects of diet and goat genotype on chevon physico- chemical quality; and
2. Determine consumer sensory scores of chevon from indigenous goat genotypes

1.3. Hypothesis

The hypothesis tested:

1. Supplementary feeding has no effect on the quality of chevon from indigenous goats of South Africa.
2. Genotype and supplementary feeding has no effect on sensory scores of chevon

1.4. References

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Chapter 2: Literature review

2.1. Introduction

In most countries in Southern Africa goats are the second most important livestock species after cattle (Rumosa Gwaze *et al*., 2009). In South Africa 50% of the country's goat population is kept under small-scale condition (Rumosa Gwaze *et al*., 2009). Compared to lamb and beef, chevon has received limited attention as a source of red meat (Lee *et al*., 2008; Swan *et al*., 1998). This chapter gives emphasis on communal goat production systems, meat quality characteristics of chevon and consumer acceptability and sensory evaluation of chevon.

2.2. Communal goat production systems

Easy handling and the effective conversion of limited food resources into meat and milk are important factors favouring the goat as a stock animal for small-scale farmers. Communal goat fulfill multiple roles that include provision of meat, milk and fibre and play a key role in achieving food and economic securities in developing regions (Sahlu *et al.*, 2004). According to Masika and Mafu (2004) and Aganga *et al.* (2005), the reasons for goat keeping in rural areas are: for slaughter during rituals, sales and to a lesser extent for milk production, and for security against crop failure in some cases. In rural areas of the Eastern Cape province South Africa, selling of live goats occurred mainly during the holiday seasons (April, June and December) when most traditional ceremonies take place (Mahanjana and Cronje, 2000, Masika and Mafu, 2004).

In 2009 there were 6.4 million goats in South Africa and about 2.3 million in Eastern Cape (Table 2.1). Indigenous goats are common in the communal areas than the improved Boer goats,

Table 2.1: South African goats numbers by Province in 2009

Province	Goat numbers
Western Cape	229 921
Northern cape	528 454
Free state	258 336
Eastern Cape	2 385 218
KwaZulu-Natal	865 427
Mpumalanga	94 724
Limpopo	1 313 255
Gauteng	44 782
North West	734 842
Total	6 454 959

National Department of Agriculture (2009) which are mostly found in commercial farms (Mamabolo and Webb, 2005). Indigenous goats have several advantages which include short generation intervals, high prolificacy and require low inputs for moderate level of production, reach maturity early and easily adaptable to a wide range of climatic conditions. Rumosa Gwaze *et al.* (2009) reported that indigenous goat breeds are better able to utilise low quality feeds and can walk for longer distances in search for water and food than imported breeds.

In South Africa, indigenous goats are reared by most communal farmers under smallholder production systems. Common indigenous goat genotypes in South Africa include the Nguni, Boer goat and theirs crosses. The Nguni goat is a small-framed breed that has been reported to be hardy and can thrive under local environmental conditions, utilising available feed resources much more efficiently (Dziba *et al*, 2003; Nyamukanza and Scogings, 2008). The Xhosa lop-eared goat is a large-framed goat breed well known for its attractive coat pattern of various colours. The numbers of the Xhosa lop-eared, one of the genotypes which were upgraded to produce the modern fast–growing Boer goat, is dwindling. As such its value on the local market has increased markedly. Indiscriminate crossing with synthetic and exotic breeds also occur, resulting in changes in some morphological traits in goats, such as stature (Masika and Mafu, 2004). These resultant crosses have been reported to dominate most communal areas (Cardellino, 2009). The Boer goat is farmed commercially on large scale farms in South Africa and is being exported worldwide and is known for its high meat production and its hardiness to several diseases (Almeida *et al.,* 2007). These local goat genotypes, however, constitute valuable sources of genetic material because of their adaptation to harsh climatic conditions, their ability to better utilize the limited and poor quality feed resources and their resistant to a range of diseases such as pulpy kidney, gall sickness and internal parasites (Mamabolo and Webb, 2005).

Although indigenous goat breeds are hardy, their growth performance is generally poor, partly as a result of high disease and parasite challenge and low nutrition (Peacock, 1996). Few of the farmers in rural areas own a buck, which will be utilised to mate the entire goat herd in the villages (Masika and Mafu, 2004). High mortality among kids and slow growth among those that survive are major constraints to goat production (Sebei *et al.,* 2004). Aganga *et al*. (2005) reported that high mortality rate of Tswana kids resulted from diseases, with kids mortality accounting for 33, 3 % and overall pre-weaning mortality caused by diseases was 44, 6 %. Most common diseases reported in communal areas were heart water, pneumonia, pulpy kidney, foot rot (Masika and Mafu, 2004; Rumosa Gwaze *et al*., 2009) and worm infestation (Rumosa Gwaze *et al.*, 2009).

Daily movement of livestock from home to grazing fields is recognised as an important aspect of management within the system. Goats are herded during the day and penned at night. In most communal areas school children are responsible for herding goats, implying that grazing is dependent on the school time table (Rumosa Gwaze *et al*., 2009). All these factors influence the growth of goats and the quality of goat meat.

2.3. Meat quality characteristics of chevon

Goat meat is an important source of protein throughout the world especially in developing countries (Ding *et al.,* 2010). Goat production has been an economically important activity helping to alleviate poverty and improve nutrition. Despite the importance of goats as a source of food limited research data are available on the yield and quality of goat. This is partially attributed to the traditionally low economic significance to these animals in many countries compared to sheep and cattle.

Perception of meat quality varies from country to country between ethnic and age groups and over time. While some countries discriminate against goat meat other communities prefer goat meat to beef such as in many tropical regions (Dhanda *et al*. 1999). Meat quality is defined as the compositional quality and the palatability of meat (Muchenje *et al*., 2009a). The quality measures may be presented in groups that are closely related and determine a defined component of meat quality.

The quality measures related to visual aspect (colour, water holding capacity and fatness) and the palatability (juiciness, flavour and aroma) are regarded as the key measures that determine consumers' initial and continued interest in meat (Muchenje *et al.*, 2009a). From growth to slaughter, there are factors such as stress, ageing, pH and breed that may affect the quality of meat.

2.3.1. Colour of chevon

Colour is one of the most important factors in consumer selection and decision to purchase meat and meat products (Muchenje *et al*., 2009a). Colour of meat depends upon several individual factors and their interactions. Differences in meat colour have been associated with variations in intramuscular fat and moisture content, age dependent changes in muscle myoglobin content, the pHu of the muscle (Muchenje *et al*., 2008). Myoglobin is the basic pigment in fresh meat and its content varies with production factors such as species, animal age, sex, feeding system, type of muscle and muscular activity. Specific reactions such as lipid oxidation also increase the rate of pigment oxidation (Kannan *et al*., 2001).

Meat colour is defined in terms of the colorimetric co-ordinates, L *, a * and b*(Commission International De I' Eclairage, 1976). L* is the lightness component indicating the black-whiteness of the meat. Its values ranges from 0 (all light absorbed) to 100 (all reflected), a* spans from -60 (green) to +60 (red) and b* spans from -60 (blue) to +60 (yellow). Chevon has been reported to have lower lightness and higher redness than lamb, mainly due to the lower intramuscular fat of goat carcasses (Kannan *et al*., 2001).

Some L*, a* and b* values that have been reported for *M. semimembranosus* and *M. longissimus* of goats are shown in Table 2.2. Dhanda *et al*. (1999) reported that chevon became darker with increase in age. In another case, Dhanda *et al*. (2003) found that genotype had a significant effect on muscle colour. Lee *et al.* (2008) reported no differences in lightness (*L** value) of loin chops between goats and lambs. Chevon chops had, however, lower redness (*a**) values than lamb chops. Kannan *et al*. (2001) also reported that time of storage had an effect on a^* value or redness of chevon cuts. The average values were high at day 0, low at days 8 and 12, and intermediate at day 4. The colour values for chevon from indigenous goats are not known.

Table 2.2: Colour co-ordinates of goat *M. semimembranosus* and *M. longissimus thoracism* measured at 24 hours *post-mortem*

Goat	L*	a*	b*	Source
Boer × Angora	37.7	12.0	3.0	Dhanda *et al.* (1999)
Boer × Saanen	37.7	14.8	2.1	□
Feral	37.1	14.4	2.0	□
Saanen × Angora	37.0	14.0	2.5	□
Saanen × Feral	34.6	12.7	1.7	□
Spanish does	42.5	17.8	8.9	Kannan *et al.* (2001)

L* = Lightness, a* = redness, b* = yellowness

2.3.2. Tenderness of chevon

Meat tenderness is the most difficultly predicted trait, but it is very important to meat quality and consumer acceptance. Tenderness is based on ease of chewing that is contributed by many factors. Among them, the fibrous nature of muscle contributes to chewing resistance (Gerrard and Grant, 2003). Tenderness varies mainly due to changes to the myofribrillar protein structure of muscle in the period between animal slaughter and meat consumption. If the carcass is refrigerated too hastily immediately after slaughter, muscle fibers contract severely, the result is cold shortening which will require a force to shear the fibers after cooking (Muchenje *et al*., 2009a).

The animal's age, sex or the muscle location, live weight, breed and ante-mortem stress are other factors that attribute to tenderness variation (Muchenje *et al*., 2009a). Studies in the evaluation of goat meat and its palatability have compared the meat to lamb or mutton and other meats (Babiker *et al*., 1990; Griffin *et al.*, 1992; Tshabalala *et al*., 2003). Tenderness and palatability values of chevon are often in the acceptable range (Table 2.3).

Table 2.3: Average tenderness ratings of chevon

Tenderness rating	Hedonic scale	Source
5.5	8 point	Griffith *et al*. (1992)
4.3	9 point	Tshabalala *et al*. (2003)
2.8	5 point	Babiker *et al*. (1990)

2.3.3. pH and quality of chevon

A high ultimate pH is generally indicative of stress in animals (Dhanda *et al.*, 2003; Muchenje *et al.*, 2009b). It may result from transportation, rough handling, inclement temperatures, or anything that causes the animal to draw on its glycogen reserves before slaughter. Mushi *et al*. (2009) reported that higher pHu for goats can be associated with low glycogen reserve due to insufficient nutrition. Nutritional stress can result in dehydration, electrolyte imbalances, negative energy balance, glycogen depletion in muscle, and catabolism of protein and fat, ultimately increasing the pHu (Dhanda *et al.*, 2003; Mushi *et al*., 2009). Meat tenderness is normally related to the pHu value (Muchenje *et al*., 2008).

2.3.4. Cooking loss

Cooking loss refers to the reduction in weight of meat during the cooking process (Jama *et al*., 2008). Major components of cooking losses are thawing, dripping and evaporation. Thawing loss refers to the loss of fluid in meat resulting from the formation of exudates following freezing and thawing. Dripping is the loss of fluid from meat cuts and water evaporation from the shrinkage of muscle proteins (actin and myosin) in the form of drip (Yu *et al*., 2005). Gadiyaram and Kannan (2004) reported that cooking losses were the lowest for chevon sausages compared to the other types of sausages. Babiker *et al*. (1990) found cooking loss of 30-35%. Dhanda *et al*. (1999), however, reported cooking loss from different genotypes in the range of 33 – 45 %, with the exception of chevon from Boer x Angora crossbred goats, which lost 51.5%.

2.4. Consumer acceptability and sensory evaluation of chevon

Consumers consider several characteristics in order to determine the acceptance of food products, sensory characteristics, nutritional value, convenience and its impact on health (Monson *et al*., 2005; Muchenje *et al*., 2009a). Tenderness is one of the most important criteria for meat quality and it has been demonstrated that consumers are ready to pay a higher price once assured that the meat is tender (Monson *et al*., 2005). Tenderness can be attributed to a person's perception of meat such as softness to tongue, resistance to tooth pressure and adhesion (Muchenje *et al*., 2009a).

Monson *et al.* (2005) reported that consumers can focus on flavour when meat is tender and flavour becomes the major factor in acceptability. The authors also concluded that most consumers (51%) on the survey identified tenderness as the attribute that contributes most to eating satisfaction, but when steaks were evaluated at home, flavour affected overall ratings more than tenderness ratings. Furthermore, Muchenje *et al*. (2009a) found flavour to be one of the most important components of sensory evaluation that affect meat acceptability by consumers.

Simela *et al*., (2008) reported that chevon is an acceptable meat in the South African market and can be as acceptable as mutton if the meat is from young goats of about a year to two years old (milk teeth to 6 permanent incisors). One aspect that may undermine the acceptance of chevon to South African consumers is their general lack of exposure to goat meat. Most studies in the evaluation of goat meat and its palatability have compared goat meat to mutton (Babiker *et al.*, 1990; Tshabalala *et al*., 2003). The tenderness of meat is affected by the solubility and the amount of collagen, while the sensation of juiciness in cooked meat is closely related to the intramuscular fat content. The more tender the meat, the more rapidly juices are released by chewing and the fewer residues remain in the mouth after chewing (Ding *et al.*, 2010). Ding *et al.* (2010) reported that genotype strongly affected the tenderness and juiciness of the *longissimus thoracis*.

Lawrie (2006) stated that cooked meat has two different organoleptic components. The first is the impression of wetness during the first few chews and is produced by the rapid release of meat fluid. The second is the sustained juiciness resulting from stimulatory effect of fat on salivation. The latter component explains why, for example, meat from young animals gives initial impression of juiciness but ultimately a dry sensation due to the relative absence of fat (Lawrie, 2006).

Chevon products have been reported to be less juicy than mutton products (Tshabalala *et al.*, 2003) and this has been attributed to the low fat content of chevon. Tshabalala *et al.* (2003) reported that indigenous goat patties were least juicy and greasy and differed significantly compared to those from Boer goat and the sheep breeds. Sheep meat was found to be juicier, tender and contained less connective tissue residue and more palatable compared to chevon. Generally, juiciness of meat is directly related to the intramuscular lipids and moisture content of the meat (Muchenje *et al.,* 2008). McMillin and Brock (2005) observed that high-energy intake increased fat content of chevon and hence, the juiciness, tenderness and texture of chevon, Nevertheless, Webb *et al*. (2005) reported that goat meat and goat products are reportedly less juicy compared to mutton and this has been attributed to the lower intramuscular lipid content of goat meat.

Flavour and aroma are two complex attributes of meat affected by species, age, fatness and type of tissue, locality, gender, diet and method of cooking (Webb *et al*., 2005). These attributes are the most easily detected and assed by consumers as to being either acceptable or not (Webb *et al.,* 2005). Flavour is one of the most important sensory attributes for the overall acceptance of meat (Meinert *et al.,* 2007). There are literally hundreds of compounds in meat that contribute to flavour and aroma (Calkins and Hodgen, 2007). Many of them are altered through storage and cooking, making meat flavours an incredibly complex topic (Calkins and Hodgen, 2007). The characteristic meat flavour is formed during the cooking process (Meinert *et al*., 2007), when the non-volatile flavour precursors react through a series of complex biochemical processes (Meinert *et al*., 2007). Age affects flavour with the younger goats has more desirable flavour (Webb *et al.,* 2005). The degree of marbling of the muscle is significantly related to flavour intensity, and meat with a desirable flavour tended to have higher levels of intramuscular fat and more intense marbling (Ping *et al.,* 2008). Many compounds that contribute to meat smell and flavour are lipid breakdown products (Calkins and Hodgen, 2007).

A number of studies have been conducted on the palatability and acceptability of chevon, but most instances the studies have employed trained taste panels. In most of them, chevon and chevon products were rated high quality (Tshabalala *et al*., 2003). Despite these outcomes indications are that consumers perceive chevon as tough and smelly (Mahanjana and Cronje, 2000).

2.9. Summary

Indigenous goats of South Africa are hardy. Their productivity is slowed down by several constraints that include high prevalence of disease and parasites. It is also found that goats produce meat that has lower fat compared to other red meat. It is, therefore, important to develop research and development programs to improve the quality of chevon from indigenous goats and to understand the acceptance of chevon among consumers.

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Chapter 3: Effect of dietary supplementation on chevon quality of indigenous goat genotypes of South Africa

By Nomasonto Martha Xazela

Abstract

The effect of breed and sunflower cake dietary supplementation on meat quality of goat genotypes was assessed using forty-eight 6-month-old Xhosa lop-eared (XLE), Nguni (NGN), Xhosa-Boer cross (XBC) and Boer (BOR) castrated goats. The goats were slaughtered at day 90 to determine slaughter weight (SLW), cold dress mass (CDM), meat colour, cooking loss, meat pH and sheer force values. Supplemented BOR and XBC goats had a significantly higher ($P < 0.05$) SLW and CDM than non-supplemented groups. The XLE and NGN goats had higher pH_{24} ($P < 0.05$) than BOR and XBC goats. Supplemented BOR goats had higher L* values than their non-supplemented counterparts ($P < 0.05$). The supplemented BOR and NGN goats had higher b* values compared to their non-supplemented counterparts. The XLE and NGN had meat quality attributes that were comparable to the Boer goat. Dietary supplementation improved meat quality attributes of the goats.

Keywords: Boer goat; meat colour; Nguni goats; ultimate pH; Xhosa lop-eared goats

3.1. Introduction

Meat quality is important for consumers when it comes to making purchasing decisions. The colour, tenderness and sensory properties or eating quality are important factors affecting meat acceptability (Muchenje *et al*., 2009a; Peña *et al*., 2009; Warren *et al.,* 2008). One of the major factors that affect the eating quality of meat is the nutritional status of goats with breed and diet having an impact on flavour (Warren *et al*., 2008). Meat quality is also affected by intrinsic factors in the animal, such as the proportions of different muscle fibres (Wood *et al*., 2004). Meat from goats has gained popularity mainly because of its low-fat content (Peña *et al*., 2009; Santos *et al.,* 2007), especially in developed countries. Chevon has been reported to contain higher collagen and lower solubility compared to other red meats (Kannan *et al*., 2006) and its intramuscular connective tissue remains unchanged during post-mortem aging (Kannan *et al.*, 2002).

Nutritional status of goats and type of feed have been found to have significant effect on slaughter and carcass weights (Oman *et al*., 1999), carcass measurements (Argüello *et al.*, 2005; Oman *et al*., 1999), muscle pH decline (Kannan *et al*., 2006) and possibly the rate of carcass cooling postmortem. It is, however, not clear whether the influence of dietary supplementation is consistent among different breeds and species.

Dhanda *et al*. (2003) reported that genotype had an influence on cooking loss, pigment concentration, muscle colour and sensory scores. Other authors, however, found no breed effects on meat quality (Esenbuga *et al.,* 2009). There are various goat breeds that are used as meat breeds in South Africa. The Boer, a meat breed, is the most popular breed that is commercially farmed in Southern Africa both in communal and commercial production systems. Other breeds kept in the communal areas include the Nguni breed, an ecotype of the small-framed East African goat, the large-framed Xhosa goat (commonly kept in northern eastern parts of South Africa, Namibia and southern Zimbabwe) and the Boer crosses with the Nguni and Xhosa dams. The Xhosa goat is believed to have been used to develop the modern improved Boer goat and other big framed breeds; however its population sizes is fast decreasing (Ramsey *et al*., 2000). There is a renewed interest in farmers that prefer this breed, largely because of its twinning ability, fast growth rates and excellent body conformation.

In general, little chevon is consumed in South Africa, particularly in the Eastern Cape. Most goat meat is consumed during traditional ceremonies (Mahanjana and Cronje, 2000; Masika and Mafu, 2004; Rumosa Gwaze *et al.*, 2009). In addition, whether (and to what extent) the quality of meat will be influenced by breed, diet and the body condition of the goat at slaughter has not been established. Understanding the meat quality of these breeds ensures the appropriate characterization and valuation of indigenous goats to assist in making decisions on breed conservation. The response of different goat genotypes to dietary supplementation has not been established. The objective of the study was, therefore, to determine the effect of genotype and supplementary feeding on the quality of chevon from indigenous goats. It has been hypothesized that there are no effects of genotype and supplementary feeding on quality scores of chevon.

3.2. Materials and methods

3.2.1. Site description

The study was conducted at the University of Fort Hare, Alice, Eastern Cape, South Africa. The site is 520 m above sea level and is located 32.48°S and 26.53°E. It is situated in the False Thornveld of the Eastern Cape, and the vegetation is characterised by several trees, shrubs, and grass species with *Acacia karroo, Themeda triandra, Panicum maximum, Digitaria eriantha, Eragrostis spp., Cynodon dactylon*, and *Pennisetum clandestinum* being the dominant plant species. The average rainfall is approximately 480 mm per year, and mostly comes in summer. Mean temperature of the farm is about 18.7°C per year. The topography of the area is generally flat with a few steep slopes.

3.2.2. Management of goats

Forty eight 6-month-old Xhosa lop-eared (XLE), Nguni (NGN), Xhosa-Boer cross (XBC) and Boer (BOR) castrated goats with body weights of between 20 and 25 kg were used in the study. From birth till weaning, the goats ran on the pastures with their dams. At weaning (3 months), the kids were vaccinated and de-wormed then assembled in a single flock. The goats were housed in an open-sided barn that complies with local welfare standards in two pens with free access to a basal diet of *Medicago sativa*. The nutritional composition of the basal diet is shown in Table 3.1.

3.1: Nutritional composition of the *Medicago sativa* and Sunflower cake used in the study (% DM basis)

Component	***Medicago sativa***	**Sunflower cake**
Dry matter	91.5	89.6
Crude protein	20.3	35.3
Crude fibre	33.5	25.9
Neutral detergent fibre	48.3	43.5
Acid detergent fibre	41.2	32.9
Ether extract	2.5	3.6
Calcium	1.4	0.9
Phosphorus	0.8	0.5

The basal diet met the needs for the goats for maintenance and growth (80 g/day CP; 5.69MJ/day ME). The goats also had free access to clean water. The goats were randomly divided into two balanced groups, with half of the goats provided with a supplementary feed. There were six goats per genotype per pen. Each of the two pens had a total of 24 goats.

The supplemented groups were given an additional 200g per head per day of sunflower cake (Table 3.1), such that the dietary supplemented diet would provide 160g/day CP, the apparent requirements of metabolisable protein (MP). The supplementary feed was given to the goats individually in individual crates. The goats were fed twice a day at 0800h and at 1700h.

The goats were kept for 90 days. The goats were weighed every two weeks. A day before slaughter, the goats were deprived of feed for 24 hours, but clean water was provided *ad libitum*. The animals were weighed before slaughter. An electrical stunner was used to stun the goats and then slaughtered using standard procedures. Skinning, evisceration and washing procedures were completed while the carcasses were on the overhead rail.

3.2.3. Meat quality measurements

Slaughter live weight (SLW) of each goat was taken before slaughter. Dressed carcasses were stored at 2°C for 24 h for maturation. The *Longissimus* muscle was collected from the right side at 0, 1, 4, 7, 12 and 24 h post-mortem to determine the pH and temperature of the meat. These were estimated using a pH meter with a piercing electrode and temperature probes (Crison pH 25, Crison Instruments, S.A., Alella, Spain). Cold dressed mass (CDM) for each carcass was also taken after 24 h.

Meat colour (lightness, L*; redness, a*; yellowness, b*) was measured (24 h after slaughter) from the *longissimus* muscle using a colour-guide 45/0 BYK-Gardener GmbH. For determination of cooking loss and Warner-Bratzler shear force (WBS) values, samples were weighed and then cooked for two minutes for each side and turned, which four minutes in total. After cooling, the samples were reweighed. Cooking loss (CL) was calculated using the following formula: Cooking loss % = [(weight before cooked – weight after cooked) ÷ weight before cooked] × 100.

After measurement of cooking loss, the cooked samples were used to determine shear force values. Three sub samples measuring 10 mm core diameter were cored parallel to the grain of the meat. The samples were sheared perpendicular to the fibre direction using a Warner Bratzler (WB) shear device mounted on an Instron (Model 3344) Universal testing apparatus (cross head speed at 400mm/min, one shear in the centre of each core).

3.2.4. Statistical analysis

The PROC GLM procedure was used to analyse the effect on breed and diet of slaughter weight, cold dress mass, cooking loss, L*, a*, b*, shear force values. Data on pH and temperature were analysed using the repeated measures in the mixed model procedure for repeated measures of SAS (2003).

The model used was:

$Y_{ijk} = \mu + B_i + D_j + (B \times D)_{ij} + E_{ijk}$

Where Y_{ijk} = slaughter weight, cold dress mass, cooking loss, L*, a*, b*, shear force values

μ = overall mean common to all observations

B_i = effect of breed (Xhosa lop eared, Nguni, Xhosa-Boer cross and Boer)

D_j = effect of diet

$(B \times D)_{ij}$= interaction between diet and breed

E_{ijk}= random error

3.3. Results

3.3.1. Slaughter weight and cold dressed mass

The effect of breed and diet on SLW and CDM are shown in Table 3.2. Diet had an influence ($P < 0.05$) on SLW. The supplemented BOR and XBC goats had a significantly higher SLW than non-supplemented goats. There was no difference in SLW of XLE and NGN irrespective of supplementation (Table 3.2). The SLW for all the non-supplemented genotypes were similar. Diet had an influence ($P < 0.05$) on CDM in all the genotypes, with supplemented goats being heavier than their non-supplemented counterparts (Table 3.2). All the non-supplemented genotypes had similar CDM.

Table 3.2: Meat quality characteristics of indigenous genotypes

	Breed								
	BOR		**XBC**		**XLE**		**NGN**		**SEM**
	NS	**Supp**	**NS**	**Supp**	**NS**	**Supp**	**NS**	**Supp**	
SLW (kg)	22.0^{a}	28.5^{bc}	22.3^{a}	28.5^{b}	20.3^{a}	21.8^{a}	20.3^{a}	23.5^{a}	1.52
CDM (kg)	8.3^{a}	12.3^{cd}	9.4^{ab}	12.4^{cde}	7.9^{a}	10.4^{bc}	7.8^{a}	10.4^{c}	0.71
CL (%)	32.3	33.5	34.0	29.0	40.5	40.5	33.0	35.8	4.62
L*	34.6^{b}	37.1^{c}	32.7^{a}	33.2^{a}	30.8^{a}	33.9^{b}	29.3^{a}	32.0^{a}	1.67
a*	13.4^{a}	14.7^{ab}	15.6^{b}	16.6^{b}	15.9^{b}	13.9^{a}	17.3^{b}	17.1^{b}	0.82
b*	9.3^{a}	12.5^{bc}	12.3^{b}	11.2^{b}	10.8^{a}	10.1^{a}	10.9^{a}	13.1^{c}	0.92
WBF (N)	35.7^{b}	31.2^{ab}	28.8^{a}	22.9^{a}	24.5^{a}	23.9^{a}	24.8^{a}	24.8^{a}	3.41
pH_{24}	5.8^{a}	5.7^{a}	5.8^{a}	5.9^{ab}	6.1^{b}	6.1^{b}	6.2^{b}	5.9^{ab}	0.09

Means in the same row with different superscript are significantly different ($P < 0.05$).

BOR =Boer, XBC = Xhosa × Boer cross, XLE = Xhosa lop eared, NGN = Nguni

NS =Non-supplemented, Supp = Supplemented

SLW = Slaughter weight, CDM = cold dress mass, CL = Cooking loss, L* =Lightness, a*= redness, b* = yellowness, WBF = Warner Bratzler Force value

3.3.2. Changes in pH and temperature in carcasses

Figures 3.1a and 3.1b show pH changes overtime for the supplemented and non-supplemented genotypes. All the genotypes had the same pH after 1 hour of slaughter. However, the pH of all breeds except the NGN breed, declined sharply after 4 hours to a constant. The decline in pH was more pronounced in the BOR carcasses. The rate of pH drop was slowest in the NGN goats. From 12 hours post-mortem, the pH in BOR and XBC was similar, and markedly lower than XLE and NGN carcasses. After 1 hour of slaughter, the supplemented XLE and NGN goats had higher pH values than the supplemented BOR and XBC. The pH in all genotypes dropped after four hours, and the supplemented BOR genotype had the lowest pH value. However, an increase in pH was observed in all genotypes after 7 hours. The supplemented XLE goats maintained highest pH values throughout the observation period. Supplementary feeding had no effect on the pH_{24} in all the four genotypes (Table 3.2). Genotype, on the contrary, had a significant effect on pH_{24} (Table 3.2). The XLE and NGN goats had higher pH_{24} ($P < 0.05$) than BOR and XBC goats. pH_{24} values were highest for XLE and lowest in the XBC.

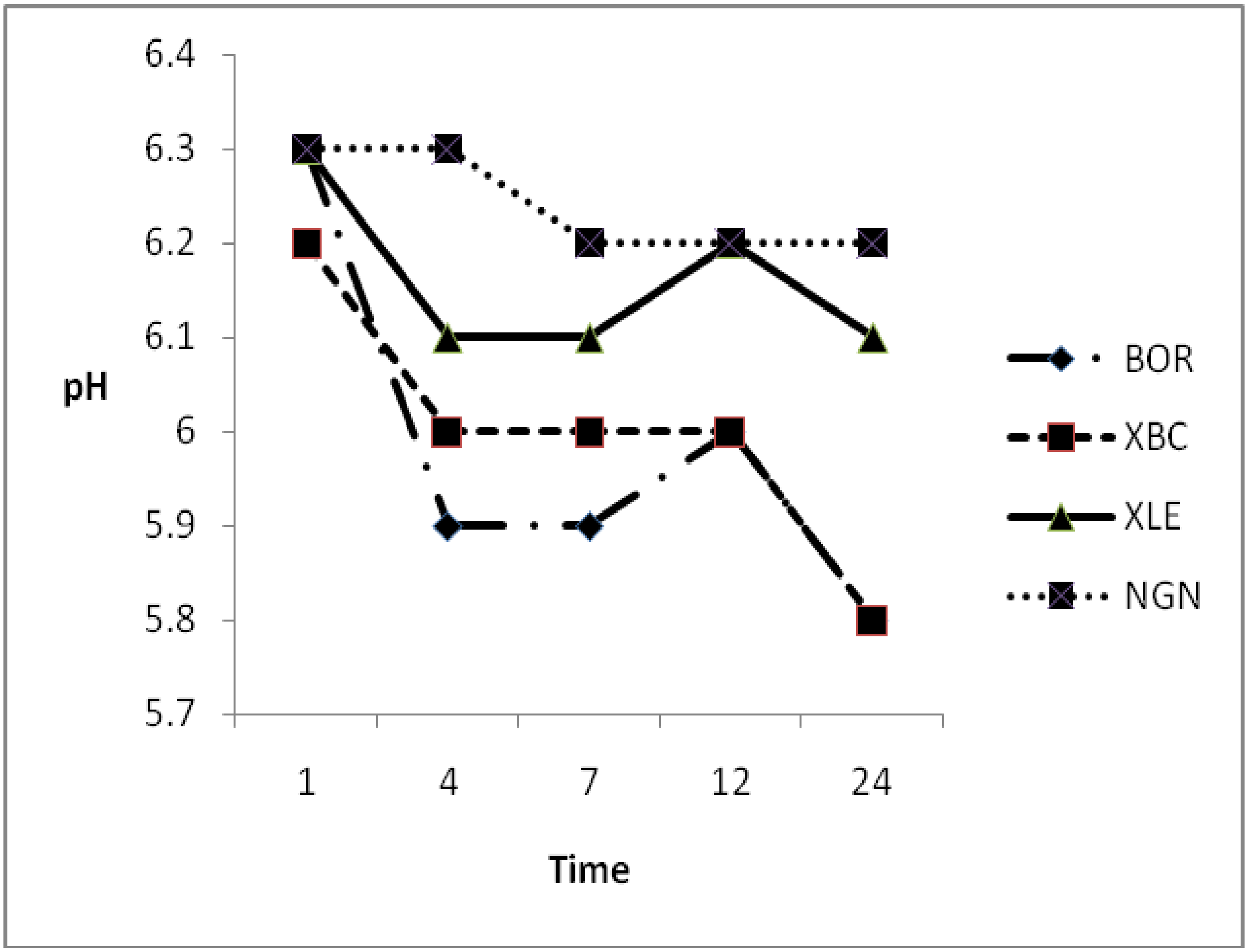

Figure 3.1a: pH changes overtime for non-supplemented Boer (BOR), Boer × Xhosa cross (XBC), Xhosa lop eared (XLE) and Nguni (NGN) goats

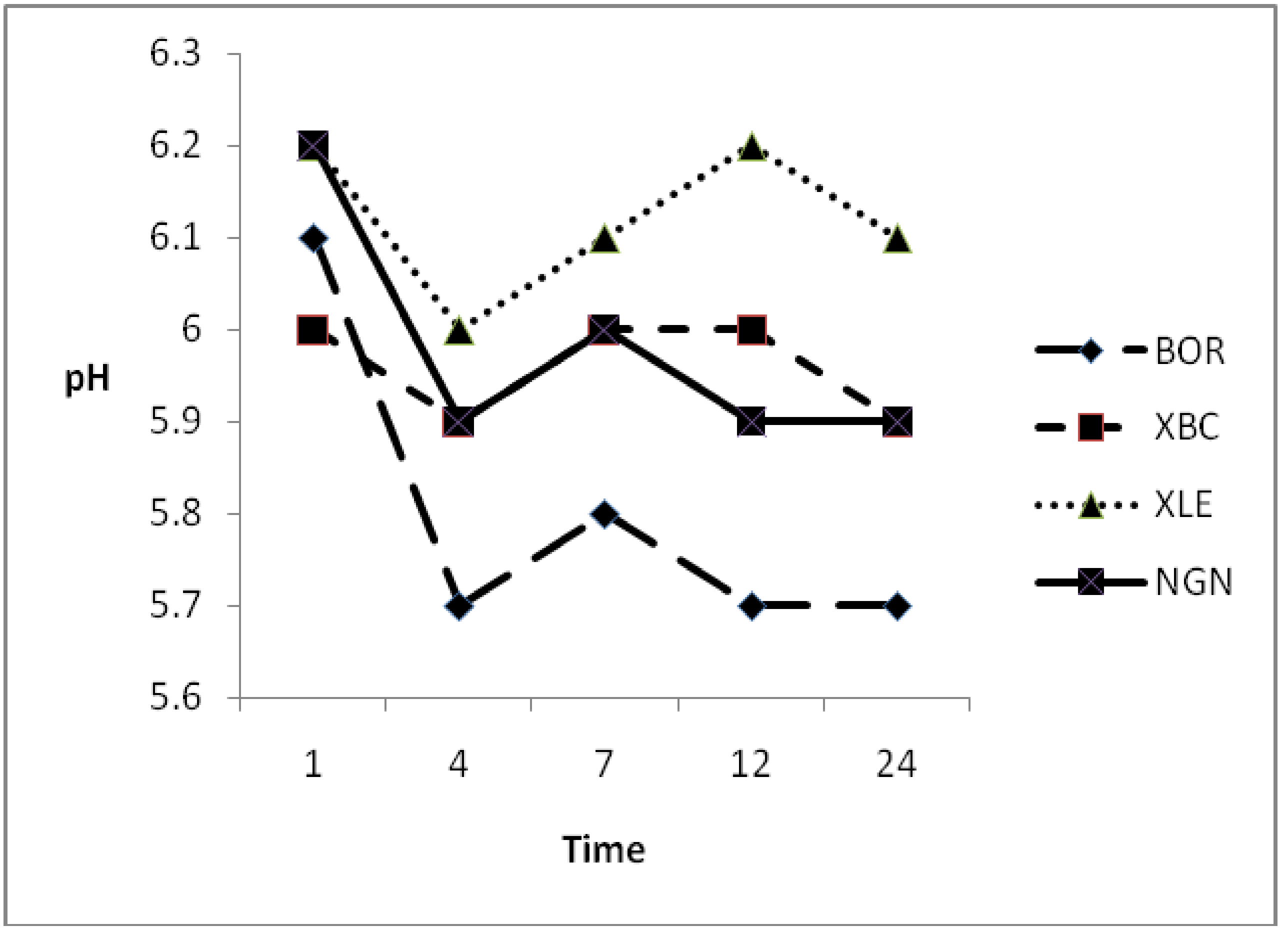

Figure 3.1b: pH changes overtime for supplemented Boer (BOR), Boer × Xhosa cross (XBC), Xhosa lop eared (XLE) and Nguni (NGN) goats

Temperature changes overtime in supplemented and non-supplemented genotypes are shown in Figure 3.1a and 3.1b. The temperature in all genotypes after one hour post-mortem was similar. Post-mortem temperature changes were also similar in all genotypes. After one hour of slaughter BOR and XLE had similar temperature values and NGN had higher value than XBC. At four hours after slaughter BOR, XBC and XLE were similar, NGN was slightly higher. After seven hours of post-mortem XBC and XLE had similar values of temperature, BOR and NGN had similar values. From 12 hours BOR and XBC had similar temperature values, markedly lower than XLE and NGN values.

3.3.3. Physico - chemical quality characteristics

As shown in Table 3.2, genotype had a significant influence ($P < 0.05$) on WBF. The WBF for all genotypes, however, were not affected by dietary supplementation. Feed supplementation had not increased the tenderness of BOR meat ($P > 0.05$) however the BOR had higher score. Both diet and genotype had no significant influence ($P > 0.05$) in CL. There was a significant interaction between genotype and diet ($P < 0.05$) on a* values. For each genotype, the supplemented and non-supplemented goats had similar a* values, except for the XLE goats (Table 3.2). In the XLE goats, the a* values were lower in the supplemented goats. Genotype had an effect ($P < 0.05$) on L* values (Table 3.2). Supplemented BOR goats had higher L*values than their non-supplemented counterparts ($P < 0.05$). No differences in the NGN and XBC goats were observed. Contrary to the a* values, supplemented XLE had higher L* values than non-supplemented goats. Supplementation improved meat quality attributes, and indigenous genotypes had qualities that were comparable to Boer goat. Significant diet × genotype interaction was observed on b* values. The supplemented BOR and NGN goats had higher b* values as compared to their non-supplemented counterparts. Supplementary feeding had no effect on b* values on the XBC and XLE goats.

3.4. Discussion

The high SLW observed in the supplemented BOR and XBC compared to the non-supplemented could be that they are able to utilise feed more efficiently than XLE and NGN goats. The BOR goat and XBC are regarded as meat breeds which have been selected for efficient utilisation of feed for maximum muscle deposition (Ramsey *et al.*, 2000). The NGN and XLE are indigenous breeds which are adapted to the fibrous feeds which characterise most communal production systems. The disparity in CDM observed between the supplemented and non-supplemented XLE and NGN, having same SLW, could be attributed to the big abdominal cavity in the non-supplemented goats to cater for the fibrous feeds (Silanikove *et al*., 1993) and, hence, small muscle accretion in contrast to the supplemented goats with small abdominal cavity but high muscle accretion.

The observed ultimate pH ranging from 5.7 to 6.2 could be considered to be on the higher side though they are within the acceptable range (Dhanda *et al.*, 2003; Muchenje *et al*., 2009a). A high ultimate pH is generally indicative of stress in animals (Dhanda *et al.*, 2003; Muchenje *et al.*, 2009b). The higher muscle pH values in the NGN and XLE goats irrespective of supplementation could be attributed to inherent breed characteristics and possibly, due to differences in their response to pre-slaughter handling. The BOR goats, with the lowest pH, were developed as a meat breed and, therefore, are normally calm while XLE and NGN are not typically developed as a meat breeds. The NGN and XLE are temperamental breeds (Ndou *et al*., 2010). They are highly active and can be easily agitated, and hence results in significant reduction in glycogen reserves. A high pHu also reflects depletion of muscle glycogen due to stress or other factors (Dhanda *et al.,* 2003, Muchenje *et al*., 2009b; Mushi *et al*., 2009). Generally, the supplemented goats had lower pH than non-supplemented because the supplemented goats were likely to have higher glycogen levels than the non-supplemented. Unfortunately glycogen concentration was not measured in this study. Mushi *et al*. (2009) reported that higher pHu for goats can be associated with low glycogen reserve due to insufficient nutrition. Nutritional stress can result in dehydration, electrolyte imbalances, negative energy balance, glycogen depletion in muscle, and catabolism of protein and fat, ultimately increasing the pHu (Dhanda *et al.,* 2003, Mushi *et al*., 2009). Meat tenderness is normally related to the pHu value (Muchenje *et al*., 2008). Although there was no apparent variations in temperature decline between the breeds in this study, it has been observed that the rates of muscle pH and temperature decline and pH–temperature interaction during the immediate postmortem period generally has a remarkable effect on meat tenderness (Kannan *et al.,* 2006).

The observed insignificant variation in WBF between the breeds concurs with other authors who also observed lack of variation in WBF between breeds (Madruga *et al.,* 2008; Yilmaz *et al.,* 2009). The mean Warner Bratzler shear force results in the current study (between 22.9 and 35.7 N) were within the normal range, but they were lower than those reported for meat samples of several goat kid genotypes (Dhanda *et al.,* 2003; Kadim *et al.,* 2003). Considering that the Warner–Bratzler force values exceeding 54 N which often would be considered to be tough by consumers (Shackelford *et al*., 1991), the meat from the indigenous goats from the current study could, therefore, be classified as moderately tender, though it is generally believed that goat meat does not always attain a higher degree of acceptable tenderness (Madruga *et al.*, 2008).

More often than not, the colour of meat is used to judge the freshness and quality of meat by consumers at the point of purchase (Ekiz *et al*., 2010). The XLE had lower a* values in the supplemented goats. The redness values in meat are influenced by factors such as breed (Dhanda *et al*., 1999; Ekiz *et al*., 2010; Santos *et al*, 2007) slaughter weight (Martinez-Cerezo *et al*., 2005) production system, ultimate pH (Ekiz *et al*., 2010). From the results, supplementation and its interaction with genotype caused some significant variation in the redness of the meat. Supplemented BOR goats had higher L* values while the NGN had the highest values for both a* and b*. The darker colour observed is consistent with the high pHu (6.1) recorded for these genotypes. Carcasses with low pHu had a better colour quality (Simela *et al*., 2004). Supplemented XLE had higher L* values, but lower a* values. Redness of meat is normally related to pHu of meat (Dhanda *et al*., 1999; Santos *et al*, 2007).

3.5. Conclusion

The high SLW observed in the supplemented BOR and XBC compared to the non-supplemented could be attributed to their ability to utilise feed more efficiently than XLE and NGN goats. The disparity in CDM observed between the supplemented and non-supplemented XLE and NGN, having same SLW, could be attributed to the big abdominal cavity in the non-supplemented goats to cater for the fibrous feeds. The higher muscle pH values in the NGN and XLE goats irrespective of supplementation could be attributed to inherent breed characteristics and possibly, the differences in their response to pre-slaughter handling. The mean Warner Bratzler shear force results in the current study (between 22.9 and 35.7 N) were within the normal range.

Supplemented BOR goats had higher L* values while the NGN had the highest values for both a* and b*. The indigenous genotypes had meat quality attributes that were comparable to the Boer goat, which is a meat breed. Additionally, supplementary feeding significantly improved meat quality attributes of the goats. However, it is crucial to evaluate the influence of supplementary feeding and the methods of preparing the chevon on acceptance by consumers.

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Chapter 4: Consumer sensory evaluation of chevon from indigenous goat genotypes fed on a dietary supplement

By Nomasonto Martha Xazela

Abstract

The objective of the study was to evaluate the effect of genotype and supplementary feeding on sensory scores of chevon from different indigenous goat genotypes prepared using different thermal treatments. Forty eight 6-month-old Xhosa lop-eared (XLE), Nguni (NGN), Xhosa-Boer cross (XBC) and Boer (BOR) castrated goats with a body weight range of between 20 and 25 kg were used in the study. Half of the goats were supplemented with 200 g per head per day of sunflower cake. A consumer sensory evaluation was done with consumers of different ages, tribes and gender. In the non-supplemented XLE and BOR goats, the aroma intensity scores of the fried meat were significantly higher than cooked meat. Female respondents gave higher ($P < 0.05$) scores than male respondents for both cooked and fried meat on aroma intensity. Shona consumers gave higher ($P < 0.05$) aroma intensity scores than the Xhosa and the Zulu consumers for both cooked and fried meat. In the non-supplemented goats, fried meat for all genotypes was superior ($P < 0.05$) to the cooked meat for initial impression of juiciness. Age and gender of respondents and thermal treatment influenced initial impression of juiciness scores ($P < 0.05$). In meat from the non-supplemented XLE and NGN goats, the consumers gave higher ($P < 0.05$) muscle fibre and overall tenderness scores in cooked meat than the fried meat.

Key words: Dietary supplementation, fried chevon, cooked chevon, Xhosa lop-eared goats, Nguni goats, Boer goats.

4.1. Introduction

Studies have been conducted on the palatability and acceptability of chevon (Simela *et al*., 2008). In most instances, however, the studies have employed trained taste panels (Tshabalala *et al*., 2003; Simela *et al*., 2008). Trained sensory panels function as laboratory instruments, and hence their judgment usually matches results of instrumental evaluations of chevon quality (Simela *et al*., 2008). Therefore, while laboratory methods can provide precise and reliable information concerning technical (as described in Chapter 3) and sensory attributes, only consumers can provide reliable and appropriate information about the acceptability of the meat (Simela *et al*., 2008). Recently, Sveinsdóttir *et al*. (2009) established that trained panel assessments of food products can correspond with that of consumers. Consumers tend to evaluate cooked meat quality on the basis of tenderness, juiciness and flavour. The advantage of using consumers over panelists is that they are the end users of the meat and they give a real life assessment of meat quality. Unfortunately, their sentiments and perceptions are largely ignored in most studies. Meat tenderness and flavour appear to be the most important sensory characteristics that determine meat quality (Sañudo *et al.*, 1996; Tshabalala *et al*., 2003). The more tender the meat, the more rapidly juices are released by chewing and the fewer residues remain in the mouth after chewing (Muchenje *et al*., 2008a).

There are various goat breeds, as described in Chapter 3, which are used as meat breeds in South Africa. There is, however, no information on their acceptability and palatability and sensory characteristics to consumers. In several studies, goat genotypes have been shown to show different organoleptic scores (Campo *et al*., 1999; Marlinez-Cerezo *et al*., 2005; Bureš *et al*., 2006). Consumers should, therefore, also consider possible breed differences when purchasing chevon (Esenbuga *et al*., 2009). Information on meta from indigenous South African genotypes is unfortunately not known.

Dietary supplementation is required for body maintenance, growth, reproduction, pregnancy and production of products such as meat. Maphosa *et al*., (2009) showed that nutrition had an effect on milk production. Supplementation also improves carcass conformation and fatness (Mapiye *et al.*, 2010). Diets that influence body condition score or amount of fat deposition are likely to have an effect on the flavor and juiciness of the chevon. Preparation of meat and thermal treatment varies widely between cultures, ethnic and age groups (Tornberg, 2005). Variations in methods of cooking have been shown to affect sensory, mechanical and cooking properties of meat (Dzudie *et al*., 2000). Boiling, frying, roasting, and grilling are the most common thermal treatments used. When testing products, it is important to use consumers from different backgrounds in tasting meat (Dyubele *et al*., 2010). Sveinsdóttir *et al*. (2009) demonstrated that, within each country, different segments of consumers exist with different preferences, motives and demographic background. The differences in countries might be explained by different consumption patterns of chevon within countries. For example, goat meat in the Eastern Cape Province, South Africa is mostly consumed during traditional ceremonies (Mahanjana and Cronje, 2000; Masika and Mafu, 2004; Rumosa Gwaze *et al*., 2009).

In general, little goat meat is consumed in South Africa (Rumosa Gwaze *et al*., 2009). In addition, whether consumer acceptability would be influenced by cooking methods, breed and the body condition of the goat at slaughter has not been established. The objective of the study was, therefore, to evaluate the effect of goat genotype and supplementary feeding on consumer sensory scores of chevon prepared using different thermal treatment methods. It has been hypothesized that there is no effect of genotype, supplementary feeding and thermal treatment on sensory scores of chevon.

4.2. Materials and methods

4.2.1 Study site and management of goats

The study site, experimental animals and management of the goats are described in Chapter 3.

4.2.2. Thermal treatments

Two thermal treatments were used in this study, namely boiling and frying. The sample from each carcass was split into two. The boiled meat was done by first deboning the meat and cutting into small pieces approximately of 2cm x 2cm. Meat from each carcass was cooked separately. The pieces were put into the pot and water was added to cover the meat and cooked for 45 minutes. Salt was added to taste. Frying was done using the frying pan. Cooking oil was added to the pan. The meat was fried until it was firm.

4.2.3. Sensory evaluation

Meat tasting for each thermal treatment was done randomly by a consumer panel composed of a total of 82 students and staff from the University of Fort Hare. The meat form each thermal treatment was randomly presented to the tasting panel. The consumers were invited verbally and also using emails. The panelists were of different gender (female, male), ages (≤ 20, 21-25, 26-30, ≥ 30) and tribes (Xhosa, Shona, Zulu). All the participants were trained on making inferences and recording the scores for each sample. The waiting period between meat sample tasting was about 10 minutes. After tasting each piece, the consumers would rinse their mouths with water before tasting the next sample, to reduce crossover effects.

Eight point descriptive scales were used to evaluate aroma intensity (1= extremely bland to 8= extremely intense), initial impression of juiciness (1 = extremely dry to 8 = extremely juicy), first bite (1 = extremely tough to 8 = extremely tender), sustained impression of juiciness (1 = extremely dry to 8 = extremely juicy), muscle fibre and overall tenderness (1 = extremely tough, to 8 = extremely tender), amount of connective tissue (1= extremely abundant to 8 = none), overall flavour intensity (1= extremely bland to 8 = extremely intense), a-typical flavour intensity (1= none to 8 = extremely intense). The off-flavour indicators were livery/bloody, cooked vegetable, pasture/grassy, animal like/kraal (manure), metallic, sour and unpleasant.

4.2.4. Statistical analysis

After testing for normality, the effect of thermal treatment, genotype and diet on the meat sensory scores was analyzed using the general linear model procedure of SAS (2003). The model was:

$Y_{ijkl} = \mu + C_i + G_j + D_k + (G \times D)_{jk} + (G \times C)_{ij} + (D \times C)_{ik} + (G \times D \times C)_{ijk} + E_{ijkl}$

Where Y_{ijkl} = 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)

μ = overall mean common to all observations

C_i = effect of thermal treatment (boiled, fried)

G_j = effect of genotype (XLE, NGN, XBC and BOR)

D_k = effect of diet

$(G \times D)_{jk}$= interaction between diet and genotype

$(G \times C)_{ij}$ = interaction between thermal treatment and genotype

$(D \times C)_{ik}$ = interaction between diet and thermal treatment

$(G \times D \times C)_{ijk}$ = interaction between diet, genotype and thermal treatment

E_{ijkl} = random error distribution as N(0,I δ^2)

A separate model was used to test for the effects of cooking method, gender, tribe and sex of panelist on the sensory scores. The Tukey's HSD procedure was used for comparison of means.

4.3. Results

The effects of thermal treatment, breed, diet and their interactions on various sensory attributes are shown on Tables 4.1, 4.2, 4.3 and 4.4. Tables 4.5, 4.6 and 4.7 show the influences of gender, tribe and sex on the sensory attributes of chevon. Thermal treatment and diet had a significant influence ($P < 0.05$) on aroma intensity. Genotype, however, had no influence ($P > 0.05$) on aroma intensity. There was an interaction ($P < 0.05$) between cooking method, genotype and diet on aroma intensity scores. Fried meat had higher scores ($P < 0.05$) than cooked meat. In the non-supplemented goats, the aroma intensity scores of fried XLE and BOR meat were significantly higher than those of the cooked meat. In the supplemented XLE goats, however, no ($P > 0.05$) difference in aroma intensity was observed between the cooked and fried meat. On the contrary, in supplemented BOR goats, cooked meat had stronger aroma intensity than the fried meat ($P < 0.05$). No differences in aroma intensity between the cooked and fried meat were observed in both the supplemented and non-supplemented NGN and XBC goats. Tribe and gender of respondents influenced aroma intensity scores ($P < 0.05$). Female respondents gave a

Table 4.1: Levels of significance of factors affecting sensory characteristics

	T	G	D	T × G	T × D	G × D	T × G × D
Aroma intensity	***	NS	***	NS	***	NS	**
Initial impression of juiciness	***	**	***	***	***	*	NS
First bite	**	NS	***	***	NS	***	NS
Sustained impression of juiciness	NS	NS	***	***	NS	***	NS
Muscle fibre and overall tenderness	**	NS	***	***	NS	***	NS
Amount of connective tissue (Residue)	**	NS	**	NS	NS	**	*
Overall flavour intensity	**	NS	NS	NS	**	NS	*
Atypical flavour intensity	NS	NS	NS	**	NS	NS	NS
Off- flavour character	**	**	NS	NS	NS	NS	NS

$P < 0.05$ = *, $P < 0.01$ = **, $P < 0.001$ = ***, NS = not significant ($P > 0.05$)

T × G = Thermal treatment × Genotype, T × D = Thermal treatment × Diet, G × D = Genotype × Diet, T × G × D = Thermal treatment × Genotype × Diet

Table 4.2: Influence of breed, diet and thermal treatment on aroma intensity, initial impression of juiciness and at first bite

		XLE	NGN	XBC	BOR
		Aroma intensity			
Non supplemented	C	4.4 ± 0.16[a]	4.3 ± 0.15[a]	4.7 ± 0.15	4.0 ± 0.15[a]
	F	5.2 ± 0.14[c]	4.7 ± 0.14[abc]	4.9 ± 0.14	4.9 ± 0.14[cd]
Supplemented	C	4.7 ± 0.14[ab]	4.8 ± 0.14[bc]	4.9 ± 0.14	5.3 ± 0.14[d]
	F	4.9 ± 0.15[bc]	4.9 ± 0.15[c]	5.0 ± 0.15	4.7 ± 0.15[bc]
		Initial impression of juiciness			
Non supplemented	C	4.3 ± 0.15[a]	4.3 ± 0.15[a]	3.8 ± 0.14[a]	4.2 ± 0.14[a]
	F	5.1 ± 0.13[d]	4.8 ± 0.13[cd]	4.9 ± 0.13[cd]	4.8 ± 0.13[bc]
Supplemented	C	4.7 ± 0.13[bc]	4.7 ± 0.13[bcd]	4.4 ± 0.13[b]	5.4 ± 0.13[d]
	F	4.9 ± 0.14[cd]	4.8 ± 0.14[d]	5.1 ± 0.14[d]	4.9 ± 0.14[c]
		First bite			
Non supplemented	C	5.1 ± 0.14[b]	4.9 ± 0.14[ab]	4.2 ± 0.14[a]	4.4 ± 0.14[a]
	F	4.6 ± 0.13[a]	4.5 ± 0.13[a]	4.6 ± 0.13[ab]	4.2 ± 0.13[a]
Supplemented	C	4.9 ± 0.13[ab]	5.0 ± 0.13[b]	4.6 ± 0.13[b]	5.5 ± 0.13[c]
	F	4.7 ± 0.14[a]	4.5 ± 0.14[a]	5.0 ± 0.14[c]	4.9 ± 0.14[b]

XLE = Xhosa lop-eared, NGN = Nguni, XBC = Boer × Xhosa, BOR = Boer, C = cooked, F = fried.

Values within column with different superscript are significant different ($P < 0.05$).

Table 4.3: Influence of breed, diet, and thermal treatment on sustained impression of juiciness, muscle fibre and overall tenderness and amount of connective tissue

		XLE	NGN	XBC	BOR
		Sustained impression of juiciness			
Non Supp	C	4.4 ± 0.14[a]	4.8 ± 0.13	4.1 ± 0.13[a]	4.3 ± 0.13[a]
	F	4.5 ± 0.12[abc]	4.6 ± 0.12	4.8 ± 0.12[cd]	4.7 ± 0.12[bc]
Supplemented	C	4.8 ± 0.13[c]	4.7 ± 0.13	4.6 ± 0.12[bc]	5.4 ± 0.13[d]
	F	4.7 ± 0.13[bc]	4.7 ± 0.13	5.1 ± 0,13[d]	5.0 ± 0,13[c]
		Muscle fibre & overall tenderness			
Non Supp	C	5.1 ± 0.14[b]	5.2 ± 0.13[c]	4.6 ± 0.13[a]	4.4 ± 0.13[a]
	F	4.7 ± 0.12[a]	4.7 ± 0.12[ab]	4.6 ± 0.12[a]	4.5 ± 0.13[a]
Supplemented	C	5.0 ± 0.12[ab]	5.0 ± 0.13[bc]	4.7 ± 0.12[a]	5.4 ± 0.13[c]
	F	4.8 ± 0.13[ab]	4.6 ± 0.13[a]	5.1 ± 0.13[b]	5.0 ± 0.13[b]

XLE = Xhosa lop-eared, NGN = Nguni, XBC = Boer × Xhosa, BOR = Boer

C = cooked, F = fried

Non Supp = Non- supplemented.

Values within column with different superscript are significant different ($P < 0.05$).

Table 4.4: Influence of breed, diet and thermal treatment on amount of connective tissue (residue) and overall flavour intensity

		XLE	NGN	XBC	BOR
		Amount of connective tissue (Residue)			
Supp	C	4.5 ± 015[a]	4.9 ± 0.15[b]	4.4 ± 0.14	4.2 ± 0.15[a]
	F	4.6 ± 0.14[a]	4.4 ± 0.14[a]	4.4 ± 0.14	4.3 ± 0.14[a]
Supplemented	C	5.0 ± 0.14[b]	4.6 ± 0.14[ab]	4.4 ± 0.14	5.1 ± 0.14[b]
	F	4.6 ± 0.14[ab]	4.4 ± 0.14[a]	4.5 ± 0.14	4.5 ± 0.15[a]
		Overall flavour intensity			
Non Supp	C	4.7 ± 0.13	4.3 ± 0.13[a]	4.7 ± 0.13[a]	4.7 ± 0.13[a]
	F	5.0 ± 0.12	4.9 ± 0.12[d]	4.8 ± 0.12[ab]	5.0 ± 0.12[ab]
Supplemented	C	4.7 ± 0.12	4.7 ± 0.12[bcd]	4.7 ± 0.12[a]	5.2 ± 0.12[b]
	F	4.7 ± 0.13	4.8 ± 0.13[cd]	5.1 ± 0.13[b]	4.9 ± 0.13[ab]

XLE = Xhosa lop-eared, NGN = Nguni, XBC = Boer × Xhosa, BOR = Boer

C = cooked, F = fried

Non Supp = Non-supplemented.

Values within column with different superscript are significant different ($P < 0.05$).

Table 4.5: Influence of age, tribe, thermal treatment, tribe x thermal treatment, thermal treatment × age and gender × thermal treatment on sensory characteristics

	A	Tb	G	Ttr	Tb × Ttr	Ttr × A	G × Ttr
Aroma intensity	NS	**	***	NS	NS	NS	*
Initial impression of juiciness	*	NS	***	***	NS	NS	**
First bite	***	NS	NS	***	NS	NS	**
Sustained impression of juiciness	***	NS	***	NS	NS	*	NS
Muscle fibre and overall tenderness	***	***	**	***	NS	NS	NS
Amount of connective tissue	***	***	**	***	NS	NS	NS
Overall flavour intensity	***	NS	***	*	NS	NS	*
A-Typical flavour intensity	***	***	*	NS	NS	NS	*
Off- flavour character	**	***	***	NS	NS	***	*

Tb × Ttr = Tribe × thermal treatment, Ttr × A = thermal treatment × Age, G × Ttr= Gender × thermal treatment
P < 0.05 = *, P < 0.01 = **, P < 0.001 = ***, NS = not significant (P > 0.05)

Table 4.6: Influence of gender and thermal treatment on sensory characteristics

Gender	Cooked	Fried
	Aroma intensity	
Male	4.6 ± 0.08[a]	4.6 ± 0.07[a]
Female	5.5 ± 0.11[b]	5.8 ± 0.11[b]
	Initial & sustined impression of juiciness	
Male	4.5 ± 0.08[a]	4.8 ± 0.08[a]
Female	4.9 ± 0.11[b]	5.6 ± 0.11[b]
	Muscle fibre & overall tenderness	
Male	5.1 ± 0.07[a]	4.7 ± 0.07[a]
Female	5.5 ± 0.09[b]	5.3 ± 0.09[b]
	Amount of connective tissue (Residue)	
Male	4.8 ± 0.07[a]	4.6 ± 0.06[a]
Female	5.3 ± 0.10[b]	4.9 ± 0.10[b]
	Overall flavour intensity	
Male	4.8 ± 0.07	4.9 ± 0.06[a]
Female	5.0 ± 0.09	5.3 ± 0.09[b]
	Off- flavour character	
Male	4.9 ± 0.24[b]	4.1 ± 0.13[b]
Female	3.4 ± 0.24[a]	3.6 ± 0.25[a]

Values within column with different superscript are significant different ($P < 0.05$).

Table 4.7: Influence of tribe and thermal treatment on sensory characteristics

Tribe	Xhosa	Shona	Zulu
	Aroma intensity		
Cooked	4.7 ± 0.09[a]	5.3 ± 0.15[b]	5.1 ± 0.16[b]
Fried	5.1 ± 0.09	5.4 ± 0.13	5.2 ± 0.16
	Juiciness		
Cooked	4.5 ± 0.09[a]	4.9 ± 0.14[b]	4.7 ± 0.15[b]
Fried	5.1 ± 0.08	5.1 ± 0.12	5.4 ± 0.15
	Muscle fibre & overall tenderness		
Cooked	4.9 ± 0.08[a]	5.5 ± 0.13[b]	5.6 ± 0.14[b]
Fried	4.9 ± 0.08	4.9 ± 0.12	5.1 ± 0.14
	Amount of connective tissue (Residue)		
Cooked	4.7 ± 0.09[a]	5.0 ± 0.14[a]	5.5 ± 0.15[b]
Fried	4.6 ± 0.08[a]	4.5 ± 0.13[a]	4.9 ± 0.15[b]
	Overall flavour intensity		
Cooked	4.9 ± 0.08	4.9 ± 0.13	5.0 ± 0.14
Fried	4.9 ± 0.07[a]	5.1 ± 0.12[a]	5.3 ± 0.14[b]
	Off-flavour character		
Cooked	3.9 ± 0.24[a]	3.9 ± 0.30[a]	5.4 ± 0.36[b]
Fried	3.9 ± 0.30	3.5 ± 0.58	4.9 ± 0.43

Values within a row with different superscript are significant different ($P < 0.05$).

higher score than males for both cooked and fried meat. Shona consumers gave higher score than the Xhosa and Zulu consumers for both cooked and fried meat.

The diet, genotype and thermal treatment significantly affected the initial impression of juiciness. Only diet, cooking method × diet and breed × diet interactions, however, affected sustained impression of juiciness ($P < 0.05$). In the non-supplemented goats, fried meat for all breeds was rated significantly ($P < 0.05$) superior to the cooked meat. On the contrary, in the supplemented goats, differences in initial impression of juiciness were observed for the meat from only the XBC and BOR goats. In the supplemented XBC goats, fried meat was juicier than the cooked meat, whilst, in contrast, cooked BOR meat was juicier ($P < 0.05$). Age, gender and thermal treatment of respondents influence initial impression of juiciness scores ($P < 0.05$). Female respondents gave a higher score than males for both cooked and fried meat. Fried meat had higher score than cooked meat for initial impression of juiciness. Respondents that were ≥ 30 of age gave the highest scores in cooked and the respondents 26-30 of age gave the highest scores for fried.

In all the non-supplemented goats, except for the NGN goats, the sustained impression of juiciness scores was higher for the fried meat compared to the cooked meat. No differences in scores between the fried and cooked meat were observed for the NGN goats. Similarly to the initial impression of juiciness, in the supplemented goats, differences in sustained impression of juiciness were observed for the meat from only the XBC and BOR goats. Fried meat from the XBC goats was rated significantly higher and juicier than the cooked meat whereas in the BOR, cooked meat was rated as juicier than the fried meat ($P < 0.05$). Age and gender influenced sustained impression of juiciness scores ($P < 0.05$). Respondents that were 26-30 of age gave the highest scores in cooked. Female respondents gave higher scores than males for both cooked and fried meat.

Thermal treatment, diet and the interactions between thermal treatment and diet; and genotype and diet significantly affected first bite. In the non-supplemented goats, in all breeds except the XBC, first bite for the cooked meat was rated as superior ($P < 0.05$) compared to the fried meat. In contrast, fried meat was rated higher ($P < 0.05$) in the fried XBC meat compared to the cooked meat. A similar trend was also observed in the supplemented goats where the first bite was rated higher in cooked meat from all the breeds except the XBC meat which had high score ($P < 0.05$) for the fried meat compared to the cooked meat. Age and gender influenced first bite scores ($P < 0.05$). Cooked and fried were rated significantly higher by ages 26-30 and ≥ 30 with slight differences for first bite. Female respondents gave higher scores than males for both cooked and fried meat for first bite.

Muscle fibre and overall tenderness were closely associated with thermal treatment, diet and the interactions between thermal treatment and breed, and diet and breed on muscle fibre and overall tenderness were significant. Muscle fibre and overall tenderness scores indicated that the panelists regarded cooked meat from the non-supplemented XLE and NGN goats as more tender ($P < 0.05$) than the fried meat. No differences on tenderness were observed between fried and cooked meat from the XBC and BOR goats. In the supplemented goats, cooked meat from the NGN and BOR breeds was rated as more tender ($P < 0.05$) than the fried meat. On the contrary, fried meat from the XBC goats was scored higher ($P < 0.05$) than the cooked meat. No significant difference was observed between cooked and fried meat from the XLE goats. Age, tribe, gender and thermal treatment influenced muscle fibre and overall tenderness scores ($P < 0.05$). Female respondents gave higher scores than males for both cooked and fried meat. Zulu and Shona consumers gave higher scores for cooked meat than Xhosas and Zulus gave the highest scores in fried meat.

As shown in Table 4.4, thermal treatment, diet and the three way interaction (thermal treatment × genotype × diet) affected the amount of connective tissue and overall flavor scores. Cooked meat from the non-supplemented NGN goats had more ($P < 0.05$) connective tissue than the fried meat. No differences in the amount of connective tissue scores were observed in other breeds in the same category. In the supplemented goats, the cooked XLE and BOR meat was found to be chewier compared with the fried meat. No differences between the fried and cooked meat were, however, observed for the NGN and XBC goats. Age, tribe, gender and thermal treatment influenced the amount of connective tissue scores ($P < 0.05$). Female respondents gave higher scores than males for both cooked and fried meat. Respondents that were 21-25 of age gave the lowest amount of connective tissue scores for both cooked and fried meat. Cooked meat had higher amount of connective tissue scores than the fried meat. Zulu consumers found both cooked and fried meat to have the lowest amount of connective tissue.

In the non-supplemented goats, the overall flavour intensity was observed to be higher ($P < 0.05$) in the fried meat than in the cooked meat in all breeds except for the XBC goats. For the supplemented goats, no differences were observed between the cooked and fried meat in all breeds except the XBC where the fried meat had significant stronger overall flavor intensity compared to the cooked meat. Age, gender and thermal treatment influenced overall flavour intensity scores ($P < 0.05$). Female respondents gave higher scores than males for both cooked and fried meat.

4.4. Discussion

The observed lack of influence of genotype on sensory attributes is contrary to the findings by Swan *et al*., (1998), Tshabalala *et al.* (2003) and Muchenje *et al*. (2008a) who observed breed differences in aroma intensity and tenderness. Tshabalala *et al.* (2003) observed that the aroma intensity of Boer goat meat was significantly higher than that of the indigenous goats. Furthermore, Boer goat meat had a stronger goaty aroma than indigenous goats. Generally, flavour and aroma are two complex attributes of meat affected by species, age, fatness, and type of tissue, locality, gender, diet and method of cooking (Calkins and Hodgen, 2007; Muchenje *et al.*, 2009). The observed significant effect of thermal treatment on aroma intensity is however consistent with the observation by Tornberg (2005) that cooking normally changes the composition of animal fat and increases the meat's energy density thereby influencing sensory attributes. From the results in this study, it would appear that supplementary feeding reduced variation of sensory scores due to the two thermal treatment methods.

Regardless of genotype, the initial impression and sustained impression of juiciness for the cooked meat was significantly higher in the supplemented goats than the non- supplemented ones. When the animal is supplemented it accrues more intra-muscular fat than non-supplemented. Generally, juiciness of meat is directly related to the intramuscular lipids and moisture content of the meat (Muchenje *et al.,* 2008a). It appears, therefore, that the supplementation was able to increase the intra muscular fat thereby increase the marbling of the meat. McMillin and Brock (2005) also observed that high-energy intake increased fat content of chevon and hence, the juiciness, tenderness and texture of chevon, Nevertheless, Webb *et al*., (2005) reported that goat meat and goat products are reportedly less juicy compared to mutton and this has been attributed to the lower intramuscular lipid content of goat meat. Unfortunately the intramuscular fat content and fatty acid profiles were not determined in the current study. It seems deep frying also influenced the composition of meat fat such that the panelist could not detect the difference between chevon from supplemented and non-supplemented goats in terms of juiciness. High scores for sustained impression of juiciness in the fried XBC and BOR meat compared to the XLE and NGN are consistent with the findings by Webb *et al.* (2005) who observed that indigenous goat patties were less juicy and greasy than those from Boer goats and the sheep breeds.

Ideally, meat quality levels should combine the capacity to retain high nutritional value in the cooked form and to excel in functional roles such as flavour development, tenderness and juiciness of the cooked product among other roles (Dzudie *et al.*, 2000; Muchenje *et al*., 2008a). Cooked meat from the non-supplemented NGN and XLE goats appeared to be more tender than that of the other two breeds. Supplementation however, seemed to improve tenderness of both the cooked and fried meat of the Xhosa-Boer and Boer goats. Overall, in all breeds cooked meat appeared to be more tender than the fried meat. Generally, tenderness varied due to changes to the myofribrillar protein structure of muscle in the period between animal slaughter and meat consumption (Swan *et al.*, 1998; Muchenje *et al.*, 2008b). There two main components to meat tenderness, are myofibrillar (muscle) component and a connective tissue (collagen) component. The size of the muscle fibres increases with increasing age and may be tougher. Factors such as fat content, muscle fibre composition, electrical stimulation, aging regime, and cooking also can affect tenderness (Swan *et al.,* 1998; Muchenje *et al.*, 2008b).

The observed overall flavour intensity of the fried meat from non-supplemented goat was significant higher than that of cooked meat. With supplementation, the aroma intensity of all the genotypes was similar. Lack of genotype effect on the flavor intensity is contrary to observation made by Martinez-Cerezo *et al*. (2005) who observed higher flavour intensity in cooked meat samples of Maltese kids which were related with direct effects of genotype. Tshabalala *et al*. (2003) found lower flavour intensity in indigenous goats compared with Boer goats, and they explained this result by higher proportions of unsaturated fatty acids in meat samples of indigenous goats. Generally meat flavour is affected by a number of factors including animal age and genotype, feeding regime, carcass fatness level and slaughter weight (French *et al*., 2001; Martinez-Cerezo, *et al*., 2005; Muchenje *et al*., 2009). Flavour can be influenced by the type of diet through the deposition of unique components in the fat and animal species. Muchenje *et al*. (2008a) reported that the flavour depends on the quantity and composition of fat in the meat and meat with a desirable flavour tended to have higher levels of intramuscular fat and more intense marbling. Thermal treatment also affects the flavour through the alteration of fat composition and degree of saturation of the fats (Dzudie *et al.,* 2000).

More often than not, consumer perceptions on the acceptability of meat are linked to socio-cultural factors, especially in the African context. Although goat meat and meat products are also of satisfactory eating quality, factors such as gender, tribe and age tend to affect acceptability of chevon from one community to the next (Mahanjana and Cronje, 2000; Dyubele *et al.*, 2010).

Results from the current study suggest that female consumers tend to give higher scores in most of the sensory attributes and hence find chevon more acceptable. Similar observations were also made by Simela *et al*. (2008). The effect of tribe was clear as in most sensory scores there were significances differences observed. From the results, it would seem the Xhosa tribe couldn't distinguish between the fried and cooked meat unlike the other two tribes. Moreover, the Xhosas generally gave low scores in all the sensory attributes compared to the other two tribes. This could be attributed to characteristic nature of the Xhosa tribe who generally prefer mutton over goat meat because of cultural reasons as observed in other studies (Dyubele *et al.*, 2010). Generally, the common culture of a particular tribe in any community is the most likely the overriding reason on the perceptions of the goat meat and the cooking methods used (Tornberg, 2005). The culture of a community is in itself a very complex phenomenon influenced by available resources, pragmatic practices and beliefs (Webb *et al.*, 2005).

4.5. Conclusion

Thermal treatment and supplementation were observed to influence sensory scores. There was an interaction between cooking method, genotype and diet in some sensory characteristics aroma intensity scores of fried non-supplemented XLE and BOR meat higher than those of the cooked meat. In supplemented BOR goats, cooked meat had stronger aroma intensity than the fried meat. Generally, however, there was lack of goat genotype influence on the sensory attributes of goat meat unlike in other studies. Consumers preferred fried meat to cooked meat, although the fried meat was rated as having more connective tissue than the cooked meat. Consumer acceptability of meat was dependent on age, gender and tribe. These factors should therefore be taken into consideration when developing marketing strategies for chevon.

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Chapter 5: General Discussion, Conclusions and Recommendations

5.1. General discussion

The objective of the study was to determine the effect of dietary supplementation on meat quality and consumer acceptability of chevon from indigenous goat genotypes. Forty eight XLE, NGN, XBC and BOR castrated goats were used in the study. The effects of genotype and sunflower cake dietary supplementation on meat quality of the four goat genotypes were determined in Chapter 3. In Chapter 4 effects of the four goat genotypes and sunflower cake dietary supplementation on sensory scores of chevon prepared using different thermal treatments were determined.

In Chapter 3, slaughter weight, cold dress weight, meat colour, cooking loss, meat pH and Warner-Bratzler shear force values were determined. The XLE and NGN goats had higher $pH_{24,}$ which resulted in darker meat colour, than the BOR and XBC goats. The higher muscle pH_{24} values in the NGN and XLE goats, irrespective of supplementation, could be attributed to the inherent genotypic differences and, possibly, the differences in their response to pre-slaughter handling. The NGN and XLE were reported to be temperamental breeds (Ndou *et al.*, 2010). They were highly active and could be easily agitated, and this may have resulted in significant reduction in glycogen reserves (Muchenje *et al*., 2009). A high pHu reflects a depletion of muscle glycogen due to stress or other factors (Dhanda *et al.*, 2003, Muchenje *et al*., 2009; Mushi *et al*., 2009). There was a significant supplementation and genotype interaction effects on. Supplemented BOR goats had higher L* values while the NGN had the highest values for both a* and b*.

The effects of genotype and sunflower cake dietary supplementation on sensory scores of chevon prepared using different thermal treatment methods was determined in Chapter 4.

Thermal treatment and dietary supplementation influenced sensory scores. Fried meat was preferred over cooked meat though the fried meat was rated as having more connective tissue than the cooked meat. Regardless of genotype, the initial impression and sustained impression of juiciness for the cooked meat was significantly higher in the supplemented goats than the non-supplemented ones. This may be due to the fact that when the animal is supplemented it is to have more intra-muscular fat than non-supplemented (Mapiye *et al*., 2010). McMillin and Brock (2005) also observed that high-energy intake increased fat content of chevon and hence, the juiciness, tenderness, and texture of chevon. Generally, juiciness of meat is directly related to the intramuscular lipids and moisture content of the meat (Cross *et al*., 1986; Muchenje *et al.*, 2008).

In all genotypes, cooked meat was more tender than the fried meat. Results from the current study also suggested that female consumers gave higher scores in most of the sensory attributes and hence find chevon more acceptable. Similar observations were also made by Simela *et al*. (2008). The Shona consumers gave higher scores than the Xhosa and the Zulu consumers for both cooked and fried meat. Consumer perceptions on the acceptability of meat are linked to social-cultural factors, especially in the African context. Although goat meat and meat products are also of satisfactory eating quality, factors such as gender, tribe and age tend to affect acceptability of chevon from one community to the next (Mahanjana and Cronje, 2000, Dyubele *et al.*, 2010).

5.2. Conclusions

The indigenous genotypes had meat quality attributes that were comparable to the Boer goat, which is a meat breed. Supplementation improved meat quality attributes of the goats. Thermal treatment and supplementation were observed to influence sensory scores. Sensory scores for chevon from indigenous goat were comparable to chevon from Boer goat. It was also observed that consumer acceptability of chevon was dependent on consumer background.

5.3. Recommendations

The indigenous genotypes show the attributes that are comparable to the meat breeds (Boer). It has been recommended they can be used as meat breeds as they produced chevon that is acceptable to consumers.

Areas that require further research include:

- ✓ The effect of handling animals on farms, transportation and pre-slaughter environment on meat quality. The study should focus on relationship between stress hormone levels at farms, at arrival and before slaughter, and their relationship with glycogen depletion, glycolytic potential, glycolysis, pH and temperature changes postmortem as these can affect chevon quality.

- ✓ Intramuscular fat content in meat is a very important compound influencing the palatability properties such as taste, juiciness and texture. For example, the quantitative intramuscular fat content has been shown to influence the palatability characteristics of meat. In addition, the visual appearance of the fat does influence the consumers overall acceptability of meat and therefore the choice when selecting meat before buying. The intramuscular fat content and fatty acid profiles of chevon from these indigenous goats need to be determined.

- ✓ Offals are highly consumed and preferred in Eastern Cape, South Africa. There is, therefore, need to document the consumption patterns and enhancing the quality of offals. The chemical composition of offals also needs to be assessed.

- ✓ The effects of sex and age of slaughter of these indigenous goat genotypes on chevon quality need to be determined. Appropriate ages at slaughter for each sex need to be understood.

- ✓ The effects of supplementation with locally available feed resources (for example *Accacia karroo*) and their effects on chevon quality need to be evaluated. Goats lose liveweight and body condition during dry season. The use of locally available browse and other plant materials as supplements and their effects on meat yield and quality require further investigation.

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Appendix 1. Goat carcass record sheet

GOAT CARCASS ABATTOIR & pH RECORD SHEET

Carcass no.	WGHT (1)	WGHT (2)	CLASS	pH1	T1	pH4	T4	pH7	T7	pH12	T12	pH24	T24

Appendix 2: Meat sensory evaluation form

Sensory analysis of Chevon

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

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

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

Name:………………………………….. **Date:………………**

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

	Characteristics	**Rating scale**		**Cooked (plain)**				**Fried**			
				1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
1	**Aroma intensity** Take a few short sniffs as soon as you remove the foil. Typical chevon aroma	**1=Extremely bland 2= Very bland 3= Fairly bland 4= Slightly bland 5=Slightly intense 6= Fairly intense 7= Very intense**	**LE**								
			N								
			BC								

		8=Extremely intense	**B**								
2	**Initial impression of juiciness** The amount of fluid exuded on the cut surface when pressed between the thumb and forefinger	**1= Extremely dry 2= Very dry 3= Fairly dry 4= Slightly dry 5=Slightly juicy 6= Fairly juicy 7= Very juicy 8=Extremely juicy**	**LE**								
			N								
			BC								
			B								
3	**First bite** The impression that you form on the first bite	**1=Extremely tough 2= Very tough 3= Fairly tough 4= Slightly tough 5=Slightly tender 6= Fairly tender 7= Very tender 8=Extremely tender**	**LE**								
			N								
			BC								
			B								
4	**Sustained impression of juiciness** The impression of juiciness that you form as you start chewing	**1= Extremely dry 2= Very dry 3= Fairly dry 4= Slightly dry 5=Slightly juicy 6= Fairly juicy 7= Very juicy 8=Extremely juicy**	**LE**								
			N								
			BC								
			B								
	Characteristics	**Rating scale**		**Cooked (plain)**				**Fried**			
				1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
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**	**LE**								
			N								
			BC								
			B								
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**	**LE**								
			N								
			BC								
			B								

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**	**LE**								
			N								
			BC								
			B								
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**	**LE**								
			N								
			BC								
			B								

Please evaluate the following off flavour characteristics.

	Characteristics		**Cooked (plain)**				**Roasted**				**Fried**			
			1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
1	LIVER/BLOODY	**LE**												
		N												
		BC												
		B												
2	COOKED VEGETABLE	**LE**												
		N												
		BC												

		B												
3	PASTURE/ GRASSY	**LE**												
		N												
		BC												
		B												
4	ANIMAL-LIKE/KRAAL (MANURE)	**LE**												
		N												
		BC												
		B												
5	METALLIC	**LE**												
		N												
		BC												
		B												
6	SOUR	**LE**												
		N												
		BC												
		B												
7	UNPLEASANT	**LE**												
		N												
		BC												
		B												
8	**GOAT ODOUR**	**LE**												

		N												
		BC												
		B												

ANY COMMENTS……

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